

Mining and Reclamation Technology Symposium

June 23-24, 1999



[Disclaimer](#)

[About this CD](#)

[Annotated Agenda](#)

[Participants List](#)

[Table of Contents](#)

Contents

Disclaimer

About this CD

Annotated Agenda

Participants List

Mountaintop Mining Environmental Impact Statement

Mining Methods

Overview of Mining Methods

Underground Mining Methods

Truck and Shovel Methods

Auger and Highwall Miner

From Perception to Procedures

Outlook of Surface Coal Mining

Future of Surface Coal Mining

Mountaintop Reclamation

Schor Consulting

West Virginia Case Study

Disclaimer

This report was prepared as an account of work co-sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency or any co-sponsor thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

About this CD

This proceedings is completely linked and bookmarked in Adobe Acrobat portable document format (PDF).

Presentations show on your screen in the thumbnail view. Use the **Help** button to find out how to view the presentations in full-screen or bookmark views.

Bookmarks help you navigate; double-clicking on a bookmark takes you to the indicated section. Thumbnails help you view a presentation page by page; simply select and click the thumbnail frame.

Lengthy presentations are internally bookmarked. The Auger and Highwall Miner presentation includes three movies which are also bookmarked.

Mining and Reclamation Technology Symposium
Federal Energy Technology Center
Morgantown, West Virginia
June 23 and 24, 1999

[**Final Participants List**](#)

Wednesday June 23, 1999

Dr. Jan Wachter, Federal Energy Technology Center Director, Environmental, Safety and Health Division, welcomed a total of 98 participants representing the state and federal regulatory community, coal mining industry, industry consultants, and environmental interest groups. Dr. Wachter introduced Dr. Paul Ziemkiewicz, Director, National Mine Land Reclamation Center, who served as the symposium facilitator throughout the two-day proceedings.

Dr. Ziemkiewicz highlighted the scope and purpose of the symposium. The Mining and Reclamation Technology Symposium was commissioned by the Mountaintop Removal Mining/Valley Fill Environmental Impact Statement (EIS) Interagency Steering Committee as an educational forum for the members of the regulatory community who will participate in the development of the EIS. The Steering Committee sought a balanced audience to ensure the input to the regulatory community reflected the range of perspectives on this complicated and emotional issue. The focus of this symposium is on mining and reclamation technology alternatives, which is one of eleven topics scheduled for review to support development of the EIS. Others include hydrologic, environmental, ecological, and socio-economic issues.

Overall Purpose of the Symposium in Relevance to the EIS

Mr. Mike Robinson, Chief, Program Support Division, Appalachian Regional Coordination Center, Office of Surface Mining, Reclamation, and Enforcement provided the background of the Mountaintop Mining/Valley Fill EIS including the 1998 legal settlement that required the EIS to be completed within two years. He identified the current concerns about the practice of mountaintop removal mining, why the EIS is being conducted, and what will be studied. His briefing includes geographic information system (GIS) views of the existing valley fill areas throughout West Virginia, Kentucky, Virginia, and Tennessee, which are the only areas of the United States known to be suitable for the mountaintop mining technique and, therefore, expected to need valley fills to receive the excess spoil material. Members of the EIS Steering Committee include, Mr. Robinson, Office of Surface Mining; Ms. Rebecca Hanmer, U.S. EPA; Mr. Rodney Woods, U.S. Army Corps of Engineers; Mr. Dave Densmore, U.S. Fish & Wildlife Service; and Mr. Charley Stover, West Virginia Division of Environmental Protection.

[**Mountaintop Mining Environmental Impact Statement**](#)

Mining Primer: A General Description of Various Mining Techniques

Mr. Stanley Suboleski, Head, Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, provided the overview presentation on mining methods suitable for steep slope terrain. He identified four major methods and two niche methods and discussed the basic economic and physical factors that determine where each is likely to be employed. The two major surface methods are mountaintop mining and contour/point mining and the two major underground methods are room and pillar and longwall mining. He cited auger and highwall mining as surface related niche methods. His presentation included figures on the amount of surface mining that is conducted in the United States and the southern Appalachian region. He also discussed the capital expenditures, coal reserves, and other factors necessary for a particular mining method to be economically viable. The percentage of reserve area recovered by the various surface methods ranges from approximately 33% for single augers to 100% for areas mined by mountaintop removal. Coal recovery for underground methods range from approximately 40% for room and pillar operations to 80% overall for longwall mines. Both longwall and mountaintop removal methods require large capital expenditures which necessitate larger reserve areas for a mine to be

economically feasible.

The speakers following Mr. Suboleski provide more detail on the surface mining techniques. Mr. Suboleski prepared a presentation detailing underground methods, which is included in this proceedings, but the presentation was not given during the symposium in an effort to make up time.

[Overview of Mining Methods](#) [Underground Mining Methods](#)

Surface Mining- Loader/Truck and Shovel/Truck Methods

Mr. Tom Meikle; Progress Coal Company

Mr. Kermit E. Fincham, Jr., Elk Run Coal Company, Inc.

Mr. Meikle described the mountaintop removal and contour/point methods of surface coal mining using a case study example. The case study served to highlight the decision making process that industry typically uses to evaluate the economic feasibility of a prospective surface mining operation. He highlighted that most of the low ratio (ratio of total overburden to recoverable clean coal) coal reserves in Appalachia have been extracted and the higher ratio reserves that remain will require more capital to extract. The typical mountaintop removal operation removes multiple seams of coal, often eight down to the Coalburg seam, removing an average of 436 vertical feet of terrain. Mr. Meikle was joined by Mr. Kermit Fincham who presented the detailed reserve evaluation that is conducted to assess the value and features of the coal reserve that will drive the overall mining operation. Mr. Meikle continued with the remaining activities that are considered in the feasibility analysis through final reclamation and the results of his case study. His case study concluded that this typical operation had an internal rate of return of 9.6% (net present value), which he remarked makes the project only marginally feasible. Furthermore, he concluded that the low rate of return is further impacted by uncertainty in environmental regulations that is further discouraging the large capital investments necessary to conduct these operations.

[Truck and Shovel Methods](#)

Surface Mining- Dragline Method

Mr. Peter Lawson, Arch Coal, Inc.

Mr. Lawson reviewed the history of dragline operations dating back to 1904 and development of the Chicago canal. Today, only two firms continue to manufacture large draglines, including P&H Mining Equipment and Bucyrus Erie. Dragline equipment has grown in capacity to 118 cubic yards (bucket size) and typically operated on the overburden leading to extraction of the lowest seams. Draglines are not appropriate for all surface mining operations and, like other methods, are evaluated on the basis of several factors. He highlighted several benefits of large area surface mines including reclamation of legacy Acid Mine Land (AML) sites within the operating area, elimination of miles of pre-SMCRA highwalls, elimination of underground fires, and creation of wetlands and passive water treatment sites.

Those interested in receiving a copy of Mr. Lawson's presentation should contact him directly at:

Mr. Peter Lawson

Arch Coal, Inc.

5914 Cabin Creek Road

Eskdale, WV 25075

(304) 595-7240

plawson@archcoal.com

Surface Mining- Conventional Auger and Highwall Miner Methods

Mr. Ian Carr, AEI Resources

Mr. Carr presented the results of his international research into state-of-the-art auger and highwall mining technology. These technologies are used to increase the recovery of coal underneath a highwall for a depth of several hundred to a thousand or more feet after continued removal of the highwall becomes uneconomical. Single, double, and triple augers typically have a lower coal recovery rate than highwall miner technologies, but highwall miner technologies require a higher capital investment. Mr. Carr's presentation featured auger technologies from Salem Tool, and Brydet and highwall systems from Arch Technologies (Archveyor), Superior- Highwall Miners, and ADDCAR Highwall Mining Systems.

[Auger and Highwall Miner](#)

Environmentally Responsible Options in Mining

Mr. John Morgan, Morgan Worldwide Consultants

Mr. Morgan is one of three experts retained by the EPA for the Plaintiffs as a result of the settlement suit to support the EIS. Calling his presentation "From Perception to Procedures," he focused on the public participation process and encouraged the mining industry to engage the affected local public on key issues earlier in the process and more effectively for a more successful outcome. He cited key issues as mitigation of short-term effects (dust, noise, blasting, traffic, etc.), Approximate Original Contour (AOC), AOC variances and post-mining land use, and minimization of areas disturbed by mining. He noted the need for a "rational approach" to determining optimum mine configuration and recommended the concept of "banking" to aid in matching optimum fill capacity to excess spoil.

[From Perception to Procedures](#)

Outlook for U.S. Coal Markets through 2020

Ms. Mary Hutzler, Director, Office of Integrated Analysis and Forecasting, Energy Information Administration (EIA)

Ms. Hutzler presented the government's long-range forecast for coal extraction and economics. EIA's congressionally mandated mission is to develop independent energy data and analyses that help enhance the understanding of energy issues on the part of business, government, and the general public. The EIA has similar forecasts for other fuels. She cited the recent dip in coal prices as a result of an oversupply of fuels, particularly foreign oil, and a resulting underdemand for coal. For the long-term, the EIA projects a shift to natural gas combined cycle energy technology as the nation retires more than forty percent of the nuclear energy production capacity. Electricity rates overall will decline about one percent per year through 2020 due to electric utility industry restructuring and retail competition. EIA also projects a continuing decline in minemouth coal prices through 2020 due to projected coal extraction productivity increases of 2.3 percent per year and increased production of western coal reserves, at a lower cost, compared to eastern coal reserves. If Congress chooses to ratify the Kyoto Accord, the fraction of energy produced from coal will decline from fifty percent to near twenty percent with associated declines in coal employment from 80,000 to 29,000.

[Outlook for U.S. Coal Markets through 2020](#)

Panel Discussion: The Future of Surface Coal Mining

Nirmal Gangotadhyay, New Land Leasing Company; Ben Greene, WV Mining and Reclamation Association; John Morgan, Morgan Worldwide Consultants; Barry Doss, Addington Enterprises, Inc.; Tim Backus, P&H Mining Equipment

Mr. Gangotadhyay highlighted the fact that the costs of extracting coal and obtaining permits have continued to increase, while the methods have remained essentially unchanged. The regulatory issue is

complicated by the several agencies trying to simultaneously regulate the industry and the continuing debate regarding AOC nearly 25 years after the passage of SMCRA. He noted that valley fills in place for several years have not affected downstream water quality and expressed concern that the Judicial Branch of government was exerting undue control over the mining industry.

Mr. Greene focused on the shortcomings of long-range predictions like those presented by the EIA and suggested that unexpected events like the oil embargo in the 1970's have always had a positive effect on the coal industry. Large equipment has come to West Virginia increasing the total coal production with record levels in 1998. He suggested that the industry choose the "keep at it" approach and not be discouraged or dissuaded by long-range forecasts. Mr. Green also suggested the Steering Committee rethink the value of reclaiming these large areas with forestry operations.

Mr. Morgan made the point that the productivity increases projected by the EIA may not be achievable considering the declining grade of the reserve base (more difficult to extract). Western reserves are more competitive, therefore drawing the available mining capital away from West Virginia. He cited the European movement away from coal and oil to natural gas as an additional threat to the demand for coal. Reduction in mining will make retaining a qualified labor force more difficult - particularly as mining methods become more sophisticated.

Mr. Doss made a brief presentation to the audience on the coal operator perspective. He projected that existing operations will be mined to depletion within the next ten years. Due to the difficulty in obtaining a permit and the affect on available capital, there will be a reduction in new mountaintop removal permit applications. He expects to see an increase in the use of multi-method mining or hybrid operations where a number of different mining methods are used on the same site. He also noted that re-mining in marginal, previously mined areas could increase. He does not expect to see further increases in the size of large equipment, but he does believe manufacturers will meet the changing market with improvements in technology, productivity, and efficiency - particularly in the areas of fuel efficiency and digital and control technology. He cited the positive effects of large area mining including affects on employment and economics and the lack of evidence of environmental impact from existing valley fills.

[Future of Surface Coal Mining; Mr. Doss](#)

Mr. Backus noted the larger trucks and shovels and the effect they have had on productivity. Truck sizes have grown as large as 360 tons and are limited by the state of tire technology. Shovel size will follow increases in truck size. Large dragline operations are limited by maintenance and downtime costs. He projected slow growth in eastern mining operations, and expects the main growth for equipment manufacturers to come from overseas operations. Lower prices for all fuels and the potential for lower profit margins will drive the need for larger, more efficient mining equipment.

The panel received questions from the audience. A member of the audience asked the panel members to respond to the specific projections and ideas offered by Mr. Doss and Mr. Backus. Panel members cited the need to reduce uncertainty and delays before companies will invest in eastern coal, and noted the apparent large discrepancy between the values cited for coal reserves and mineable coal. Considering the earlier presentation by Mr. Meikle, a member of the audience asked what is an acceptable rate of return and what improvements in mountaintop mining will be necessary to make up the difference (will increased permitting efficiency be sufficient). The panel thought that a rate of return closer to 12 to 15 percent with some reduction in the level of risk would be necessary to attract new capital. Some capital investments are already committed and are subject to whatever rates are available but are loosing money.

Mr. Meikle, speaking from the audience pointed out there is a direct relationship between risk and return. The uncertainty over costs and risk has most capital frozen making it impossible to determine the extent of mineable reserves.

Another member of the audience, identifying himself as a member of the UMWA and the West Virginia Legislature, asked why the mountaintop removal mining has become such a problem now? Mr. Morgan pointed out that the size of mountaintop removal operations has continued to increase. The size of the Arch Coal permit in 1998 was only the catalyst to question the practice.

Mr. Jim Kotcon posed a hypothetical scenario and asked which equipment would provide a reasonable economic return while minimizing the impacts to the environment. What specific technologies are selected for mountaintop mining and how does the industry convince nearby residents of their choices? The panel pointed out that every selection is site specific according to the factors considered in the mining plan and available equipment and capital. There is no unique guidebook. The panel also noted that every member of the community has a different agenda in the permitting process and it is not easy to please everyone who is affected. It was noted that the case study to be presented on the second day would address the question of mining method and equipment options.

The panel was asked to address the 500 acre bank and highgrading as they are related to the 250 acre threshold. Mr. Morgan noted that the 500 acre figure was just an example. The issue is whether the calculations on the optimum configuration indicate that valley fills are required. Mr. Morgan recommended a review of the 250 acres threshold because, in many instances, fewer larger fills would be easier to justify with an expected lower cumulative impact on the environment. Mr. Doss noted that the current regulations encourage companies to design more, smaller valley fills for a given mine site to avoid the 250 acre threshold. Mr. Morgan agreed and noted that this situation supports the concept of an optimum configuration and "banking," which could allow more flexibility while minimizing impacts. Mr. Greene noted that the 250 acre threshold arose from a legal ruling, and has little scientific or technical basis.

Mr. Doss highlighted the uncertainty regarding the issue of post-mining land use as a significant barrier in the permitting process. There is little additional cost to the mining company to develop the site to any of the various post-mining land uses. However, they need some stability in the process. He also emphasized the positive benefits of large area mining. The large area operation in Cabin Creek covered an estimated 5,000 acres and reclaimed an estimated 745 acres of land adversely impacted by previous mining practices.

Closing Remarks- Day 1

Dr. Paul Ziemkiewicz, Director, National Mine Land Reclamation Center

Dr. Ziemkiewicz provided four summary points from the first day of the proceedings:

- Coal mining in West Virginia is likely to continue.
- Many of the sites under consideration for mountaintop removal operations have been previously mined and are environmentally degraded.
- Previous mining has also high-graded the coal reserve making it more difficult to economically extract.
- The industry needs stability in both economic and regulatory issues to continue to operate. This need should be considered when determining which elements will be addressed during the EIS process.

Thursday, June 24, 1999

West Virginia Approximate Original Contour (AOC) Concept

Mr. Jim Pierce, West Virginia Division of Environmental Protection

Mr. Pierce is member of the five-agency team that drafted a guidance document for evaluating the AOC concept found in SMCRA and WVSMCRA. SMCRA requires that the final surface configuration, after backfilling and grading, closely resemble the general surface configuration of the land prior to mining while maintaining the necessary flexibility to accommodate site-specific conditions. The draft guidance document provides an objective and systematic process for achieving AOC on steep-slope surface mine operations while providing a means for determining excess spoil quantities. Using this process maximizes the amount of mine spoil returned to the mined area while minimizing the amount of spoil placed in excess spoil disposal

sites, e.g., valley fills. This, in turn, minimizes impacts to aquatic and terrestrial habitats through ensuring compliance with environmental performance standards imposed by WVSMCRA.

Comments from the audience expressed concern over the poor definition of “higher and better” land use necessary to obtain an AOC variance. The resulting uncertainty in the AOC variance rule eliminates the economic profitability of many sites. This could, in turn, raise the cost to the state of taking claims if landowners become involved.

[Mountaintop Reclamation: AOC and Excess Spoil Determination](#)

Landform Grading and Revegetation: A Concept for Mined Land Reclamation

Mr. Horst J. Schor, H.J. Schor Consulting

Mr. Schor pointed out that southern California and other areas have been dealing with reclamation issues similar to those in West Virginia concerning the practice of mountaintop mining. In southern California the issue arises when dealing with urban pressure to develop hillside terrain for residential development. In other areas the issue arises during post mining reclamation. Through his practice of civil engineering he has studied, categorized, and emphasized the use of natural landscape analogues in reclamation grading and revegetation. He highlights that natural terrain does not slope uniformly at a 2:1 gradient but consists of repetitive vertical curvilinear features that are more visually appealing. Furthermore, natural vegetation patterns are not uniform but are concentrated where water flow concentrates in swales. From his experience, he noted that grading contractors are very capable of reforming the land in a more natural configuration with a project cost increase of not more than two percent and little increase in the excess spoil area.

Schor published material - [Article 1](#), [Article 2](#), [Article 3](#), [Article 4](#)

Panel Discussion: AOC and Landforms Necessary to Accommodate Various Post Mining Land-Uses

Mr. Horst J. Schor, H.J. Schor Consulting; Dan Cox, Massey Coal Services; Jim Pierce, WV Division of Environmental Protection; Mike Castle, Office of Surface Mining

The panel began by taking questions from the audience. One member of the audience asked about the establishment of meandering streams in Mr. Schor’s scheme. Mr. Schor indicated that in his experience streams could be reestablished in nearly the same channel with little settlement. The fills are engineered and constructed with large rock underdrains and slate or sandstone channels to provide stability. Mr. Cox pointed out that there is nothing in Mr. Schor’s concept that cannot be accomplished at existing sites by industry- the issue will be cost. Mr. Pierce noted that the draft AOC guidance was flexible enough to accommodate natural landform grading and revegetation. However, Mr. Castle stated that some regulatory issues might exist with respect to fill saturation and maintenance of the phreatic surface to ensure stability.

The panel debated the issue of higher and lower landforms that has been cited as a regulatory impediment to permitting. Mr. Cox cited this as the biggest problem faced by the coal mining industry today. He also stated that, in his opinion, flat property is more valuable in West Virginia than regulators might believe.

A member of the audience asked for the basis for the 250 acres threshold for the size of valley fills requiring a variance and the kinds of impacts that are expected at that threshold. Mr. Castle pointed out that the 250-acre limit is an interim value until completion of the EIS.

In response to a question from the audience, Mr. Schor noted that reclamation to more natural landforms contribute to the re-establishment of natural habitat and introduction of native species.

Ms. Hanmer, speaking from the audience, noted that West Virginia has developed a Watershed Framework Document and asked how this framework was being used to address the issue of mountaintop mining and

post-mining land use? The panel pointed out that the state has established a Coalfield Development Office that should be the focus of a watershed approach to this issue.

With respect to Mr. Schor's approach for natural landforms, Mr. Hartos noted that valley fills shaped with natural landforms would probably cover more area than valley fills shaped in the traditional form. The question was posed as to how the natural landform approach maintains the stability of streams. Mr. Schor noted that reconstructed streams in natural landforms are engineered with high compaction and sandstone channels. The entire natural landform fill is also constructed with an underdrain for geotechnical stability, as are current valley fills.

Mr. Doss asked how the current draft of the AOC rule would allow the use of natural landforms. Mr. Pierce answered that the model was not yet finalized but that nothing specifically precluded alternate landforms with an approved variance. Mr. Woods of the US Army Corps of Engineers commented that the stream impact mitigation ruling that they are required to enforce allows only the minimal amount of fill to affect existing streams. Ms. Hanmer commented that the EPA position is not as rigid. Their point of view considers what the permitted firm has done to prevent, mitigate, restore, or reclaim the watershed to an equivalent aquatic value. According to Ms. Hanmer, the EPA has identified the need for study of paired watersheds with and without fills in an attempt to discern the potential impact on value of the watershed. Mr. Ziemkiewicz noted that the recent SAIC study presented to the Surface Mining Task Force, which evaluated the health of channels downstream of valley fills, is neutral with respect to the impact of the fill. However, the SAIC study was small in scope and contains insufficient data to be conclusive on the subject. Mr. Sweeney pointed out that the Programmatic EIS that the EPA has undertaken on this mining practice would pick up where the SAIC study left off.

As a closing remark of this session, Mr. Meikle made the comment that, in his opinion, the WVDEP surface mining permitting capability is shutdown until the OSM and EPA resolve the post-mining land use issues that have been raised during this symposium. Another individual added that mine permitting has been stopped without evidence that anything negative is or has occurred. Why has it stopped? Mr. Robinson rebutted that permitting has not stopped. The settlement included two parts, one to evaluate the effects of the practice and the other to address the permitting process.

Presentation of a West Virginia Case Study

John McDaniel Arch Coal, Inc.; Eugene Kitts, Summit Engineering

Mr. McDaniel and Mr. Kitts presented an extensive and detailed case study reflecting the development of a detailed mine plan in preparation for permit application. The case study was based on the development of an actual permit request and was very useful in understanding the breadth and depth of issues that a mining firm has to evaluate and make decisions about in order to determine economic feasibility of extracting coal from a reserve. The briefing material covers the breadth of the presentation and the buildup of the economic evaluation.

[West Virginia Case Study briefing materials](#)

Panel Discussion: West Virginia Case Study

John McDaniel, Arch Coal, Inc.; John Morgan, Morgan Worldwide Consultants; Anthony Szwilski, Marshall University

Mr. Hartos opened the questioning by asking how many community interactions typically occur for the determination of post mining land use. Mr. McDaniel commented first by noting that little interaction occurs because at this point the mining firm is trying to ascertain the economic viability of the project before engaging regulators and the public. Mr. Morgan made the point that too much advanced planning before

engaging the public actually creates a barrier to approval. His position is that creating an early public dialogue will enhance the participation and support of the public in the permitting process.

Mr. Szwilski presented the point of view that the mining firms would benefit from implementing an ISO 14000 Environmental Management System. This system of environmental self-management would generate a renewed confidence in those members of the industry that adhere to it. The motivation for a firm to adhere is largely intangible but adherence might serve to streamline the permitting process for those firms that are certified.

Mr. McDaniel responded to a question about environmental analyses conducted during the preliminary mine planning phase by stating that a large amount of environmental data is collected by professional scientists as part of the baseline assessment. This data is available for additional study of post-mining and valley fill environmental impacts.

Mr. Morgan commented that uncertainty and delay in acquiring permits largely drive the cost and the marginal economic viability of mining in West Virginia. The notable exception to this generality is the direct cost to achieve AOC. Anything that can be done to establish a dialogue with the public and regulators early in the process would be helpful.

Closing Remarks

Dr. Paul Ziemkiewicz, Director, National Mine Land Reclamation Center

Mr. Ziemkiewicz closed the conference by providing a conclusion based on his perspective as facilitator. He noted that West Virginia underwent a mining boom in the 1980's. Mines during this period were typically small, undercapitalized and left environmental and economic issues to resolve after closure. Additionally, these small mines served to high-grade the reserve making the remaining coal less viable to recover. Large consolidated mining operations in the area of these small mines would have the combined benefit of improving the economics of the remaining reserve and provide long-term stability for contracts, labor, planning, and other factors. These bigger operations will be easier to regulate than many small operations and will have a big effect on reclaiming previously mined areas.

He pointed out that clarity in regulation is necessary to attract mining capital back to West Virginia. The AOC policy must be coherent and post mining land use policy must be clear. In some instances growing trees may be preferable to further economic development. He also recommended a holistic watershed approach to hydrologic protection and reconstruction. Reconstructed streams and natural landform grading fit well with a watershed approach and should be considered as part of the solution.

PARTICIPANT LIST
Mining Technology Symposium
June 23, 1999 - June 24, 1999

Participant List by Name

1. Timothy D. Backus P&H Mining Equipment 4400 National Avenue Milwaukee, WI 53214 Phone: 414/671-7384 Fax: 414/671-7560 E-mail: tbac@hii.com	5. Bob Billups Pittston Coal P.O. Box 11718 Charleston, WV 25339-1718 Phone: 304/347-8233 Fax: 304/347-8980 E-mail: rbillups@pittstonminerals.com
2. Victor Badaker University of Kentucky 292 Commonwealth Drive Lexington, KY 40503 Phone: 606/323-9641 Fax: E-mail: vbadaker@engr.uk.edu	6. Ralph Blumer Office of Surface Mining 2675 Regency Road Lexington, KY 40503 Phone: 606/233-2896 Fax: 606/233-2898 E-mail: rblumer@osmre.gov
3. Carl Bauer Federal Energy Technology Center US Department of Energy 3610 Collins Ferry Road Morgantown, WV 26507-0880 Phone: 304/285-4912 Fax: 304/285-4100 E-mail: cbauer@fetc.doe.gov	7. Jason Bostic West Virginia Coal Association 1301 Laidley Tower Charleston, WV 25301 Phone: Fax:
4. Heino Beckert Federal Energy Technology Center US Department of Energy 3610 Collins Ferry Road Morgantown, WV 26507-0880 Phone: 304/285-4132 Fax: 304/285-4403 E-mail: hbecke@fetc.doe.gov	8. Gary Bryant US EPA 1060 Chapline Street Wheeling, WV 26003 Phone: 304/234-0230 Fax 304/234-0257 E-mail:

9. Melissa Bundash
US EPA
1060 Methodest Building
11th & Chapline Streets
Wheeling, WV 26003
Phone: 304/234-0246
Fax:
Email: bundash.melissa@epa.mail.epa.gov

10. Carey R. Butler
Waste Policy Institute
3606 Collins Ferry Road
Suite 202
Morgantown, WV 26505
Phone: 304/598-9383 ext. 15
Fax: 304/598-9392
E-mail: carey_butler@wpi.org

11. Roger W. Calhoun
Office of Surface Mining
Charleston Field Office
1027 Virginia Street East
Charleston, WV 25301
Phone: 304/347-7158
Fax: 304/347-7170
E-mail: rcalhoun@osmre.gov

12. Mike Caputo
United Mine Workers of America
310 Gaston Avenue
Fairmont, WV 26554
Phone: 304/363-7500
Fax: 304/367-1382
E-mail: mikeumwa@aol.com

13. Ian Carr
AEI Resources
1500 N. Big Run Road
Ashland, KY 41102
Phone: 606/928-7220
Fax: 606/928-7257
E-mail: icarr@aeiresources.com

14. Mike Castle
Office of Surface Mining
1951 Constitution Avenue
Washington, DC 20240
Phone: 202/208-2928
Fax: 202/219-3276
E-mail: mcastle@osmre.gov

15. Peter Claggeh
Canaan Valley Institute
103 Marlten Road
Woodstown, NJ 08098
Phone: 609/769-3381
Fax:
E-mail:

16. Danny Cox
Massey Coal Services Inc
P.O. Box 1951
Charleston, WV 25327
Phone: 304/345-3556
Fax: 304/345-3623
E-mail: danny.cox@masseycoal.com

17. Ron Damron
Pittston Coal Mgmt
PO Box 11716
Charleston, WV 25339
Phone: 304/347-8200
Fax: 304/347-8980
E-mail: rdamron@pittstonminerals.com

18. Thomas DeMoss
US EPA
701 Mapes Road
Ft Meade, MD 20755-5350
Phone: 410/305-2739
Fax: 410/305-3095
E-mail:

19. Dave Densmore
US Fish & Wildlife Service
315 South Allen Street
Suite 322
State College, PA 16801
Phone: 814/234-4090
Fax: 814/234-0748
E-mail: dave-densmore@fws.gov

20. Barry Doss
Addington Enterprises Inc
1100 River East Drive
Belle, WV 25015
Phone: 304/925-9577
Fax: 304/925-9569
E-mail: ccccoal@wvinter.net

21. Ken Eltschlager
Office of Surface Mining
Three Parkway Center
Pittsburgh, PA 15220
Phone: 412/937-2169
Fax: 412/937-2903
E-mail: kelts@osmre.gov

22. Diana Esher
US EPA
1650 Arch Street
Philadelphia, PA 19103-2029
Phone: 215/814-2706
Fax: 215/814-2789
E-mail: esher.diana@epamaii.epa.gov

23. Bernard Evans
United Mine Workers of America
PO Box 474
Lyburn, PA 25632
Phone: 304/752-8060
Fax 304/752-8064
E-mail: devans@xwv.net

24. Kermit E. Fincham, Jr.
Elk Run Coal Co Inc
PO Box 497
Sylvester, WV 25193
Phone: 304/837-3520
Fax: 304/837-3522
E-mail: kermit.fincham@masseycoal.com

25. Terry Flum
US EPA
26 W. Martin Luther King Drive
Cincinnati, OH 45268
Phone: 513/569-7715
Fax: 513/569-7609
E-mail: flum.terry@epa.gov

26. Nirmal Gangopadhyay
New Land Leasing Co Inc
PO Box 2243
Beckley, WV 25802
Phone: 304/255-1457
Fax: 304/255-1498
E-mail: gango@mtneer.net

27. Ray George
US EPA
1060 Chaplin Street
Wheeling, WV 26003
Phone: 304/234-0234
Fax: 304/234-0258
E-mail: george.ray@epa.gov

28. Mike Gheen
US Army Corps of Engineers
502 8th Street
Huntington, WV 25701
Phone: 304/529-5487
Fax: 304/529-5085
E-mail: mikeg@mai.oh.usace.army.mil

29. Ben Greene
West Virginia Mining & Reclamation Association
1624 Kanawha Boulevard East
Charleston, WV 25311
Phone: 304/346-5318
Fax: 304/346-5310
E-mail: wvmra@wvmra.com

30. Chris Hamilton
West Virginia Coal Association
1301 Laidley Towers
Charleston, WV 25301
Phone: 304/342-4153
Fax: 304/342-7651
E-mail: chamilton@wvcoal.com

31. Ron Hamric
Anker Energy Corporation
PO Box 4360
Star City, WV 26504
Phone: 304/983-8700
Fax: 304/983-8770
E-mail: rhamric@ankercoal.com

32. Rebecca Hanmer
US EPA
Mail Code 4505F
Washington, DC 20460
Phone: 202/260-4470
Fax: 202/401-5341
E-mail: hanmer.rebecca@epamail.epa.gov

33. Randy Harris
Federal Energy Technology Center
US Department of Energy
3610 Collins Ferry Road
Morgantown, WV 26507-0880
Phone: 304/283-4860
Fax:
E-mail: rharris@fetc.doe.gov

34. Dave Hartos
Office of Surface Mining
Three Parkway Center
Pittsburgh, PA 15220
Phone: 412/937-2909
Fax: 412/937-2903
E-mail: dhartos@osmre.gov

35. Ray Henderson
Consultant
807 Coleman Avenue
Fairmont, WV 26554
Phone: 304/363-3269
Fax:
E-mail:

36. John L Hoelle
Gaddy Engineering Company
PO Box 2742
Huntington, WV 25727
Phone: 304/697-4400
Fax: 304/525-5997
E-mail: ihoelle@ezwv.com

37. William J. Hoffman
US EPA
1650 Arch Street
Philadelphia, PA 19104
Phone: 215/814-2995
Fax: 215/814-2783
E-mail: hoffman.william@epa.gov

38. Mary Hutzler
U S Department of Energy
Energy Information Administration
1000 Independence Ave SW
Washington, DC 20585
Phone: 202/586-2222
Fax: 202/586-3045
E-mail: mhutzler@eia.doe.gov

39. Jeffrey Kelley
Upshur Property Inc
HC36
PO Box 31
Tallmansville, WV 26237
Phone: 304/472-9272
Fax: 304/472-9257
E-mail: jkelley@ankercoal.com

40. Charles R. Kimbler
United Mine Workers of America
PO Box 185
Danville, WV 25053
Phone: 304/369-3347
Fax:
E-mail:

41. Eugene Kitts
Summit Engineering
400 Allen Drive
Suite 100
Charleston, WV 25302
Phone: 304/342-1342
Fax: 304/342-1379
E-mail: wvsummit@nevvwave.net

42. Kewal Kohli
Office of Surface Mining
Three Parkway Center
Pittsburgh, PA15220
Phone: 412/937-2175
Fax: 412/937-2903
E-mail: kkohli@osmre.gov

43. Thomas Koppe
Office of Surface Mining
2675 Regency Road
Lexington, KY40503
Phone: 606/233-2892
Fax: 606/233-2898
E-mail: tkoppe@osmre.gov

44. James Kotcon
West Virginia University
Div of Plant & Soil Sciences
401 Brooks Hall PO Box 6054
Morgantown, WV 26506
Phone: 304/293-3911
Fax: 304/293-2872
E-mail: jkotcon@wvu.edu

45. William Kovacic
Office of Surface Mining
2675 Regency Road
Lexington, KY 40503
Phone: 606/233-2894
Fax: 606/233-2898
E-mail: bkovacic@osmre.gov

46. Frederick W. Kutz
US EPA
701 Mapes Road
Ft Meade, MD 20755-5350
Phone: 410/305-2742
Fax: 410/305-3095
E-mail:

47. Mary J. Lacerte
US EPA
12201 Sunrise Valley
Mail Stop 555
Reston, VA 20192
Phone: 703/648-4137
Fax: 703/648-4290
E-mail: lacerte.mary@epa.gov

48. Peter Lawson
Arch Coal Inc
5914 Cabin Creek Road
Eskdale, WV 25075
Phone: 304/595-7240
Fax: 304/595-4068
E-mail: plawson@archcoal.com

49. Tom Marks
Cecil I Walker Machinery Co
PO Box 2427
Charleston, WV 25329
Phone: 304/949-6400
Fax: 304/949-7272
E-mail: xuptam01@belle.walker.com

50. Robert Marsh
Pen Coal Corp
PO Box 191
Dunlow, WV 25511
Phone: 304/385-4950
Fax: 304/385-4594
E-mail: robert-marsh@pencoal.com

51. Richard E. Martin
Cecil I Walker Machinery Co
PO Box 2427
Charleston, WV 25329
Phone: 304/949-6400 ext. 453
Fax: 304/949-7339
E-mail: rmartin@email.com

52. John McDaniel
Arch Coal Inc
CSX Operation
PO Box 305
Madison, WV 25130
Phone: 304/369-8133
Fax: 304/369-8131
E-mail: jmcdaniel@archcoal.com

53. Rhett McGregor
Consulting Engineer
10361 Giverny Blvd
Cincinnati, OH 45241
Phone: 513/733-0552
Fax: 513/733-1235
E-mail: 73071.331 O@compuserve.com

54. Tom Meikle
Progress Coal Co
HC78
PO Box 1796
Madison, WV 25130
Phone: 304/369-9101
Fax: 304/369-9105
E-mail:

55. Michael Miano
WV DEP
10 McJunkin Road
Nitro, WV 25143
Phone: 304/759-0575
Fax: 304/759-0526
E-mail: mmiano@mail.dep.state.wv.us

56. Randy A Moore
EG&G
Collins Ferry Road
PO Box 880
Morgantown, WV 26507-0880
Phone: 304/285-4606
Fax: 304/285-4200
E-mail: rmoore@fetc.doe.gov

57. John Morgan
Morgan Worldwide Mining Consultants
PO Box 888
Lexington, KY 40588
Phone: 606/259-0959
Fax:
E-mail: mwmc@aol.com

58. Jan M. Mutmansky
Penn State University
156 Hosler Building
University Park, PA 16802
Phone: 814/863-1642
Fax: 814/865-3248
E-mail: j93@psu.edu

59. Julie Parsons
US EPA
1060 Methodist Building
11th & Chaplain Streets
Wheeling, WV 26003
Phone: 304/234-0246
Fax:
E-mail: parsons.julia@epamaii.epa.gov

60. Syd Peng
West Virginia University
Department of Mining Engineering
P.O. Box 6070
Morgantown, WV 26506
Phone: 304/293-7680
Fax: 304/293-5708
E-mail: speng2@wvu.edu

61. Christopher C Peterson
Gannett Fleming Inc
800 Leonard Street
Suite 1
Clearfield, PA 16830
Phone: 814/765-4320
Fax: 814/765-2511
E-mail: cpeterson@gfnet.com

62. Jim Pierce
WV DEP
525 Tiller Street
Logan, WV 25601
Phone: 304/792-7075
Fax:
E-mail: jpiercez@mail.dep.state.wv.us

63. Nadine Pierre-Charles
US EPA
1060 Chaplin Street
Wheeling, WV 26003
Phone: 304/234-0234
Fax: 304/234-0258
E-mail:

64. Randy Pomporio
Canaan Valley Institute
964 Clerry Hill Lane
Pottstown, PA 19465
Phone: 610/917-2138
Fax: 610/917-2139
E-mail: jrpolitico@aol.com

65. David E. Rider
US EPA
1650 Arch Street
3ES30
Philadelphia, PA 19103
Phone: 215/814-2787
Fax: 215/814-2783
E-mail: rider.david@epa.gov

66. Kurt Riitlers
USGS-BRD
NC State University
PO Box 8002 Baltimore Hall
Raleigh, NC 27695
Phone: 919/515-7581
Fax:
E-mail: kurt@usgs.gov

67. Mike Robinson
Office of Surface Mining
Three Parkway Center
Pittsburgh, PA 15220
Phone: 412/937-2882
Fax: 412/937-2903
E-mail: mrobin@osmre.gov

68. Ron Robinson
Virginia Dept. of Mines, Minerals & Energy
PO Drawer 900
Big Stone Gap, VA 24219
Phone: 540/523-8166
Fax: 540/523-8141
E-mail: rdr@mme.state.va.us

69. Terry Sammons
Jackson & Kelly Attorneys at Law
PO Box 553
Charleston, WV 25322
Phone: 304/340-1364
Fax: 304/340-1050
E-mail: tsammons@jacksonkelly.com

70. Bernie Samoski
US EPA
Region 111
1650 Arch St MS/3WP 10
Philadelphia, PA 08009
Phone: 215/814-5756
Fax: 215/814-2301
E-mail: sarnoski.bernie@epamail.epa.gov

71. Katie Scharf
Yale University
604 Hazel Road
Charleston, WV 25314
Phone: 304/345-0931
Fax:
E-mail: katherine.scharf@yale.edu

72. Horst J Schor
H J Schor Consulting
626 North Pioneer Drive
Anaheim, CA 92805
Phone: 714/778-3767
Fax: 714/778-1656
E-mail:

73. Mark Schuerger
RAG-American Coal
1520 Kanawha Blvd E
Charleston, WV 25311
Phone: 304/345-0970
Fax: 304/345-6034
E-mail:

74. Guy Shelledy
Fola Coal Company
PO Box 180
Bickmore, WV 25019
Phone: 304/587-4100
Fax: 304/587-2469
E-mail: wvsailor@aol.com

75. Gary E Slagel
CONSOL Inc
1800 Washington Road
Pittsburgh, PA 15241
Phone: 412/831-4532
Fax: 412/831-4513
E-mail: garysiagel@consolcoal.com

76. Terrence Slonecker
US EPA
12201 Sunrise Valley
Mail Stop 555
Reston, VA 20192
Phone: 703/648-4289
Fax: 703/648-4290
E-mail: slonecker.t@epa.gov

77. Keith Smith
Kentucky Dept for Surface Mining
#2 Hudson Hollow Street
Frankfort, KY 40601
Phone: 502/564-2340
Fax: 502/564-5848
E-mail: k.smith@mail.state.ky.us

78. John Smith Jr.
Mining Tech
1500 N Big Run Road
Ashland, KY 41129
Phone: 606/928-7220
Fax: 606/928-7257
E-mail:

79. Douglas E Stone
Office of Surface Mining
Big Stone Gap Field Office
1941 Neeley Rd, Suite 201, Compartment 116
Big Stone Gap, VA 24219
Phone: 540/523-0067
Fax: 540/523-5053
E-mail: dstone@osmre.gov

80. Stanley Suboleski
Virginia Polytechnic Inst/State Univ
Dept of Mining Engineering
Blacksburg, VA 24061
Phone: 540/213-6671
Fax: 540/231-4070
E-mail:

81. M J Superfesky
Office of Surface Mining
PO Box 886
Morgantown, WV 26505
Phone: 304/291-4004
Fax: 304/296-8897
E-mail: mjsuperf@osmre.gov

82. Dan Sweeney
US EPA
1650 Arch Street
Philadelphia, PA 19103
Phone: 215/814-5731
Fax: 215/814-2301
E-mail: sweeney.dan@epa.gov

83. Rick Sweigard
University of Kentucky
Dept of Mining Engineering
Lexington, KY 40506-0107
Phone: 606/257-1173
Fax: 606/323-1962
E-mail: rsweigar@engr.uky.edu

84. Tony Szwilski
Marshall University
112 Gullickson Drive
Huntington, WV 25755
Phone: 304/696-5457
Fax: 304/696-5454
E-mail: szwilski@marshall.edu

85. Joe Timms
WV Board of Professional Engineers
Phone: 304/842-4958
Fax:
E-mail: jimms@aol.com

86. Paul Travis
Kentucky Dept for Surface Mining
#2 Hudson Hollow Street
Frankfort, KY 40601
Phone: 502/564-2320
Fax: 502/564-5848
E-mail: paul.travis@mail.state.ky.us

87. Jim Truman
Hill & Associates
32 West Street
Westover, WV 26501
Phone: 304/291-2290
Fax: 304/291-2290
E-mail: ula00260@mail.wvnet.edu

88. Dave Vande Linde
WV DEP
10 McJunkin Road
Nitro, WV 25143
Phone: 304/759-0510
Fax: 304/759-0528
E-mail: dvandelinde@mail.dep.state.wv.us

89. Thomas A Vorbach
Steptoe & Johnson
PO Box 1616
Morgantown, WV 26507-1616
Phone: 304/598-8000
Fax: 304/598-8116
E-mail: vorbacta@steptoe johnson.com

90. Jan Wachter
Federal Energy Technology Center
US Department of Energy
3610 Collins Ferry Road
Morgantown, WV 26507-0880
Phone: 304/285-4607
Fax: 304/285-4403
E-mail: jwacht@fetc.doe.gov

91. Steve Wathen
P&H MinePro Services
205 Sruley Drive
St Albans, WV 25177
Phone: 304/755-1007
Fax: 304/755-8595
E-mail: swathen@hii.com

92. Mark Weaver
RAG-American Coal
1520 Kanawha Blvd
E Charleston, WV 25311
Phone: 304/345-0970
Fax: 304/345-6034
E-mail:

93. Ed Wojtowicz
WV DEP
116 Industrial Drive
Oak Hill, WV 25901
Phone: 304/465-1911
Fax: 304/465-0031
E-mail: bib00991@mail.wvnet.edu

94. Roger Wolfe
Jackson & Kelly Attorneys at Law
PO Box 553
Charleston, WV 25322
Phone: 304/340-1105
Fax: 304/340-1130
E-mail: rwlfe@jacksonkelly.com

95. Rodney Woods
US Army Corps of Engineers
PO Box 1159
Cincinnati, OH 45201-1159
Phone: 513/684-6212
Fax: 513/684-2460
E-mail: rodney.l.woods@lrdor.usace.army.mil

96. Dennis H Yankee
Tennessee Valley Authority
129 Pine Road
Norris, TN 37828
Phone: 423/632-1541
Fax: 423/632-1493
E-mail: dhyankee@tva.gov

97. G 0 Young
Pittston Coal Company
PO Box 11718
Charleston, WV 25339
Phone: 304/347-8205
Fax: 304/347-8980
E-mail: goyoung@piftstonminerals.com

98. Paul Ziemkiewicz
West Virginia University
National Mine Land Reclamation Center
PO Box 6064
Morgantown, WV 26506-6064
Phone: 304/293-2867
Fax: 304/293-7822
E-mail: pziemkie@wvu.edu



Overview of Mining Methods

Stanley C. Suboleski

Virginia Tech

Dept. of Mining & Minerals
Engineering

June 23, 1999

Four Major Methods

- Plus two niche methods
- Surface
 - MTR
 - Contour/Point Removal
- Surface-Related
 - Auger
 - Highwall
- Underground
 - Room & Pillar
 - Longwall
- Method chosen depends on economic and physical factors

What Method to Use?

■ Depth

- <100' = not UG

■ Ratio

- >15-20 yds/tn coal = not SURF.

■ Capital available

- small = not MTR, not longwall

■ Reserve size

- small = not MTR, not longwall

■ May be a combination of factors

- usually, an obvious choice

MTR

- Recovers 100% of reserves, usually from multiple seams
 - Deep mines may only get 50% or so of one seam
- Use in large reserves with ratios up to 20:1 (yds per tn)
- Large capex, large equipment
- Backstack as much rock as possible (to AOC)
 - put remainder in valley fills -- planner must balance fill volume
- 1/4 - 1/3 of output in Appalach

AOC / Valley Fills

- Fill problem arises from “swell” of material after blasting
- Must store somewhere or there is no room for equipment
- “Durable rock” is put in valley fills
 - Allows valley fills to be end dumped, not spread
 - Large rock will roll further, forms natural drain

Economic Ratios

$MTR/MTM = 13 - 20(?) : 1$

- Can vary, is a function of:
 - Price of coal - Met or Steam
 - Overburden type - SS/SH
 - Topography - average distance rock must be hauled
 - Mostly, equipment type/size
 - Large/small loader/trucks:
 - 13 yd loader + 75t trucks, up to 40 yd loader + 240/310t trucks
 - Lowest cost per yard is dragline
 - But need large capex, therefore large reserve to use larger equipment

Contour Mining

- Haulback & stack overburden
- Smaller equipment, will have smaller reserves
- Can control cost via ratio
 - Stop at the point that highwall becomes uneconomic to mine (10-12:1?)
 - Often combine with augering, highwall mining or point removal to get extra coal
- Excess rock still taken to valley fill

Sequence of Surface Operations

- Remove soil & stockpile
- Prepare drill bench
- Drill
- Blast
- Load & haul overburden
 - Dozer
 - FEL/Truck or Shovel/Truck
 - Dragline
- Load out coal
- Place rock & reclaim surface

Surface-Related Methods

- Used when too deep for surface, too thin or too small for deep
- Auger - drill 200-400 ft holes into highwall
 - Round holes, 33% max recovery
- Highwall miner - remotely mine for 400-1000 ft
 - Auger or conveyor-car haulage
 - Square holes, 45% max recovery
- Specialized method & limited reserves dictate that contractors are normally used

Underground Mining - Longwall

- Large capital, high output
- Thus, requires large reserve
 - +50 million tons, prefer twice that as minimum
- Requires regular shape of property
- Thick seam method
 - 6.0ft+ to be productive
- Not flexible

Longwall

- If conditions are favorable, there is no lower cost method
 - Rates of 1 million rom tpm with 250 people are possible
- Other items:
 - Problem if coal quality is variable
 - Still must develop with continuous miner
 - Get subsidence immediately (& no more) - 2/3 of seam thickness
 - Changes groundwater flow

Continuous Miners Room & Pillar

- Used if longwall can't be used - - in smaller or thinner reserves (or to develop for longwalls)
- Flexible layout
- Used for both development and pillarizing
- Easily moved from place to place or mine to mine (small reserves)
- Moderately low capital
- Historically has been the standard method in Appalachia

Continuous Miners

- Used in seams from 28" to 13 ft
 - Equipment comes in many size ranges
- Room and pillar plan recovers 40-60% of reserve
- Can be low cost, but not in thin seams
- Difficult to justify new “greenfield” continuous miner operation -- normally can't support cost of new processing plant and mine, too

Longwall Vs. Continuous Miners

- 100% of longwall coal is recovered, maybe 70-80% overall (?) vs 40-60%
- Lower operating cost/ much higher capital
- “Digital” in nature vs “analog”
 - Quantity and quality
- Development may be a problem
 - Many mines find it difficult to keep lw panels developed
- Both produce about 45% of underground output in U.S.

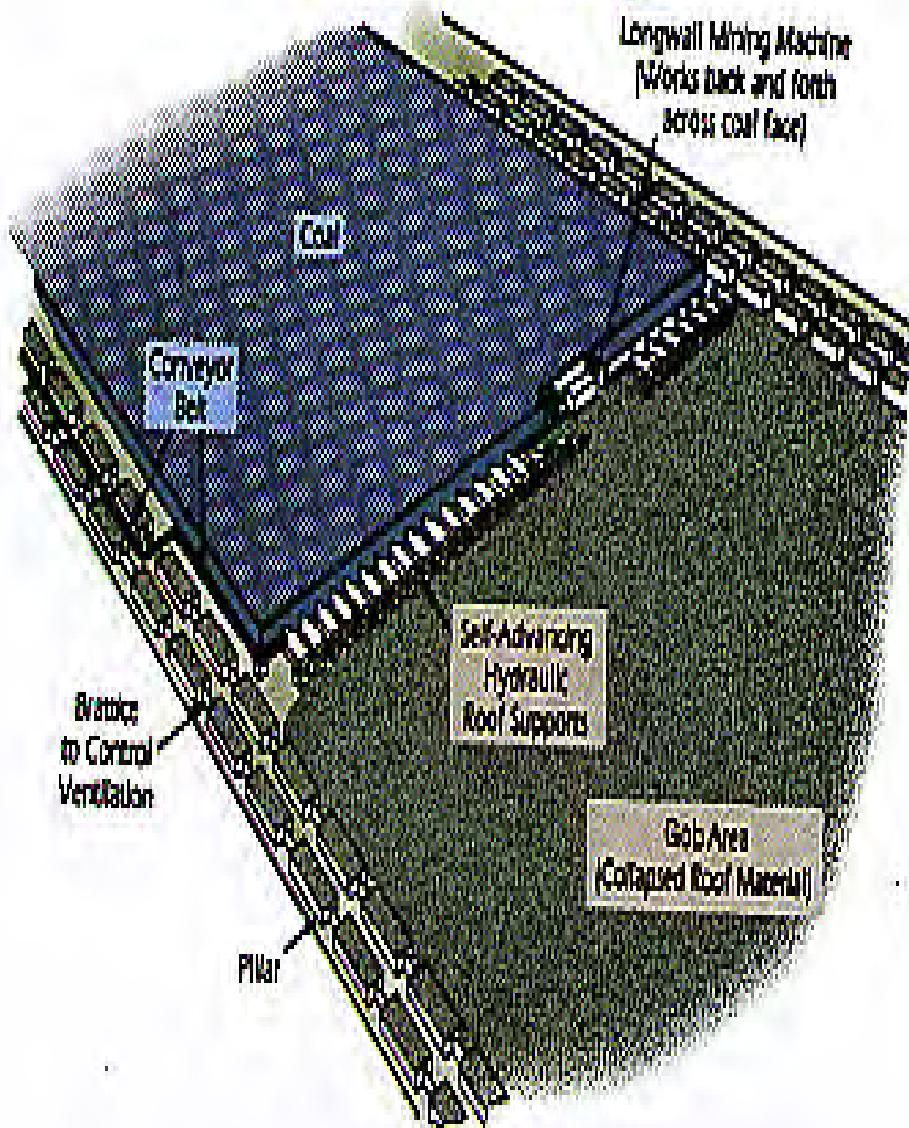
Surface Vs. Underground

- MTR recovers 100% of all seams vs. 40-75% of one or two
- All disturbance is immediate, reclamation is ongoing & close
- Eliminate roof fall danger (but substitute highwall falls)
- Mostly mine coal that is not accessible by underground methods
- Can often control cost by limiting ratio in surface mines

Summary

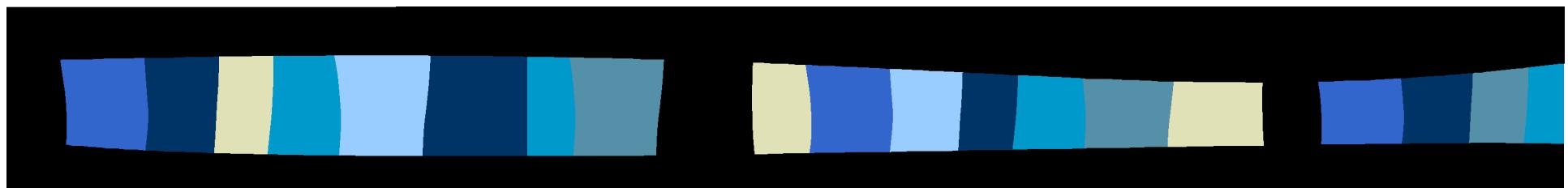
- Surface mines account for 60-65% of national output, but 30-33% in WV, 38% in KY, 25% in VA and 28% in PA
- Productivity in surface mines is 9.44 tpmh vs 3.84 tpmh in underground, nationally
 - But is 5.75 tpmh vs 4.81 tpmh in WV (approx.)

Longwall Mining





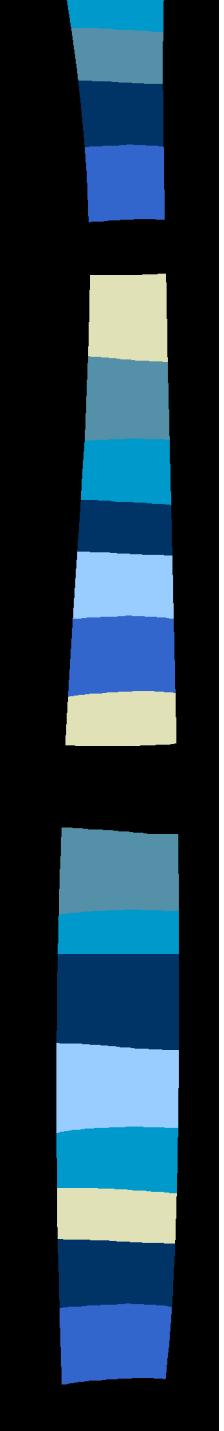
Underground Mining Methods



Stanley C. Suboleski

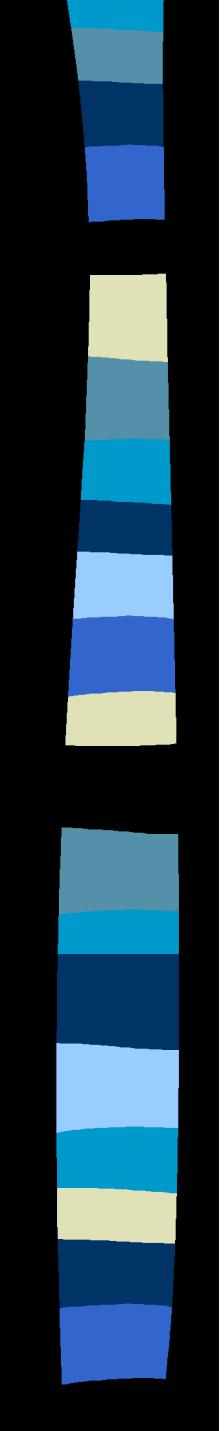
Virginia Tech

June 23, 1999



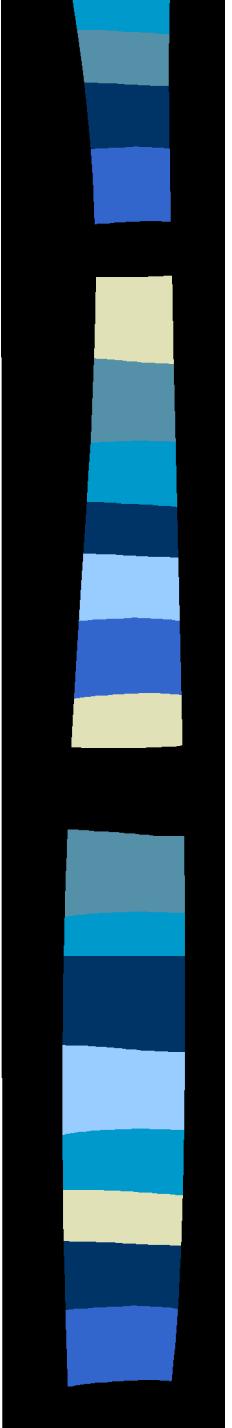
Two Main Methods

- Room & Pillar
 - Mostly with continuous miners
- Longwall
 - Develop longwall panels with room & pillar using continuous miners
- About 10% of underground production still comes from drilling & blasting
- Total underground output = 421mt (1997 data)



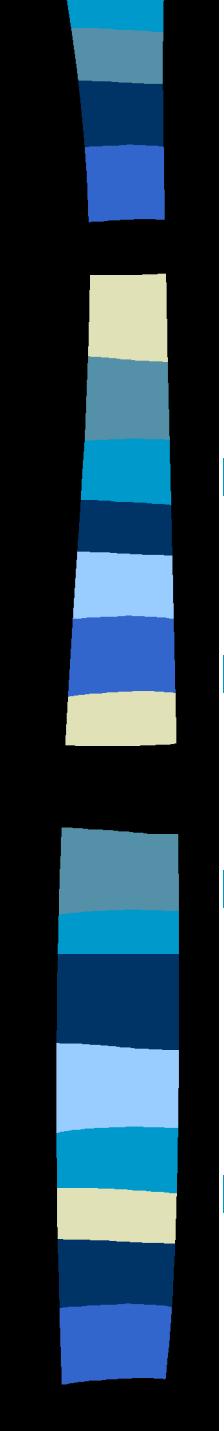
FIRST, MUST ACCESS THE MINE

- Drift (Adit)
 - Seam outcrops, access from ground level
- Slope
 - Drive incline in rock at up to 16 degrees
 - Allows belt haulage
- Shaft
 - Use: elevators/skips, for: people/coal
 - Use shaft if >1500 feet, economics dictate



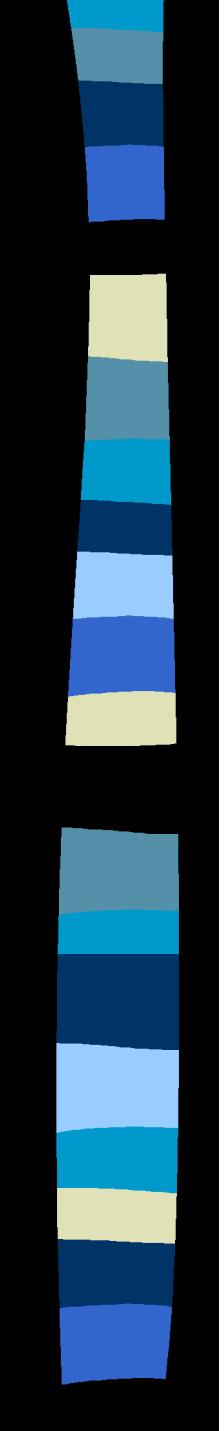
LIKE A CITY, OR LARGE BUILDING, SERVICES MUST BE PROVIDED

- Transport people (rail, rubber tired)
- Transport supplies (materials / maintenance)
- Transport product (coal)
- Support roof
- Provide electrical power
- Provide fresh air (& suppress dust)
- Provide fresh water
- Get rid of waste water
- Dispose of trash



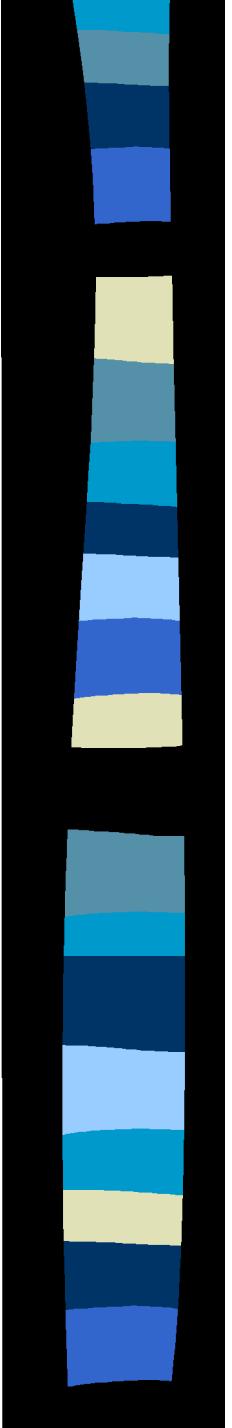
ROOM & PILLAR

- Mine “streets & avenues” (entries and crosscuts)
- Leave pillars to support roof (may mine later)
 - Designed by formula
- Plan view-looks like city with “greenbelts”
 - “Greenbelts” are large barrier pillars left to separate work areas
- Use continuous miner



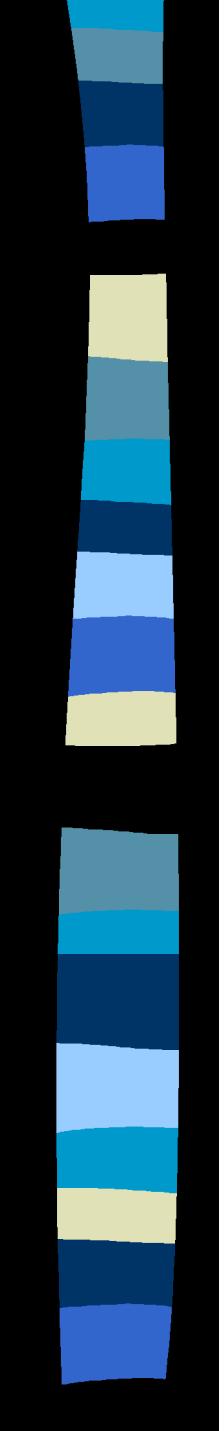
MINE PLAN

- Main entries (7-9 openings)
- Submains (5-7 openings)
- Panels (panel entries, butt entries)
- Rooms (at times)
- Openings limited to 20-ft width
 - **Openings serve as air ducts and travelways**
 - **Return air is isolated from fresh air, two escapeways must be provided from face**
- Longwall panels are solid coal blocks, usually 1000 ft by 10,000 ft, accessed by “gate” roads



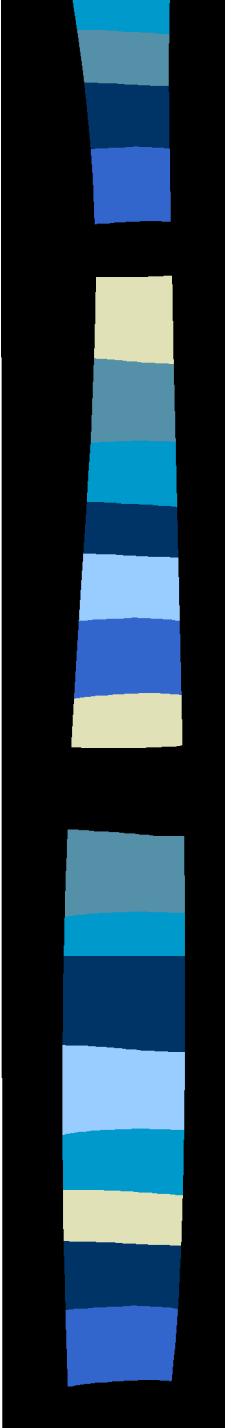
ALL SERVICES EXIST TO SUPPORT MINING AT FACE

- Continuous miner - rips coal, using tungsten carbide bits - miner mines at 4-25 t/m and conveys coal into shuttle cars
- Shuttle cars are electric (cable) “trucks” which haul for up to 600 feet or so (usual = 300-400 feet)
 - Haul to feeder-breaker which acts as surge bin/crusher and feed coal onto belt
 - Hold 3-25 tons/load, depending on seam thicknesss and amount of rock mined



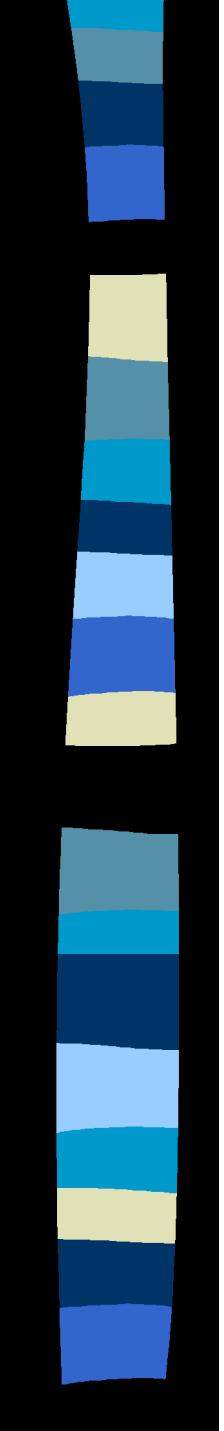
FEEDER-BREAKER FEEDS COAL ONTO BELT CONVEYORS

- Conveyors transport coal to surface or into skips for shaft access
 - Usual sizes - 42" to 72"
 - Speeds - 500 - 800 fpm
- Longwall requires largest conveyors
 - 54"-60" usual from face



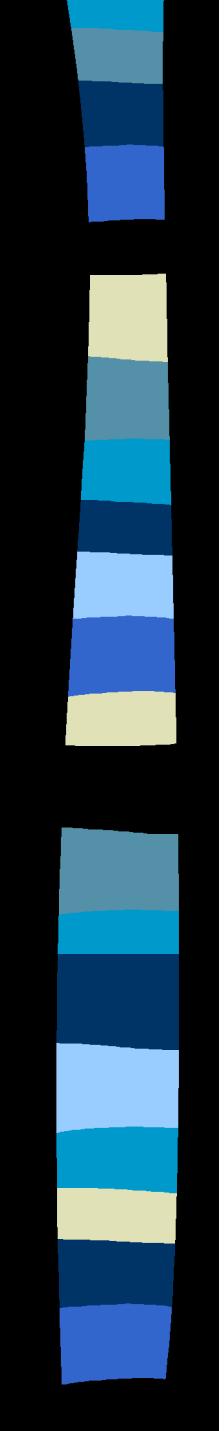
ROOF BOLTS INSTALLED BY ROOF BOLTING MACHINE

- Roof supported by inserting reinforcing rods
- No one may work under unsupported roof
 - **Cut depths limited to position of shuttle car operator (35' to 40' with remote control miner)**
- When miner place changes, bolter moves in
 - **Bolt 3-6 min/row or 0.75-1.50 min/ft**
 - **Use two bolter operators, twin-boom bolter**
- A few operations attach bolters to miners, bolt as they advance



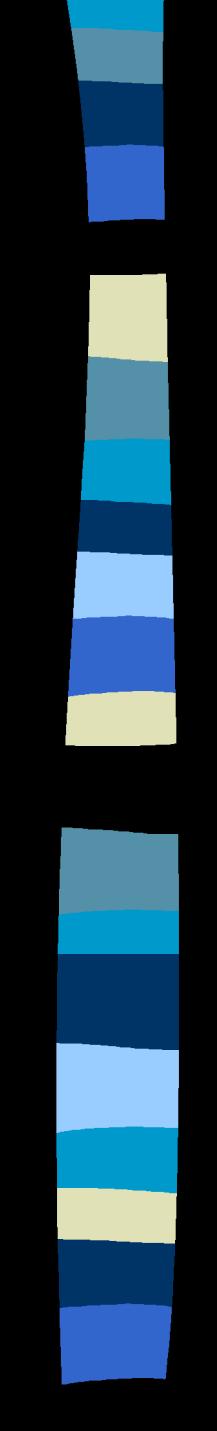
ROOF SUPPORT

- Insert bolts into the roof on regular pattern (3'-8' length, usually)
 - 4' x 4' or 5' x 5' most common
- Either “glue” (resin) a re-bar bolt in, or
- Use expansion bolt anchors or
- Glue in the anchor only
 - Anchors allow pre-tensioning of bolts



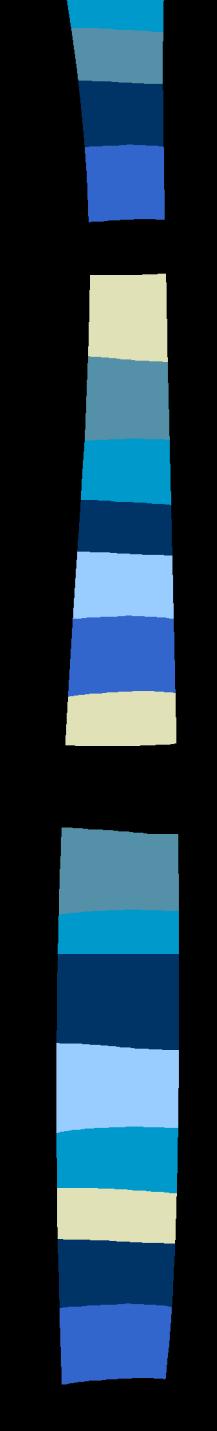
ROOF BOLTS GENERALLY WORK WELL

- Form “reinforced” rock, strong beam
- Or, may “hang” weak rock from stronger overlying rock layer
- Roof fall fatalities are now at 8 -12 per year
 - Half are in violation of the law, under non-bolted roof
 - Roof fall fatalities exceeded 100 per year around 1970



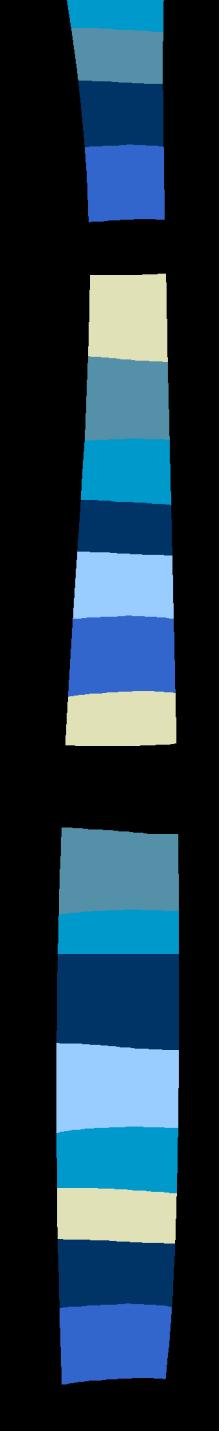
VENTILATION

- Provides oxygen, dilutes methane & dust
 - Methane explosive when at 5-15% concentration
- Most continuous miners have dust scrubber
 - Draw air into ducts at front of miner
 - Efficiency up to 96-97%
- Air directed to working face with brattice cloth (plastic curtains)
- Alternatively, hang tubing & use fan to draw air to face



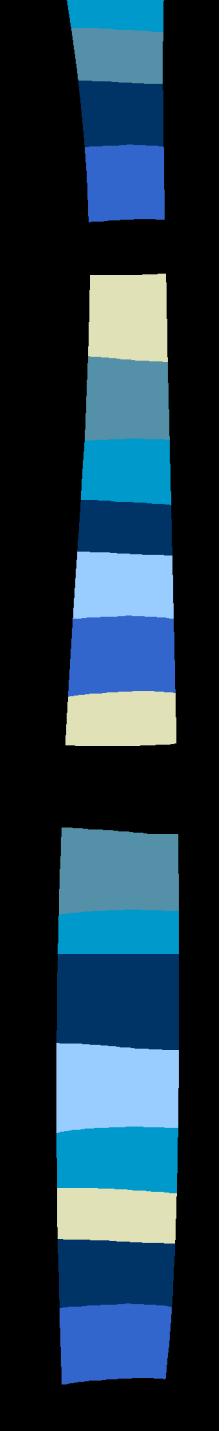
VENTILATION

- Fresh air ventilates one face only, then it is “return” air
 - Separate air streams with concrete block walls or “stoppings”
- Maximum allowable methane content is 1%
- Control major flow with adjustable doors in airways (“regulators”)



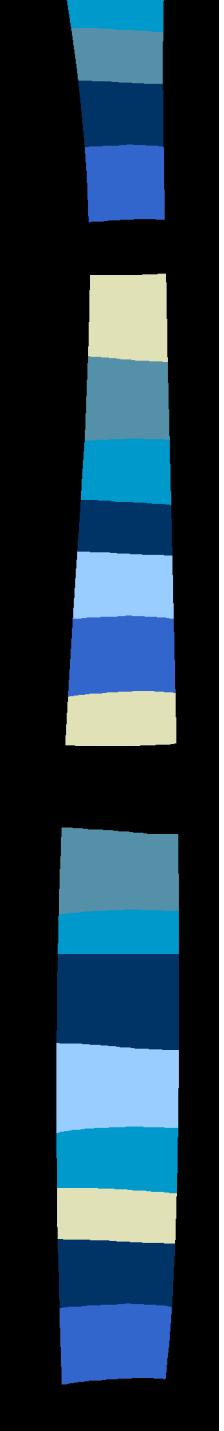
PRODUCTION RATES

- 150 - 400 ft/shift usual, tonnage depends on seam thickness
 - 500 - 2000 tons/shift (usual)
- New miners load at 10 - 25 tpm
- Most continuous miners load only 60-120 min/shift
 - **Load only 12**
 - **10-25% of shift time**



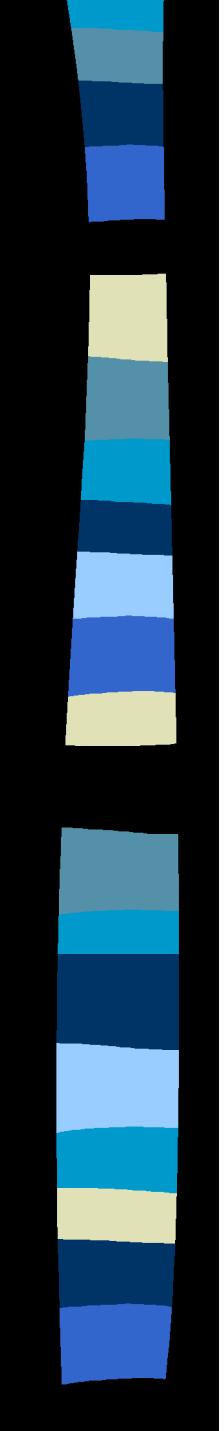
LONGWALL

- More nearly continuous method
- Analogous to “deli meat slicer” (shearer)
- Shearer mounted on chain conveyor
 - Coal cut falls onto conveyor
- Width of face usually 850 - 1100 ft
 - Depth of slice is 30 - 42 inches
- Behind face supported for 20' or so by steel supports - each 1.50 or 1.75 m wide
 - Each support holds up to 600-1200 tons
- Supports connected to conveyor
 - By pushing, lowering & pulling - can walk conveyor and selves forward



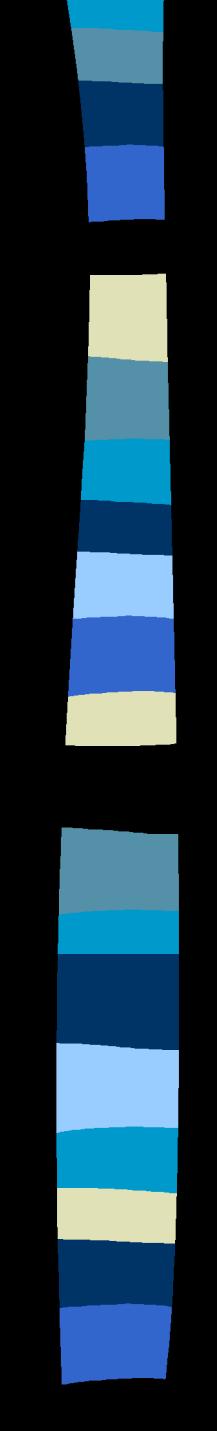
LONGWALL

- Panels (solid block of coal)
 - Usually 850' - 1100' wide & 7500' - 15,000' long
 - Contain 1.5 - 4 mm tons per panel
- Shearers cut at 35 - 65 t/min (2000-4000 tph)
- Output per year = 2 - 6 mm tons
- 6,000 - 20,000 t/day (max = 40,000)
- Cut 200-500 min/day
 - 20% - 45% of time (???)



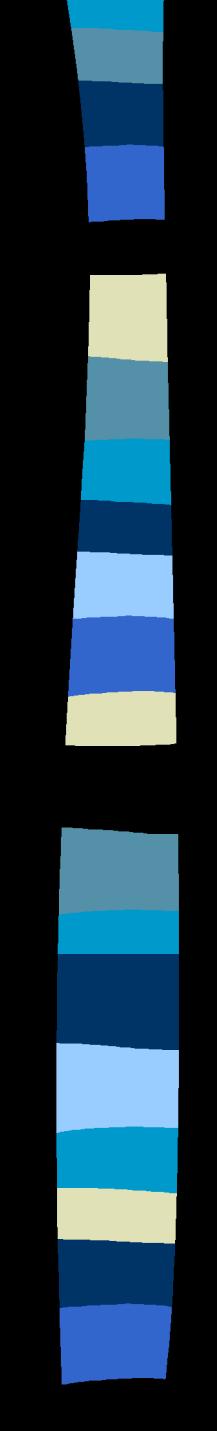
LONGWALL

- Capital intensive
 - \$30M for face equipment only
 - \$50-80M additional for mine / processing
- Require large, regularly shaped reserve
 - 50M ton minimum
 - Prefer 100-200M tons
- Mine-specific design / limited ability to move to other reserves



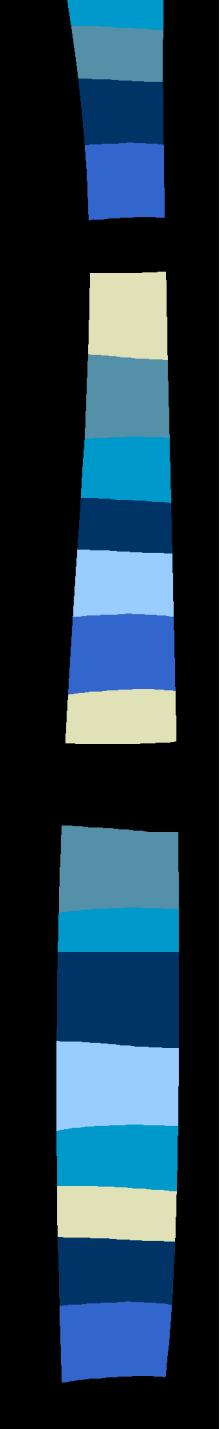
CONTINUOUS MINER SUMMARY

- Capital for section is \$3-5 million
- Flexible, can move readily to other reserves
- One longwall usually requires three continuous miners for development
- Annual output for miner section is 0.3 - 0.8 million tpy



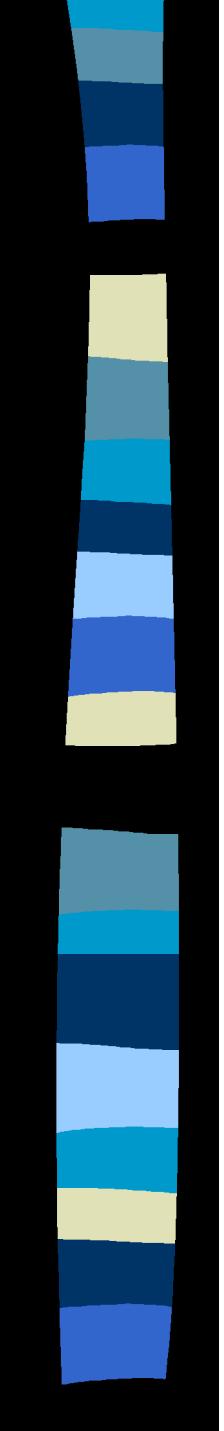
ENVIRONMENTAL

- Longwall strata caves behind supports
 - Surface subsides to maximum of 50-70% of seam thickness
 - “Tilt” area may damage structures, so must provide special support methods at the structures to minimize damage
 - Subsidence trails face position by a few days to a week or two, about 95% occurs in a few weeks



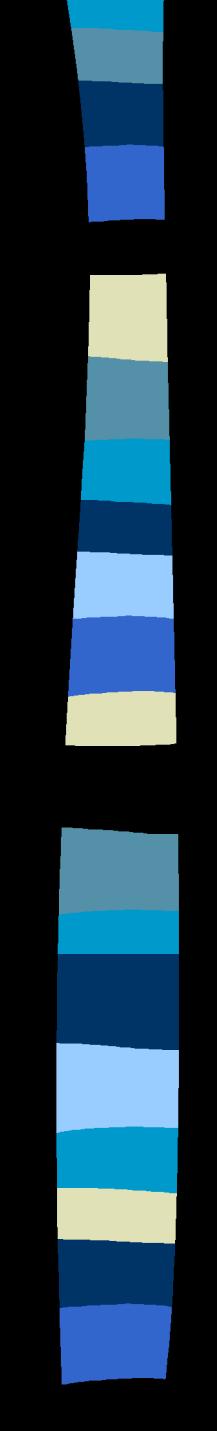
LONGWALL SUBSIDENCE

- Ground water flow is altered
- Some wells lose flow, temporarily or permanently; a few gain
- May need to drill wells deeper
- Connection from near surface to mine is possible if depth to aquifer is less than $40 \times$ seam thickness (240 ft for 6-ft seam)



SUMMARY

- Longwall (45% of UG output from only 60 faces -- average of 3 million tpy each)
 - **High output, high capital**
 - **Low operating cost, 70-80% (?) reserve recovery**
 - **Low flexibility**
- Continuous Miners
 - **Medium output, low-medium capital**
 - **Moderate operating cost, 40-60% reserve recovery**
 - **High flexibility**



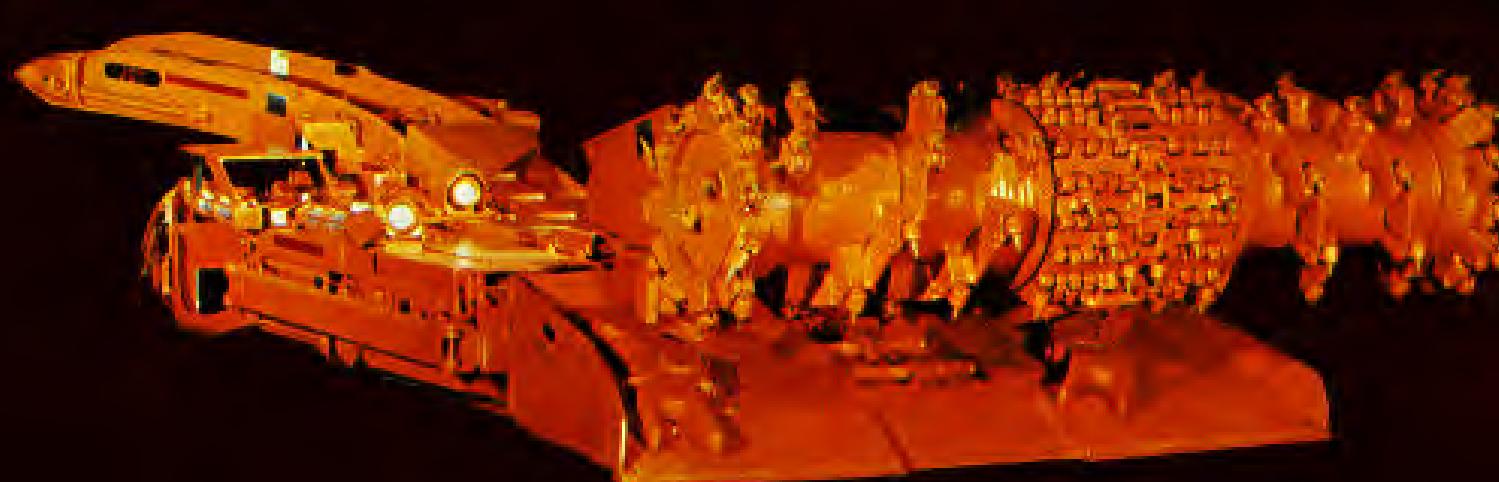
SUMMARY

- Can use underground methods in +100 ft of overburden (actual minimum depth depends on whether strip ratio favors surface mining)
 - Roof subject to surface cracks when shallower
- Use longwall in large, thick (mine 6-ft min.), regularly-shaped reserves
 - Only economic method if seam is >1500 ft deep
- Else, use continuous miner and room & pillar
- While best walls far exceed cm productivity, on average, tons per manhour are close

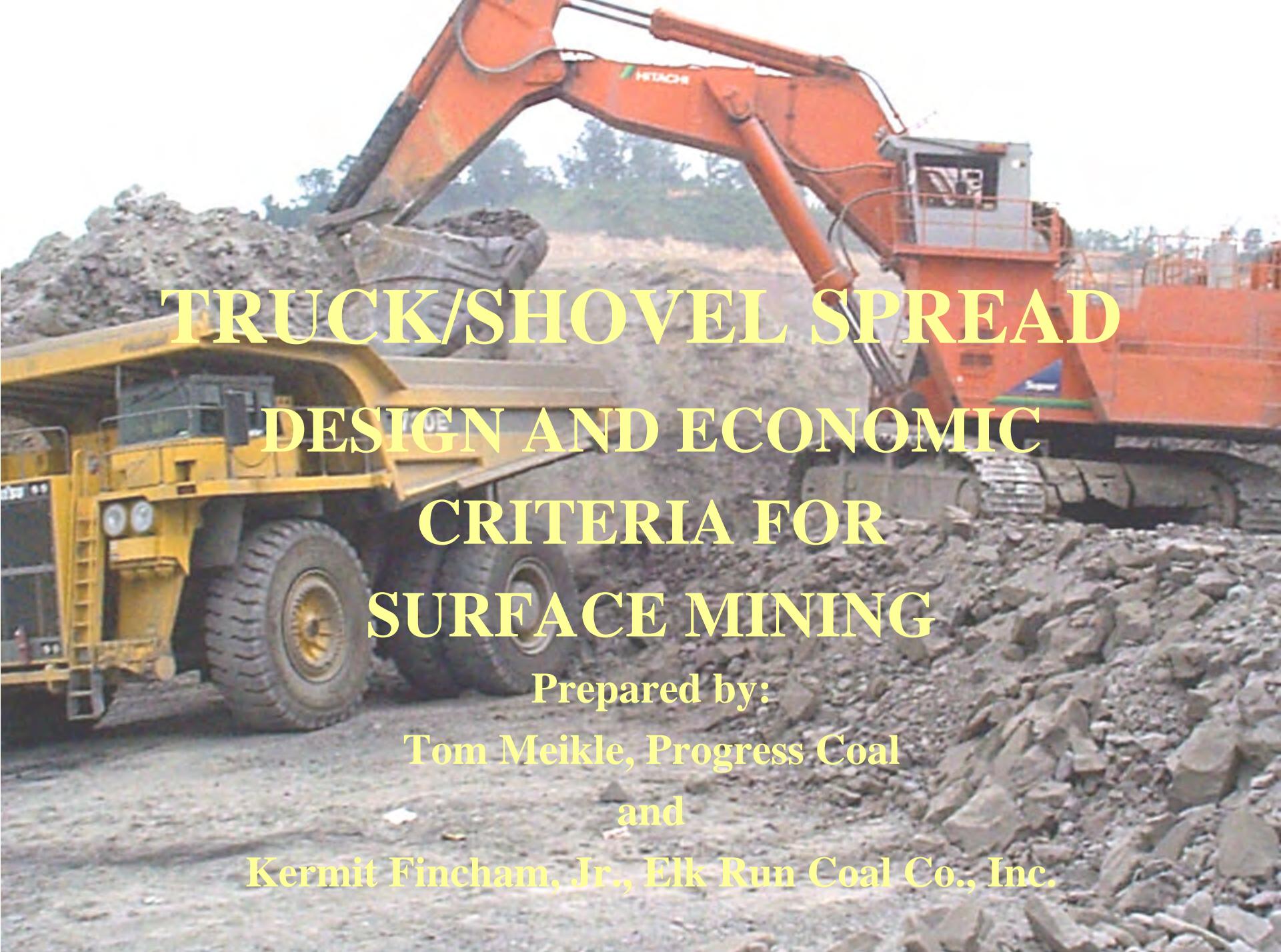


ARCH COAL INC.

Longwall mining machines have revolutionized underground coal mining, enhancing safety and productivity.



Continuous Miners
A full line for all
seam heights



A large yellow haul truck is positioned on the left, its bed filled with dark material. An orange Hitachi excavator is positioned behind it, its arm extended over a large pile of material. The background shows a hilly landscape with sparse vegetation under a clear sky.

TRUCK/SHOVEL SPREAD DESIGN AND ECONOMIC CRITERIA FOR SURFACE MINING

Prepared by:
Tom Meikle, Progress Coal
and
Kermit Fincham, Jr., Elk Run Coal Co., Inc.

SHOVEL/TRUCK MINING METHOD

- **Introduction**
- **Reserve Evaluation**
- **Mine Design and Layout**
- **Sequencing and Timing**
- **Equipment Selection**
- **Economic Evaluation - Appalachia Mining Company**
- **Summary**

INTRODUCTION

- Applications of Mining Method
- History of Mining
- Typical Regional Surface Operation
(Appalachia Mining Company)

Applications of Mining Method

- **Shovel/Truck Mining** systems are typically predominate on Mountaintop Removal (MTR) and Area Surface Mining Operations
 - **MTR Surface Mining** - Entails total mineral extraction within a reserve area provided that the entire reserve is economical to mine.
 - **Area Surface Mining** - Entails partial mineral extraction within a reserve area. This method is mainly used when only a portion of the reserves are economically viable to mine.

History of Mining

- **MTR and Area Mining methods have been in existence and practiced for over forty (40) years.**

History of Mining (Cont.)

- **Equipment productivity limited the overall size of surface mine operations in the early years.**
 - Economic factors limited mining to low ratio reserve areas.
 - Typically, these areas consisted of low ratio seams at the top of mountains and contour mining areas in conjunction with mechanical augering systems.

History of Mining (Cont.)

- As equipment productivity and efficiency improved, the economically feasible reserve base expanded.
 - Lower yardage costs associated with heavy equipment technology has made it feasible to mine higher ratio reserves.
 - Coal seams positioned at lower levels in the mountain have become feasible to mine
 - In some cases up to 600 ft. of vertical cover can be mined.
 - Remining areas to get to the lower seams has become common practice.

History of Mining (Cont.)

- The expanded reserve base has made it economically feasible to increase capital investment in larger, more productive equipment.
 - Without the reserves, capital cannot be justified.
 - Without the capital, mining higher ratio reserves cannot be economically justified.
 - If higher ratio reserves are not mined, mining will likely not be done.

History of Mining (Cont.)

- The expanded reserve base associated with mining the lower level seams has increased the size requirements of excess spoil disposal areas
 - The low ratio, single seam MTR operations in the past required a low number of relatively small fills.
 - Total overburden volume handled in these operations was small.
 - Even by placing half of the overburden in valley fills, the quantity was small.
 - Larger, more vertical, multi-seam operations of today require a larger number of relatively large fills.
 - Total overburden volume handled in these operations is large.
 - Placement of only 30% of the overburden in valley fills will result in more larger fills.

History of Mining (Cont.)

- A typical regional surface operation (Appalachia Mining Company) is described as follows:
 - Multi-seam, mountain top removal operation.
 - Total depth of cut is 436 vertical feet.
 - A total of eight (8) seams will be mined extending down to the Coalburg seam horizon.
 - The overall cumulative ratio is 15.02 to 1.
 - The average selling price of the coal removed is \$24.75 per ton.

Reserve Evaluation

- **Exploratory core drilling**
 - Define coal and rock thickness.
 - Define coal quality.
 - Define rock quality (Acid-base assessment and Slake durability)
- **Have aerial mapping prepared for the reserve area**

Reserve Evaluation

- Reserve Analysis
 - Construct a geological model using Surface Mine modeling software.
 - Calculate mining ratios for the project.
 - Calculate total overburden in bank cubic yards (BCY).
 - Calculate total recoverable clean tons (CT)
 - Seams as thin as six (6) inches can economically be recovered.
 - Calculate surface mine strip ratios.
 - **Ratio = Total BCY / Total recoverable CT**
 - Define coal quality, marketability and market value.

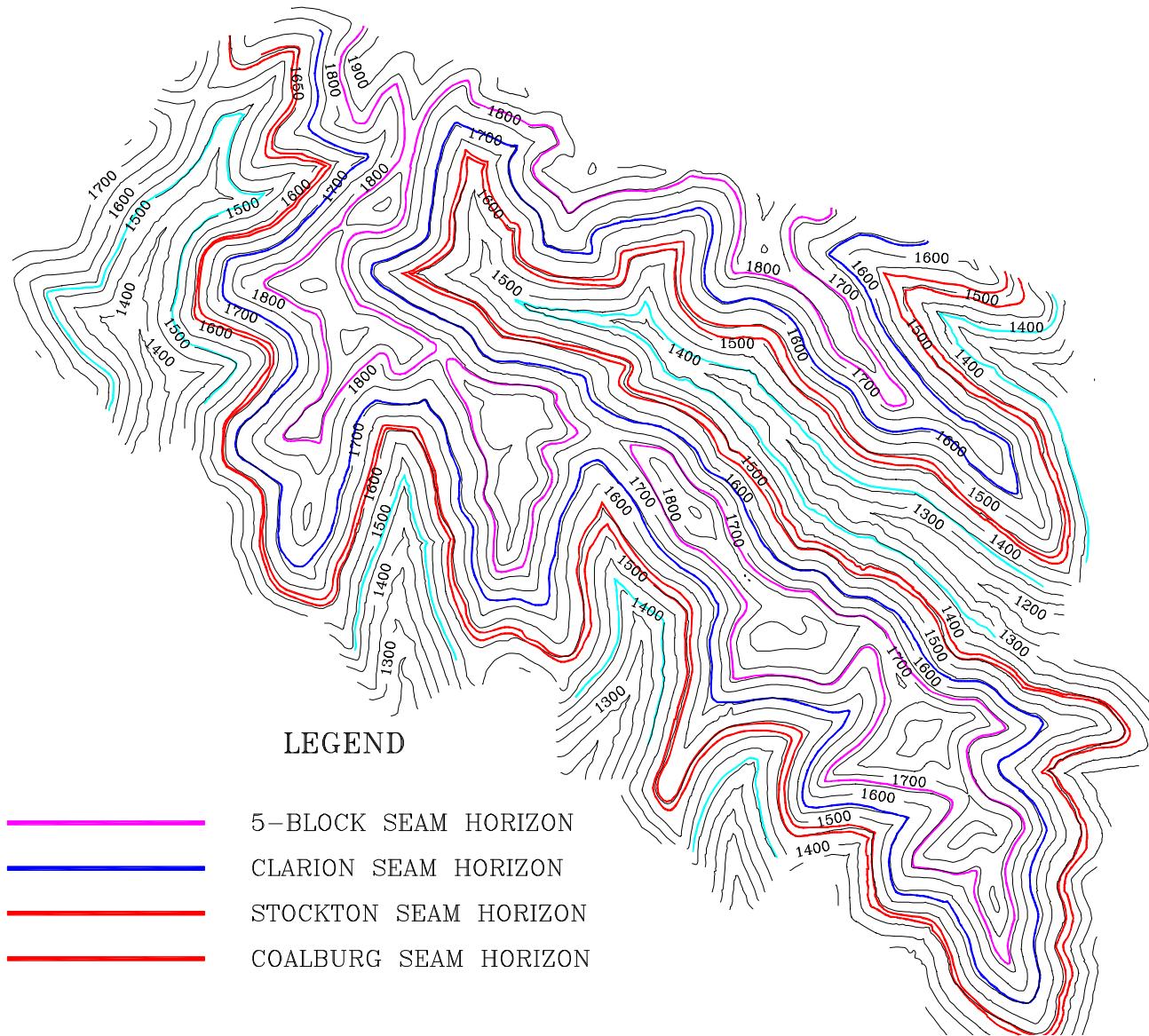
Reserve Evaluation (Cont.)

- **Environmental Considerations**
 - Evaluate the geo-chemical characteristics of the coal and rock.
 - Evaluate the geo-physical characteristics of the rock strata.
 - Determine availability of excess spoil disposal areas.
 - Determine proximity of operation to homes and communities.
 - Evaluate the potential effects of blasting operations.
 - Evaluate other site-specific environmental issues.
 - Incremental and cumulative ratio analysis.

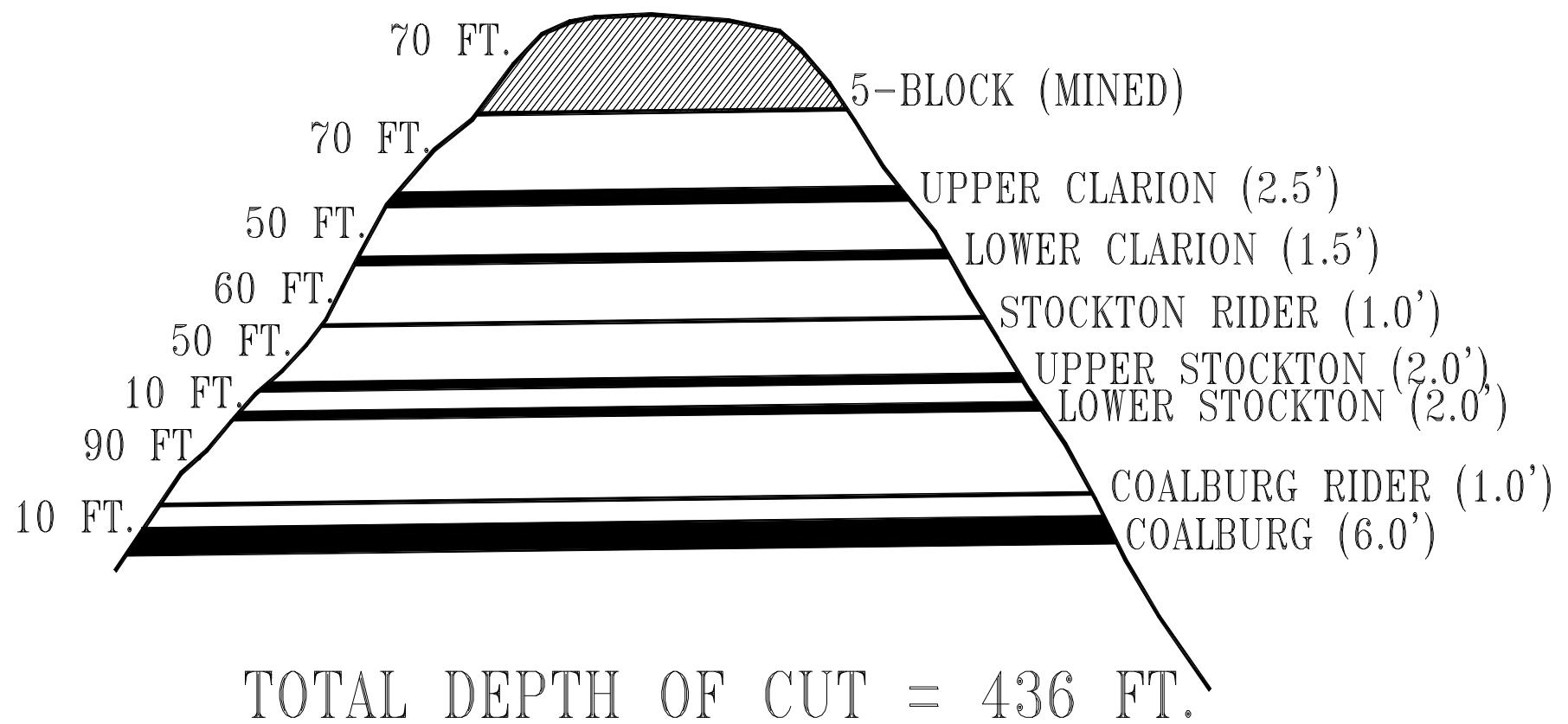
Reserve Evaluation (Cont.)

- **Ratio analysis case study - (Appalachia Mining Company)**
 - **Typical topographic map detailing reserve recovery area.**
 - **Typical cross section of the reserve area lithology.**
 - **Incremental and cumulative ratio analysis.**

CASE STUDY - APPALACHIA MINING COMPANY RESERVE ANALYSIS AREA



CASE STUDY – APPALACHIA MINING COMPANY TYPICAL LITHOLOGY CROSS SECTION



Reserve Evaluation (Cont.)

Ratio Analysis and Reserve Quality

Seam	Inc BCY	Inc C.T.	Inc. ratio	Cum. BCY	Cum. C.T.	Cum. Ratio	Burden Thick. (ft.)	Coal Hght. (ft.)
# 5 Block	7,905,333	0	NA	7,905,333	0	NA	70	0.00
Upper Clarion	18,069,333	871,200	20.74	25,974,667	871,200	29.81	70	2.50
Lower Clarion	19,360,000	784,080	24.69	45,334,667	1,655,280	27.39	50	1.50
Stockton Rider	38,720,000	871,200	44.44	84,054,667	2,526,480	33.27	60	1.00
Upper Stockton	40,454,333	2,056,032	19.68	124,509,000	4,582,512	27.17	50	2.00
Lower Stockton	8,228,000	2,090,880	3.94	132,737,000	6,673,392	19.89	10	2.00
Coalburg Rider	101,930,400	1,359,072	75.00	234,667,400	8,032,464	29.21	90	1.00
Coalburg	11,616,000	8,363,520	1.39	246,283,400	16,395,984	15.02	10	6.00
Total	246,283,400	16,395,984	15.02				410	16.00

Notes:

- 1.) Five Block seam was previously mined.
- 2.) The Five Block Seam was 8 ft. thick and contained 1.4 mm C.T. of coal @ 5.67 stripping ratio.
- 3.) All overburden overburden from Five Block Seam mining is still on the mountain and will have to be moved.
- 4.) Average Coal Quality for the project:

Quality Category	Clean Tons	Quality (ar)						Market Value
		Moisture	Ash	BTU	Sulfur	SO2	M.A.F.	
Sub - Compliance	4,256,420	5.20	10.00	12,800	0.64	1.00	15,094	\$27.50
Compliance	9,563,255	5.35	11.30	12,500	0.74	1.18	14,997	\$24.00
Conforming	2,576,309	5.40	11.45	12,424	0.95	1.53	14,942	\$23.00
Total	16,395,984	5.32	10.99	12,566	0.75	1.19	15,014	\$24.75

Mine Design and Layout

- **Develop a Potential Material Balance Plan.**
- **Develop an Overburden Handling Plan.**
- **Mining Cut Layout.**
- **Case Study - Appalachia Mining Company.**

Mine Design and Layout

- **Develop a Potential Material Balance Plan**
 - Calculate total volume of Loose Cubic Yards (LCY) in the project.
 - LCY = yards of overburden after rock is fragmented and air voids introduced.
 - A common term used for this occurrence is “swell factor (SF).
 - Sandstone typically swells 25 to 40%. The average is approximately 33%.
 - Shale and slate typically swell 15 to 25%. The average is approximately 20%.
 - Allowances have to be made for re-compaction (typically 90 to 95%).
 - The total LCY in a project represents the amount of material that must be placed in spoil disposal areas.
 - Calculate total storage volumes for all available spoil disposal areas.
 - Define “on-bench” storage capacity.
 - Remainder will define required “valley fill” storage capacity.
 - Total storage capacity must be equal to or greater than the LCY generated.

Completion of these operations will result in a “Potential Material Balance” for the project.

Develop an Overburden Handling Plan

- Define where each yard of overburden will be produced and subsequently placed.
 - Define whether each yard will be hauled, dozed, or cast by blasting.
 - If hauled, define where it will be hauled to and design the required road system.
 - If dozed or cast by blasting, define where the material will be placed.
- Develop spoil disposal areas as each yard is placed during this exercise.
 - When this sequence is complete, a “Final Material Balance” for the project will be defined.

Develop an Overburden Handling Plan

- The objective for developing the Overburden Handling Plan is to accomplish the following:
 - Minimize grade and distance requirements for overburden haulage roads.
 - Maximize the amount of overburden material that can be cast by blasting or dozed in the project. (These are the most economical placement means).
 - Plan so that the placement of overburden results in final reclamation being accomplished as part of the normal mining cycle of operations.

Mining Cut Layout

- **Pre-strip Cut Layout**
 - Pre-strip cuts consist of the mining required to remove the top portions of the mountain to the extent that cast-blasting and dozer operations can commence.
 - This pre-strip overburden must be hauled.
- **Cast-blasting and Dozer Cut Layout**
 - These cuts are typically designed in long, parallel oriented panels.
 - The overburden is placed “on-bench” on the floor of the lowest seam being mined.
 - Occasionally the material can be cast/dozed into fills providing the state 300 ft. wing dumping criteria is not exceeded.

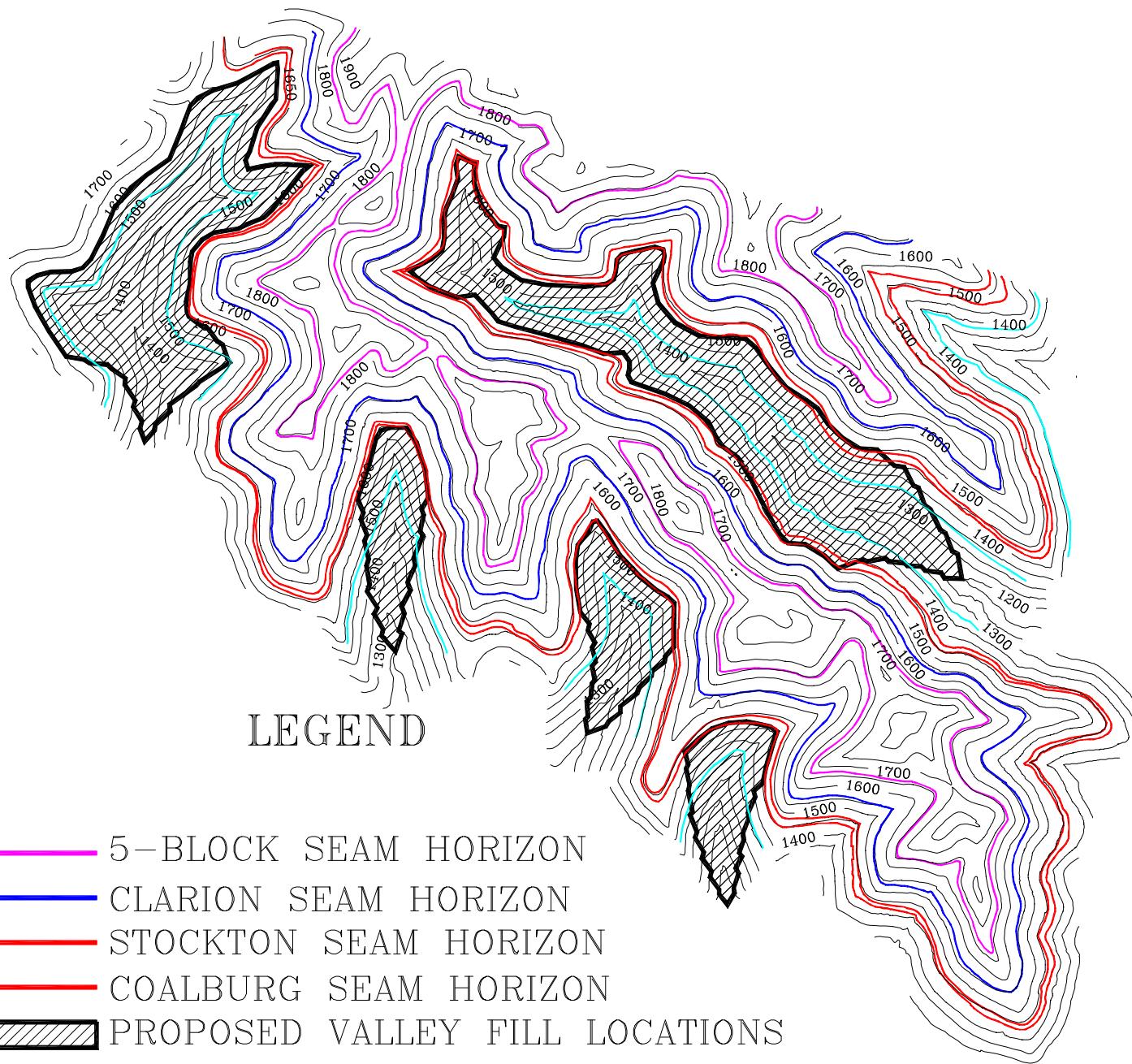
Mining Cut Layout

- **Contour Cut Layout**
 - These cuts are typically **designed along the outslope areas of the lower coal horizons to be mined.**
 - These cuts are **designed to prevent down-slope placement, provide for the establishment of “on-bench” sediment control structures, and to provide sufficient space for the establishment of a network of haulage and access road systems.**

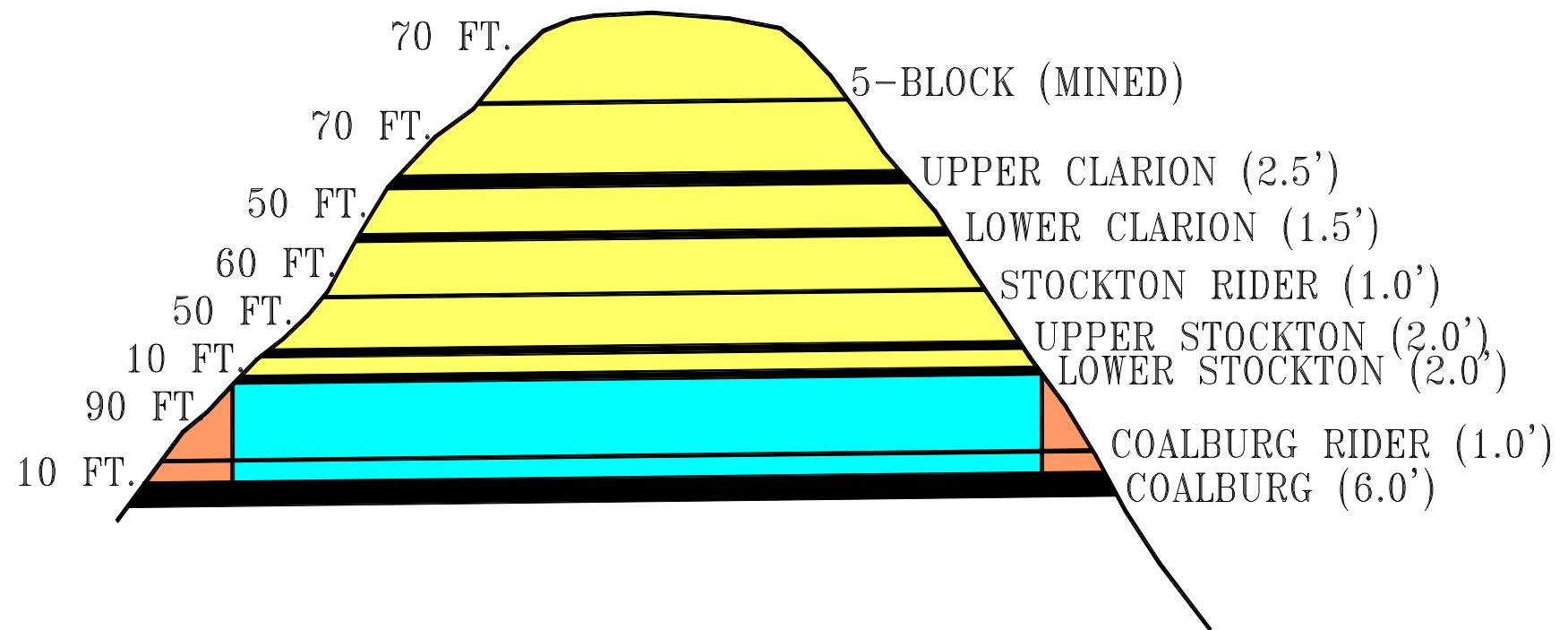
Case Study - Appalachia Mining Company

- Calculated “Swell Factor” = 30%
 - Total LCY in the project area = 320,168,420
- Spoil Disposal Capacity (by location):
 - 128,067,368 LCY placed in “Valley Fills”
 - 192,101,051 LCY placed “On-Bench”
- Distribution of Haulage vs. Cast-blasting and Dozing
 - Total overburden haulage = 172,398,380 BCY (70%)
 - Total Cast-blasting and Dozing = 73,885,020 BCY (30%)
- Typical Haul Road Profile
 - 2,500 ft. length (one-way haul)
 - 1,000 ft. of which is at an 8% grade.

CASE STUDY – APPALACHIA MINING COMPANY



CASE STUDY – APPALACHIA MINING COMPANY MATERIALS HANDLING CROSS SECTION



PRE-STRIP OVERBURDEN



CONTOUR OVERBURDEN



CAST/DOZER OVERBURDEN

SEQUENCING AND TIMING

- Start-up location for operation
 - Start-up should occur in areas with easy accessibility and large valley fill capacity.
 - All of the overburden generated from the initial mining cuts must be placed in valley fills. (Referred to as development area).
 - The initial cuts are predominantly Pre-strip and Contour cuts.
 - Dozing is limited to those yards which are positioned within the confines of the valley fills.
 - Primary objectives to be accomplished during this development phase are as follows:
 - Set up the cast-blasting and dozing production areas as readily as possible.
 - Maintain an acceptable mining ratio to ensure an economically feasible development operation

SEQUENCING AND TIMING (CONT.)

- **Subsequent to start-up and development, the objectives are as follows:**
 - **Maintain adequate levels of pre-stripping in order to sustain continuous cast-blasting and dozer operations.**
 - **Provide at least two (2) areas for cast-blasting and dozing at all times.**
 - **The dozer fleet must rotate between areas in order to maintain continuous production.**
 - **When dozing is complete in an area, it generally takes 2 to 3 weeks to remove the uncovered coal. The dozer fleet cannot sit idle during this period.**

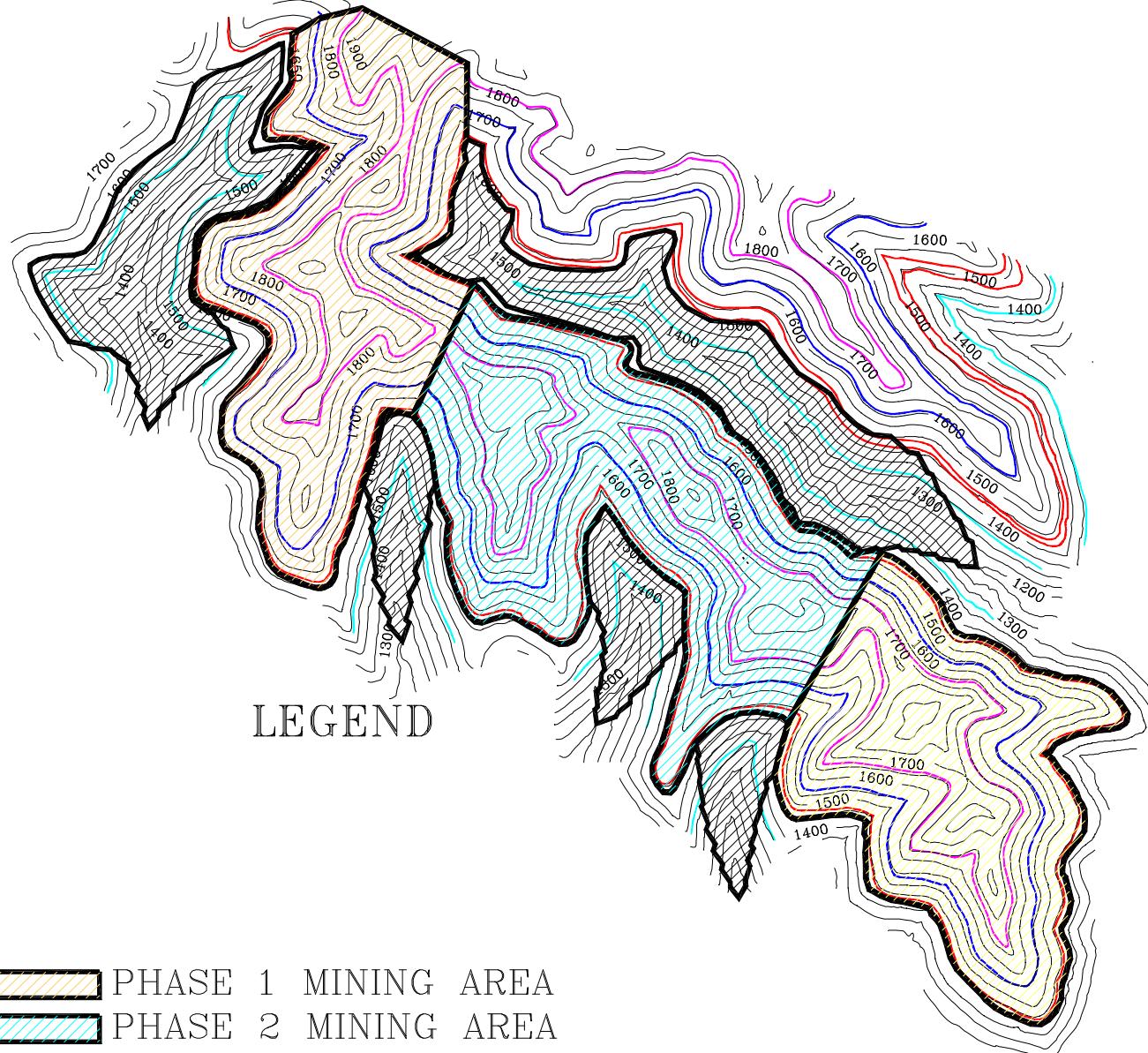
SEQUENCING AND TIMING (CONT.)

- Sequence the dozer/cast areas so that the overburden can be placed on top of the dozer push ridge at the earliest possible time.
 - This will help to minimize the amount of overburden required to be placed in “Valley Fills”.
 - The reclamation process will subsequently be accelerated.
 - Pre-strip overburden can now be more economically placed on the dozer push ridge.
 - This will minimize longer, excessive grade hauls typically associated with Pre-Strip operations.

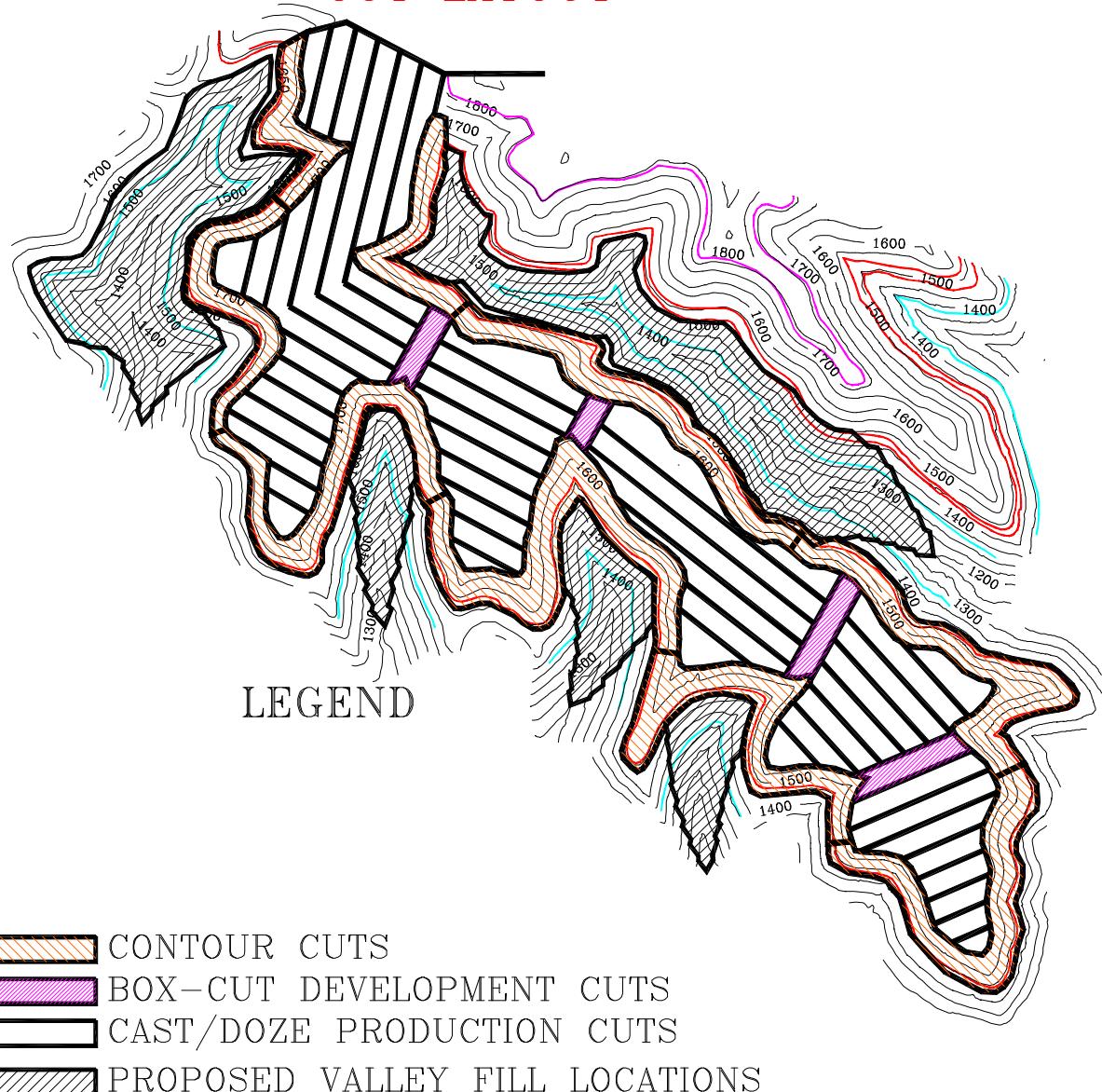
FINAL RECLAMATION

- The project will end with two (2) dozer/cast areas.
 - These areas can only be reclaimed to an elevation slightly higher than the dozer push ridge.
 - This factor was taken into account when the amount of overburden designated to be placed in the “Valley Fills” was calculated.
 - The elevation of the mountain in the start-up, development area can and will be restored to AOC.
 - The elevation of the reclaimed mountain must drop as the last mining areas are approached.
 - It is not possible to restore a mining project of this type to AOC throughout.
 - A smaller, single seam MTR however, can achieve AOC.
 - Case Study - Appalachia Mining Company
 - Mining sequence map.
 - Regrade Cross Section.

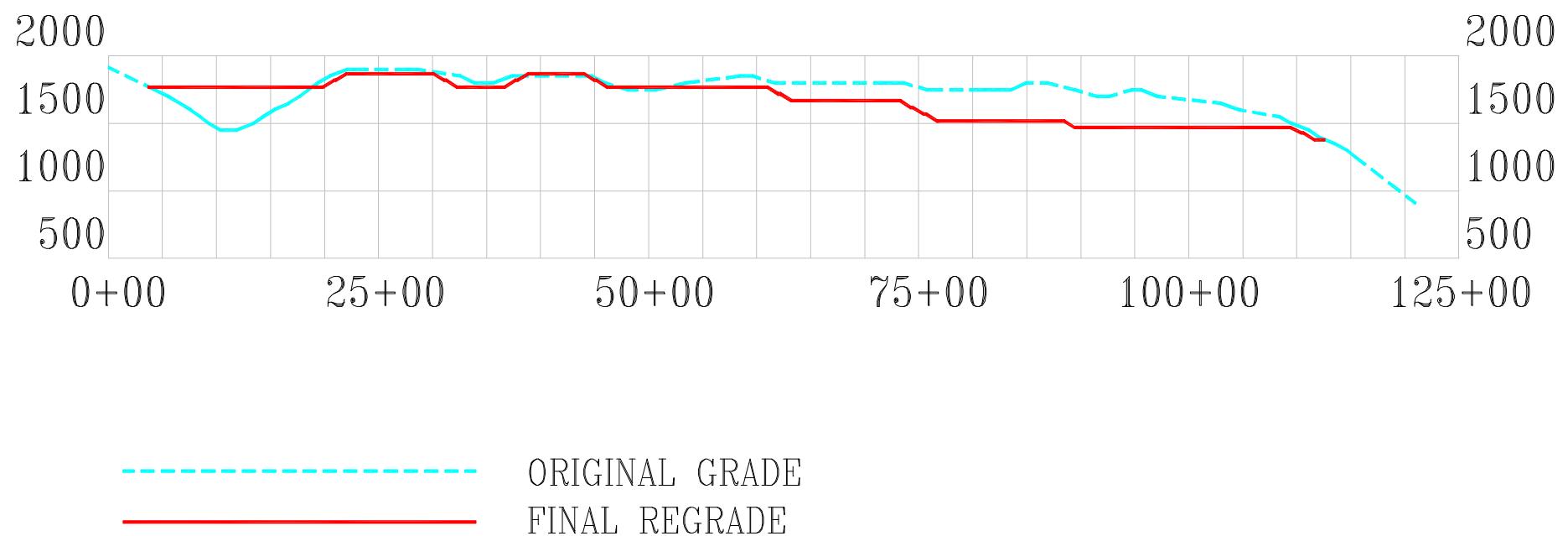
CASE STUDY – APPALACHIA MINING COMPANY
MINE DIRECTION SEQUENCE MAP – PHASES 1,2 & 3



CASE STUDY – APPALACHIA MINING COMPANY CUT LAYOUT



CASE STUDY – APPALACHIA MINING COMPANY FINAL REGRADE PROFILE



EQUIPMENT SELECTION

- **Equipment Selection is based on the following criteria:**
 - **Mine design and layout**
 - **Overburden handling requirements**
 - **Reserve size**
 - **Production Objectives**
 - **Cost Minimization**
 - **Maximize return on investment (ROI)**

EQUIPMENT SELECTION

- **Incremental Cost Behavior of Overburden Production Methods (high to low)**
 - Overburden Haulage
 - Production Dozing
 - Drag line
 - Cast Blasting

EQUIPMENT SELECTION

- **Incremental Production Costs of Overburden Haulage Methods (low to high)**
 - **53 yard Electric Shovel spread**
 - **35 yard Hydraulic Excavator spread (Shovel front or Backhoe)**
 - **25 yard Hydraulic Excavator spread (Shovel front or Backhoe)**
 - **18 1/2 yard Hydraulic Excavator Spread (Shovel front or Backhoe)**
 - **16 yard Front Endloader spread**

53 YARD ELECTRIC SHOVEL LOADING 320 TON TRUCKS





25 YARD HYDRAULIC SHOVEL
LOADING 150 TON TRUCKS



**25 YARD HYDRAULIC BACKHOE
LOADING 210 TON TRUCKS**

13.5 YARD HYDRAULIC BACKHOE LOADING 150 TON TRUCKS





**16 YARD FRONT ENDLOADER
LOADING 150 TON TRUCKS**

EQUIPMENT SELECTION (CONT.)

- Case Study - Appalachia Mining Company Overburden Production Equipment Selection
 - 25 yard Hydraulic Shovel (7.5mm BCY per year)
 - 18 1/2 yard Hydraulic Backhoe (5.8mm BCY per year)
 - 16 yard Front Endloader Spread (4.1mm BCY per year)
 - Four (4) 45 yard Bulldozers (7.8mm BCY per year)



**45 YARD DOZERS IN
SLOT DOZING AREA**



13 YARD FRONT ENDLOADER
PREPARING COAL



**13 YARD FRONT ENDLOADER
LOADING COAL**



ROTARY DRILLS ON DRILL BENCH



SHOT PREPARATION ON DRILL BENCH



**RECLAMATION DOZER
WALKING FINAL GRADE SLOPE**

EQUIPMENT SELECTION (CONT.)

- Case Study - Appalachia Mining Company Overburden Production Equipment Selection
 - Total Annual Production
 - 25.20mm BCY per year based on two (2) 10-hour shifts working 260 days per year.
 - Total Annual Coal Production @ 15.02 Stripping Ratio
 - 1.68mm Clean Tons per year
 - Projected Life of Mine
 - 10 years

ECONOMIC EVALUATION

APPALACHIA MINING COMPANY

- **Capital Requirements**
- **Manpower**
- **E.B.I.T. (Earnings Before Interest and Taxes)**
- **Capital Investment Statistics**

Economic Evaluation - Appalachia Mining Company

Capital Budget - Life of Mine

Heavy Equipment

Item	Year	Year	Years	
Description	0	1	2 thru 10	Total
25 yard Shovel	\$0	\$3,500,000	\$0	\$3,500,000
18 1/2 Yard Backhoe	\$0	\$2,650,000	\$0	\$2,650,000
16 yard Endloader	\$0	\$1,200,000	\$1,200,000	\$2,400,000
2 10 Ton Rock Trucks	\$0	\$4,500,000	\$0	\$4,500,000
150 Ton Rock Trucks	\$0	\$7,320,000	\$0	\$7,320,000
Fill Dozers	\$0	\$2,160,000	\$1,050,000	\$3,210,000
Development Dozers	\$0	\$1,440,000	\$1,440,000	\$2,880,000
Reclamation Dozers	\$0	\$720,000	\$720,000	\$1,440,000
45 yard Dozers	\$0	\$4,800,000	\$4,800,000	\$9,600,000
16 yard Coal Loader	\$0	\$2,400,000	\$700,000	\$3,100,000
9 yard Coal Loader	\$0	\$1,100,000	\$500,000	\$1,600,000
Drills	\$0	\$2,400,000	\$4,800,000	\$7,200,000
Total	\$0	\$34,190,000	\$15,210,000	\$49,400,000

Economic Evaluation - Appalachia Mining Company

Capital Budget - Life of Mine

Support Equipment

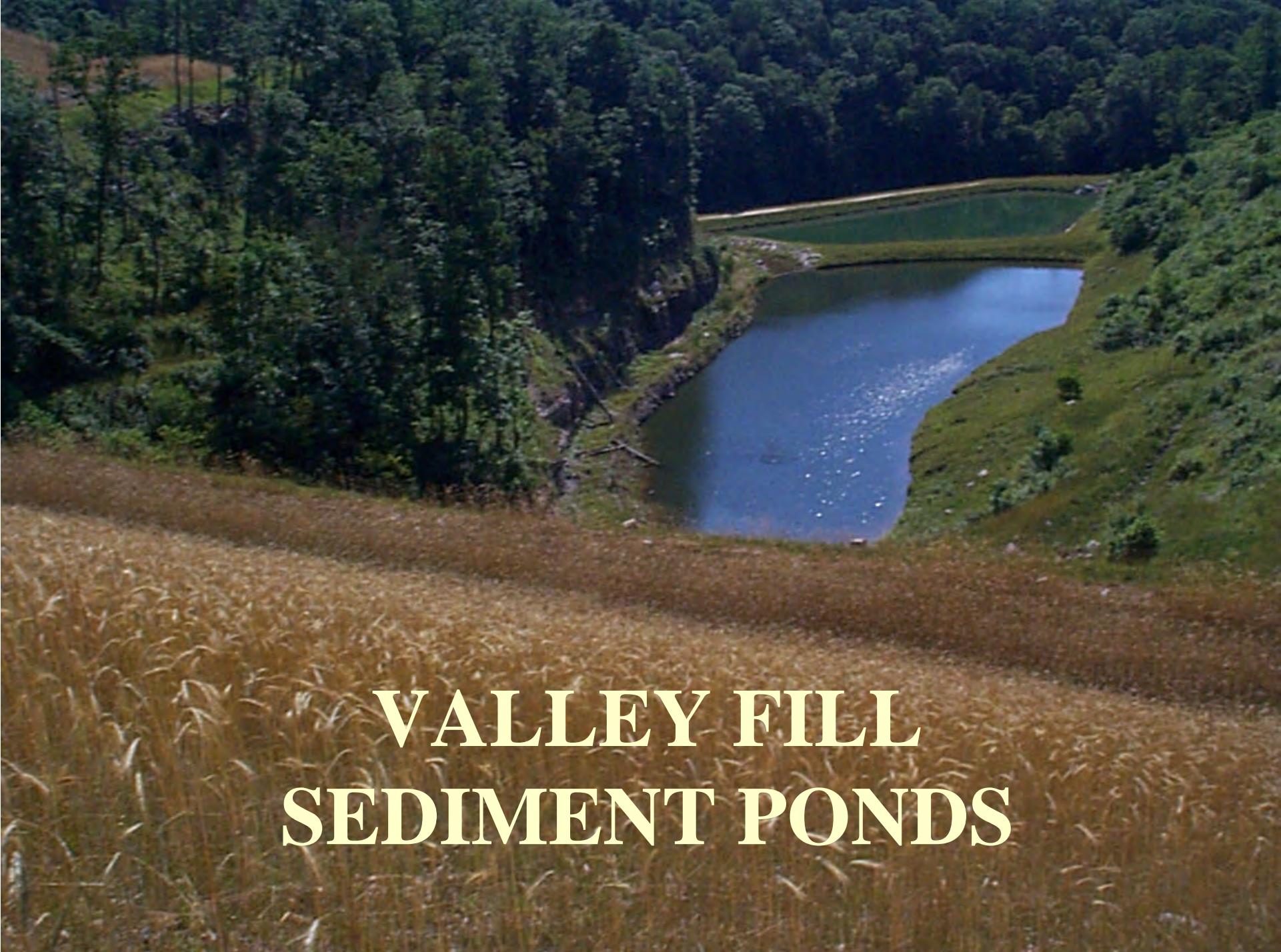
Item	Year 0	Year 1	Years 2 thru 10	Total
Description				
Motor Grader	\$0	\$450,000	\$0	\$450,000
Water Truck	\$0	\$600,000	\$0	\$600,000
5 yard Backhoe	\$0	\$300,000	\$0	\$300,000
Light Plants	\$0	\$150,000	\$0	\$150,000
Mechanics Trucks	\$0	\$520,000	\$0	\$520,000
Fuel Truck	\$0	\$130,000	\$0	\$130,000
Service Truck	\$0	\$260,000	\$0	\$260,000
Portal Trucks	\$0	\$75,000	\$0	\$75,000
Pick-Up Trucks	\$0	\$150,000	\$300,000	\$450,000
Total	\$0	\$2,635,000	\$300,000	\$2,935,000

Economic Evaluation - Appalachia Mining Company

Capital Budget - Life of Mine

Development Capital

Item	Year 0	Year 1	Years 2 thru 10	Total
Description				
Haul Road	\$1,000,000	\$0	\$0	\$1,000,000
Pond Construction	\$500,000	\$0	\$1,000,000	\$1,500,000
Stream Mitigation	\$500,000	\$0	\$0	\$500,000
Permitting Related	\$500,000	\$0	\$0	\$500,000
Exploration	\$350,000	\$0	\$0	\$350,000
Clearing & Grubbing	\$460,000	\$230,000	\$920,000	\$1,610,000
Office / Warehouse	\$200,000	\$0	\$0	\$200,000
Radio System	\$50,000	\$0	\$0	\$50,000
Pump System	\$150,000	\$0	\$0	\$150,000
Power & Phones	\$150,000	\$0	\$0	\$150,000
Total	\$3,860,000	\$230,000	\$1,920,000	\$6,010,000



VALLEY FILL SEDIMENT PONDS

Economic Evaluation - Appalachia Mining Company

Capital Budget - Life of Mine

Total Capital

Item	Year 0	Year 1	Years 2 thru 10	Total
Description				
Heavy Equip.	\$0	\$34,190,000	\$15,210,000	\$49,400,000
Support Equip.	\$0	\$2,635,000	\$300,000	\$2,935,000
Development	\$3,860,000	\$230,000	\$1,920,000	\$6,010,000
Total	\$3,860,000	\$37,055,000	\$17,430,000	\$58,345,000

Economic Evaluation - Appalachia Mining Company

Manpower Table

Period: Full Year				C.T. Per M.H.		7.25		
# Production Days = 260 days				BCY Per M.H.		108.90		
	Manpower			Job	O.B.	# Prod.	Hrs. Per	
Position	Day	Evening	Total	Discription	Production	Day's	Day	
25 yd. Front Shovel	1	1	2	O.B. Loading	7,500,000	260	10	5,200
210 Ton Rock Truck	3	3	6	O.B. Haulage		260	10	15,600
Fill Dozer	1	1	2	Run Fill		260	10	5,200
18 1/2 yd. Backhoe	1	1	2	O.B. Loading	5,800,000	260	10	5,200
150 Ton Rock Truck	3	3	6	O.B. Haulage		260	10	15,600
Fill Dozer	1	1	2	Run Fill		260	10	5,200
16 yd. Endloader	1	1	2	O.B. Loading	4,100,000	260	10	5,200
150 Ton Rock Truck	2	2	4	O.B. Haulage		260	10	10,400
Fill Dozer	1	1	2	Run Fill		260	10	5,200
45 yd. Bull Dozer	4	4	8	Prod. Dozing	7,800,000	260	10	20,800
Development Dozer	2	2	4	Development		260	10	10,400
Reclamation Dozer	1	1	2	Reclamation		260	10	5,200
16 yd. Coal Loader	2	2	4	Coal Prep. & Ldg.		260	10	10,400
9 yd. Coal Loader	2	2	4	Coal Prep. & Ldg.		260	10	10,400
Drillers	4	3	7	O.B. Drilling		260	10	18,200
Motor Grader	1	1	2	Road Maint.		260	10	5,200
Water Truck	1	1	2	Dust Control		260	10	5,200
Mechanics / Welders	2	6	8	Maintenance		260	10	20,800
P.M. Technicians	1	2	3	Maintenance		260	10	7,800
Fueler / Greaser	1	1	2	Maintenance		260	10	5,200
Blasters	6	0	6	Blasting		260	10	15,600
Blasting Foreman	1	0	1	D & B Superv.		260	10	2,600
Prod. Foreman	1	1	2	Shift Superv.		260	10	5,200
Maint. Foreman	1	1	2	Maint. Superv.		260	10	5,200
Maintenance Planner	1	1	2	Maint. Scheduling		260	10	5,200
Prod. Engineer	1	0	1	Engineering		260	10	2,600
Superintendant	1	0	1	General Superv.		260	10	2,600
Total	47	42	89		25,200,000			231,400

Economic Evaluation - Appalachia Mining Company

E.B.I.T. (Earnings Before Interest and Taxes)

Parameter	Year #1			Year #2			Year #3			Year #4			Year #5		
	\$\$	\$\$ Per BCY	\$\$ Per C.T.	\$\$	\$\$ Per BCY	\$\$ Per C.T.	\$\$	\$\$ Per BCY	\$\$ Per C.T.	\$\$	\$\$ Per BCY	\$\$ Per C.T.	\$\$	\$\$ Per BCY	\$\$ Per C.T.
Revenues	\$41,524,634	\$1.65	\$24.75	\$41,524,634	\$1.65	\$24.75	\$41,524,634	\$1.65	\$24.75	\$41,524,634	\$1.65	\$24.75	\$41,524,634	\$1.65	\$24.75
Revenues Per Ton	\$24.75			\$24.75			\$24.75			\$24.75			\$24.75		
Non - Mining Costs:															
Sales Related Costs	\$6,116,285	\$0.24	\$3.65	\$6,116,285	\$0.24	\$3.65	\$6,116,285	\$0.24	\$3.65	\$6,116,285	\$0.24	\$3.65	\$6,116,285	\$0.24	\$3.65
Intercompany Roy.	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00
Intercompany Comm.	\$419,441	\$0.02	\$0.25	\$419,441	\$0.02	\$0.25	\$419,441	\$0.02	\$0.25	\$419,441	\$0.02	\$0.25	\$419,441	\$0.02	\$0.25
Trucking	\$3,445,007	\$0.14	\$2.05	\$3,445,007	\$0.14	\$2.05	\$3,445,007	\$0.14	\$2.05	\$3,445,007	\$0.14	\$2.05	\$3,445,007	\$0.14	\$2.05
Other Trans.	\$1,006,658	\$0.04	\$0.60	\$1,006,658	\$0.04	\$0.60	\$1,006,658	\$0.04	\$0.60	\$1,006,658	\$0.04	\$0.60	\$1,006,658	\$0.04	\$0.60
Preparation Costs	\$1,304,928	\$0.05	\$0.78	\$1,304,928	\$0.05	\$0.78	\$1,304,928	\$0.05	\$0.78	\$1,304,928	\$0.05	\$0.78	\$1,304,928	\$0.05	\$0.78
Subtotal	\$12,292,319	\$0.49	\$7.33	\$12,292,319	\$0.49	\$7.33	\$12,292,319	\$0.49	\$7.33	\$12,292,319	\$0.49	\$7.33	\$12,292,319	\$0.49	\$7.33
Net Realization	\$29,232,316	\$1.16	\$17.42	\$29,232,316	\$1.16	\$17.42	\$29,232,316	\$1.16	\$17.42	\$29,232,316	\$1.16	\$17.42	\$29,232,316	\$1.16	\$17.42
Indirect Costs:															
Overhead	\$1,215,933	\$0.05	\$0.72	\$1,080,647	\$0.04	\$0.64	\$1,001,678	\$0.04	\$0.60	\$927,778	\$0.04	\$0.55	\$889,564	\$0.04	\$0.53
Reclamation	\$251,664	\$0.01	\$0.15	\$251,664	\$0.01	\$0.15	\$251,664	\$0.01	\$0.15	\$251,664	\$0.01	\$0.15	\$251,664	\$0.01	\$0.15
Subtotal	\$1,467,597	\$0.06	\$0.87	\$1,332,311	\$0.05	\$0.79	\$1,253,342	\$0.05	\$0.75	\$1,179,442	\$0.05	\$0.70	\$1,141,228	\$0.05	\$0.68
Mining Costs:															
Labor	\$8,590,556	\$0.34	\$5.12	\$8,590,556	\$0.34	\$5.12	\$8,590,556	\$0.34	\$5.12	\$8,590,556	\$0.34	\$5.12	\$8,590,556	\$0.34	\$5.12
Supplies	\$11,451,473	\$0.45	\$6.83	\$11,451,473	\$0.45	\$6.83	\$11,451,473	\$0.45	\$6.83	\$11,451,473	\$0.45	\$6.83	\$11,451,473	\$0.45	\$6.83
Power	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00
Other	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00
Subtotal	\$20,042,029	\$0.80	\$11.95	\$20,042,029	\$0.80	\$11.95	\$20,042,029	\$0.80	\$11.95	\$20,042,029	\$0.80	\$11.95	\$20,042,029	\$0.80	\$11.95
Cash Margin	\$7,722,690	\$0.31	\$4.60	\$7,857,976	\$0.31	\$4.68	\$7,936,945	\$0.31	\$4.73	\$8,010,845	\$0.32	\$4.77	\$8,049,059	\$0.32	\$4.80
Cash Margin Per Ton	\$4.60			\$4.68			\$4.73			\$4.77			\$4.80		
Cash Cost Per Ton	\$20.15			\$20.07			\$20.02			\$19.98			\$19.95		
Direct D.D. & A.	\$5,292,144	\$0.21	\$3.15	\$5,292,144	\$0.21	\$3.15	\$5,292,144	\$0.21	\$3.15	\$5,217,144	\$0.21	\$3.11	\$5,229,644	\$0.21	\$3.12
Indirect D.D. & A.	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00	\$0	\$0.00	\$0.00
Subtotal	\$5,292,144	\$0.21	\$3.15	\$5,292,144	\$0.21	\$3.15	\$5,292,144	\$0.21	\$3.15	\$5,217,144	\$0.21	\$3.11	\$5,229,644	\$0.21	\$3.12
E.B.I.T.	\$2,430,546	\$0.10	\$1.45	\$2,565,832	\$0.10	\$1.53	\$2,644,801	\$0.10	\$1.58	\$2,793,701	\$0.11	\$1.67	\$2,819,415	\$0.11	\$1.68
CY Removed	25,200,000			25,200,000			25,200,000			25,200,000			25,200,000		
BCY Per Manhour	108.90			108.90			108.90			108.90			108.90		
% Direct Ship	80.00%			80.00%			80.00%			80.00%			80.00%		
Mine Recovery	80.36%			80.36%			80.36%			80.36%			80.36%		
Tons Produced / Sold	1,677,763			1,677,763			1,677,763			1,677,763			1,677,763		
Days Worked	260			260			260			260			260		
Man Hours Worked	231,400			231,400			231,400			231,400			231,400		
Strip Ratio	15.02			15.02			15.02			15.02			15.02		
Tons Per Man Hour	7.25			7.25			7.25			7.25			7.25		

Parameter	Total Project		
	\$\$	\$\$ Per BCY	\$\$ Per C.T.
Revenues	\$405,800,604	\$ 1.65	\$24.75
Revenues Per Ton	\$24.75		
Non - Mining Costs:			
Sales Related Costs	\$59,771,560	\$0.24	\$3.65
Intercompany Royalties	\$0	\$0.00	\$0.00
Intercompany Commissions	\$4,098,996	\$0.02	\$0.25
Trucking	\$33,666,422	\$0.14	\$2.05
Other Transportation Costs	\$9,837,593	\$0.04	\$0.60
Preparation Costs	\$12,752,441	\$0.05	\$0.78
Subtotal	\$120,127,012	\$0.49	\$7.33
Net Realization	\$285,673,592	\$ 1.16	\$17.42
Indirect Costs:			
Overhead	\$8,996,465	\$0.04	\$0.55
Reclamation	\$2,459,394	\$0.01	\$0.15
Subtotal	\$11,455,859	\$0.05	\$0.70
Mining Costs:			
Labor	\$83,956,796	\$0.34	\$5.12
Supplies	\$112,056,241	\$0.45	\$6.83
Power	\$0	\$0.00	\$0.00
Other	\$0	\$0.00	\$0.00
Subtotal	\$196,013,037	\$0.80	\$11.95
Cash Margin	\$78,204,696	\$ 0.32	\$4.77
Cash Margin Per Ton	\$4.77		
Cash Cost Per Ton	\$19.98		
Direct D.D. & A.	\$51,691,246	\$0.21	\$3.15
Indirect D.D. & A.	\$0	\$0.00	\$0.00
Subtotal	\$51,691,246	\$0.21	\$3.15
E.B.I.T.	\$26,513,450	\$0.11	\$1.62

Economic Evaluation - Appalachia Mining Company E.B.I.T. (Earnings Before Interest and Taxes)

Cubic Yards Removed	246,283,400
BCY Per Manhour	108.90
Percent Direct Ship	80.00%
Mine Recovery	80.36%
Tons Produced / Sold	16,395,984
Days Worked	2,600
Man Hours Worked	2,261,507
Strip Ratio	15.02
Tons Per Man Hour	7.25

Economic Evaluation - Appalachia Mining Company

Capital Investment Statistics (mm)

Parameter	Initial Inv.	Year 0	Year #1	Year #2	Year #3	Year #4	Year #5	Year #6	Year #7	Year #8	Year #9	Year #10	Year #11
E.B.I.T.	\$0.00	\$2.43	\$2.57	\$2.64	\$2.79	\$2.82	\$1.45	\$1.55	\$1.70	\$5.22	\$3.33	\$0.00	
Taxes @ 30%	\$0.00	\$0.73	\$0.77	\$0.79	\$0.84	\$0.85	\$0.44	\$0.47	\$0.51	\$1.57	\$1.00	\$0.00	
Commissions	\$0.00	\$0.42	\$0.42	\$0.42	\$0.42	\$0.42	\$0.42	\$0.42	\$0.42	\$0.42	\$0.32	\$0.00	
Taxes on Comm.	\$0.00	\$0.13	\$0.13	\$0.13	\$0.13	\$0.13	\$0.13	\$0.13	\$0.13	\$0.13	\$0.10	\$0.00	
Intercompany Royalty	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	
Taxes on Intercompany	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	
Tax Savings Depl.	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	
Net Income	\$0.00	\$1.99	\$2.09	\$2.14	\$2.25	\$2.27	\$1.31	\$1.38	\$1.49	\$3.95	\$2.56	\$0.00	
(Add) DD&P	\$0.00	\$5.29	\$5.29	\$5.29	\$5.22	\$5.23	\$6.53	\$6.53	\$6.48	\$2.97	\$2.85	\$0.00	
(Less) CapEx	\$3.86	\$37.06	\$0.48	\$0.23	\$0.48	\$2.78	\$10.66	\$1.70	\$0.00	\$2.55	\$0.00	(\$6.65)	
Net Cash Flow	(\$3.86)	(\$29.77)	\$6.90	\$7.21	\$6.99	\$4.72	(\$2.82)	\$6.21	\$7.97	\$4.37	\$5.41	\$6.65	

N.P.V. @ 5%	\$7.45	Cash Flows 1 - 11 E.B.I.T. \$26.51 Net Inc. \$21.43 Net Cash \$19.98
N.P.V. @ 8%	\$2.26	
N.P.V. @ 10%	(\$0.52)	
I.R.R.	9.60%	
Payback Period	7.56 yrs	

SUMMARY

- **Coal Recovery**
 - Surface = 16,395,984 CT
 - Underground = 5,540,832 CT
 - Upper Clarion and Coalburg seams only.
 - CT based on 60% mine recovery.
 - Underground only recovers 33.8% of the area reserves.
- **Total Direct Mine Hours Worked**
 - Surface = 2,261,507 Hrs.
 - Underground = 871,201 Hrs.

Surface Mining will provide more employment in this reserve area.

SUMMARY (CONT.)

- **Taxes Generated from the Project:**

– Personal Property Tax	\$ 3,132,574	\$0.19 per ton
– Worker’s Compensation	\$ 5,559,085	\$0.34 per ton
– Matching F.I.C.A.	\$ 3,097,378	\$0.19 per ton
– Unmined Mineral Tax	\$ 1,173,000	\$0.07 per ton
– Franchise Tax	\$ 504,390	\$0.03 per ton
– Severance Tax	\$20,290,033	\$1.24 per ton
– Black Lung Tax	\$ 8,747,264	\$0.53 per ton
– Federal Reclamation Tax	\$ 5,566,431	\$0.34 per ton
– WV Special Assessment	\$ 819,798	\$0.05 per ton
– <u>Federal & State Income Tax</u>	<u>\$ 9,183,734</u>	<u>\$0.56 per ton</u>
– Total Tax Expense	\$58,073,684	\$3.54 per ton

SUMMARY (CONT.)

- **Tax savings if this job was operated in another state.**
 - Kentucky \$ 4,189,994
 - Virginia \$12,187,134
- **Total Direct Wages and Benefits earned from the Project**
 - \$ 83,796,596
- **Total Purchases of Services, Materials and Supplies from the Project**
 - \$145,722,663
- **Total Capital for the Project**
 - \$ 58,345,000
- **Return on Investment (ROI) for the Project.**
 - **9.60%**

SUMMARY (CONT.)

FINAL EVALUATION - APPALACHIA MINING COMPANY

- The Project is marginally feasible as planned
- If costs are increased due to regulatory changes, the project will not be feasible.
 - Increase in haul distances or grade.
 - Increase in taxes
 - Increase in permitting related expenses
 - Increase in blasting costs
 - Increase in litigation
 - Etc.

SUMMARY (CONT.)

FINAL EVALUATION - APPALACHIA MINING COMPANY

- The mountain is reclaimed in an environmentally responsible manner
 - Commercial Woodland
 - Fish & Wildlife
 - Residential
 - Farming
 - Commercial Livestock
 - Etc.



FINAL AOC RECLAMATION



FINAL AOC RECLAMATION



FINAL AOC RECLAMATION



FINAL AOC RECLAMATION



PROGRESSIVE CONTEMPORANEOUS RECLAMATION



PROGRESSIVE PHASES OF CONTEMPORANEOUS RECLAMATION

*IN WEST VIRGINIA , MOUNTAINTOP
REMOVAL MINING CAN BE HALTED
BY SIMPLY MAKING IT COST
PROHIBITIVE.*

*IF MINING IS STOPPED IN THIS
MANNER, IT CAN BE CLAIMED THAT
MINING IS STILL FEASIBLE, BUT THE
COMPANY DECIDED NOT TO DO THE
PROJECT.*

A TRUE “POLITICAL SPIN” SOLUTION

SURFACE MINING



CONVENTIONAL AUGER AND HIGHWALL MINING METHODS

Presented by:

IAN CARR

MINING TECHNOLOGIES, INC.

HIGHWALL EXPOSED COAL SEAM



AUGER MINING SYSTEMS



SINGLE AUGER

DUAL AUGER

TRIPLE AUGER

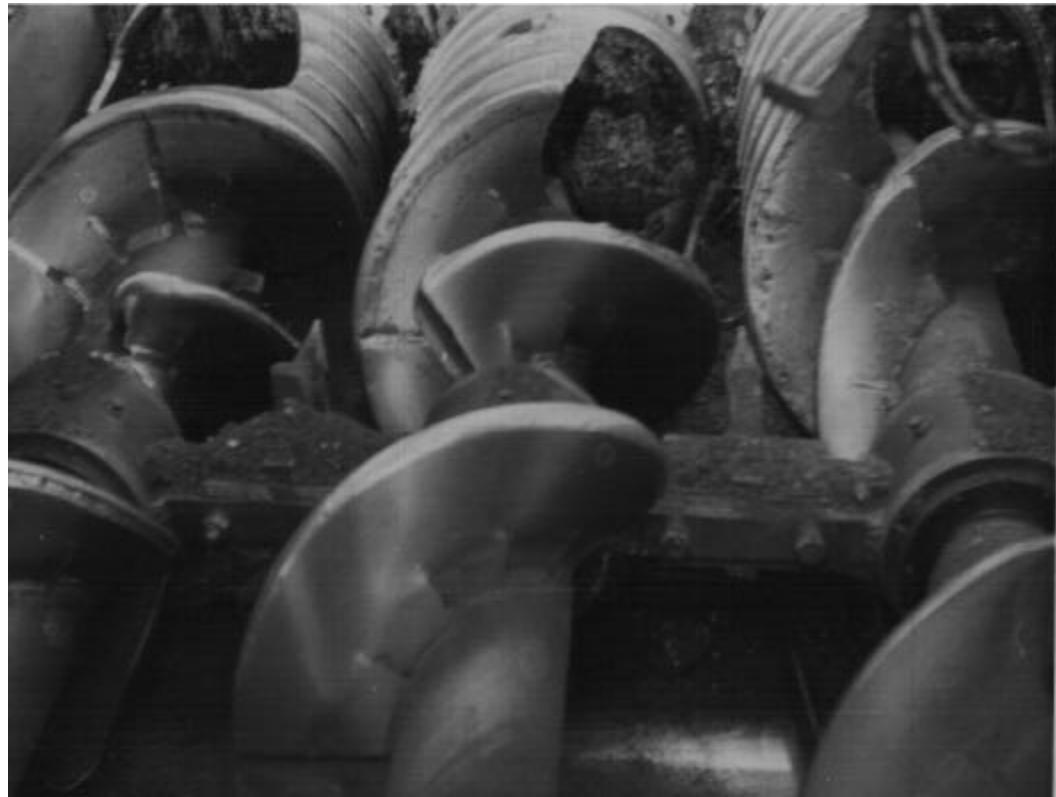
SINGLE AUGERS



DUAL AUGERS



TRIPLE AUGERS



TRIPLE AUGERS



AUGER MINING SYSTEMS



SALEM TOOL, INC.

BRYDET DEVELOPMENT CORPORATION

SALEM TOOL, INC.



SALEM TOOL, INC.



SALEM TOOL, INC.



BRYDET DEVELOPMENT CORPORATION



BRYDET DEVELOPMENT CORPORATION



BRYDET DEVELOPMENT CORPORATION



BRYDET DEVELOPMENT CORPORATION



BRYDET DEVELOPMENT CORPORATION



BRYDET DEVELOPMENT CORPORATION



BRYDET DEVELOPMENT CORPORATION



HIGHWALL MINING SYSTEMS



THE ARCHVEYOR

SUPERIOR HIGHWALL MINERS

ADDCAR HIGHWALL MINING

THE ARCHVEYOR



THE ARCHVEYOR



THE ARCHVEYOR

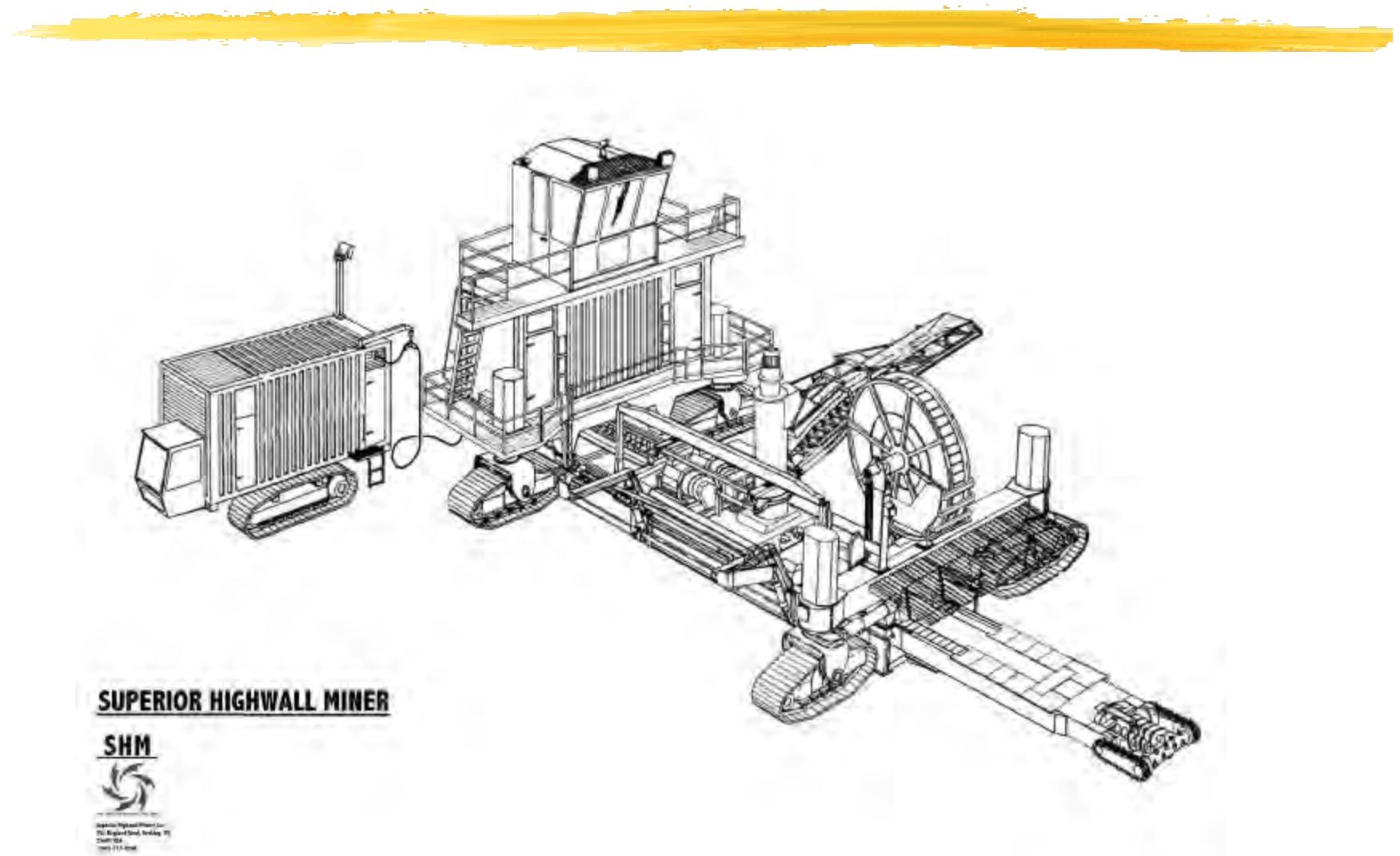


SUPERIOR HIGHWALL MINERS, INC.





SUPERIOR HIGHWALL MINERS, INC.



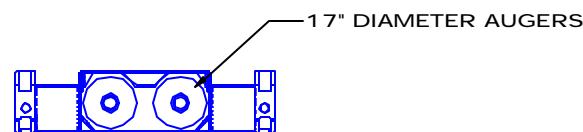
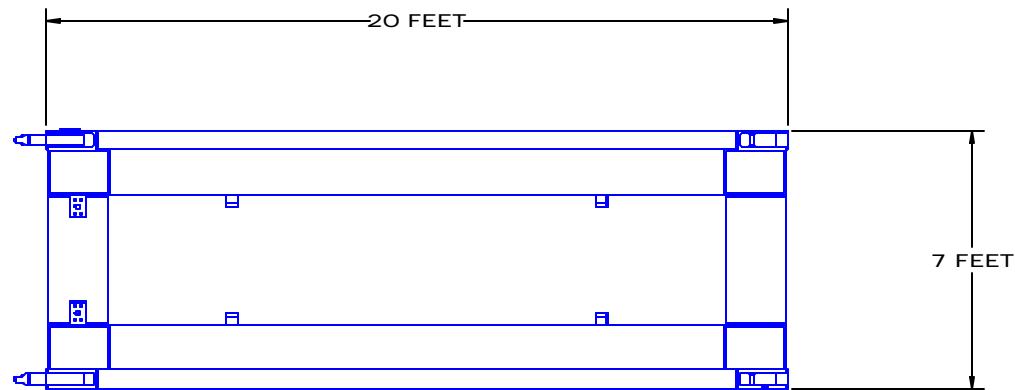
SUPERIOR HIGHWALL MINER

SHM



Superior Highwall Miner, Inc.
701 Highway 96, Brinkley, AR
72615 USA
(873) 213-4561

SHM PUSHBEAM



FRONT VIEW

SUPERIOR HIGHWALL MINERS, INC.



ADDCAR HIGHWALL MINING SYSTEM





ADDCAR SYSTEM COMPONENTS



CONTINUOUS MINER

CONVEYOR CARS

LAUNCH VEHICLE

STACKER CONVEYOR

WHEEL LOADER

CONTINUOUS MINER



CONVEYOR CARS



LAUNCH VEHICLE





STACKER CONVEYOR

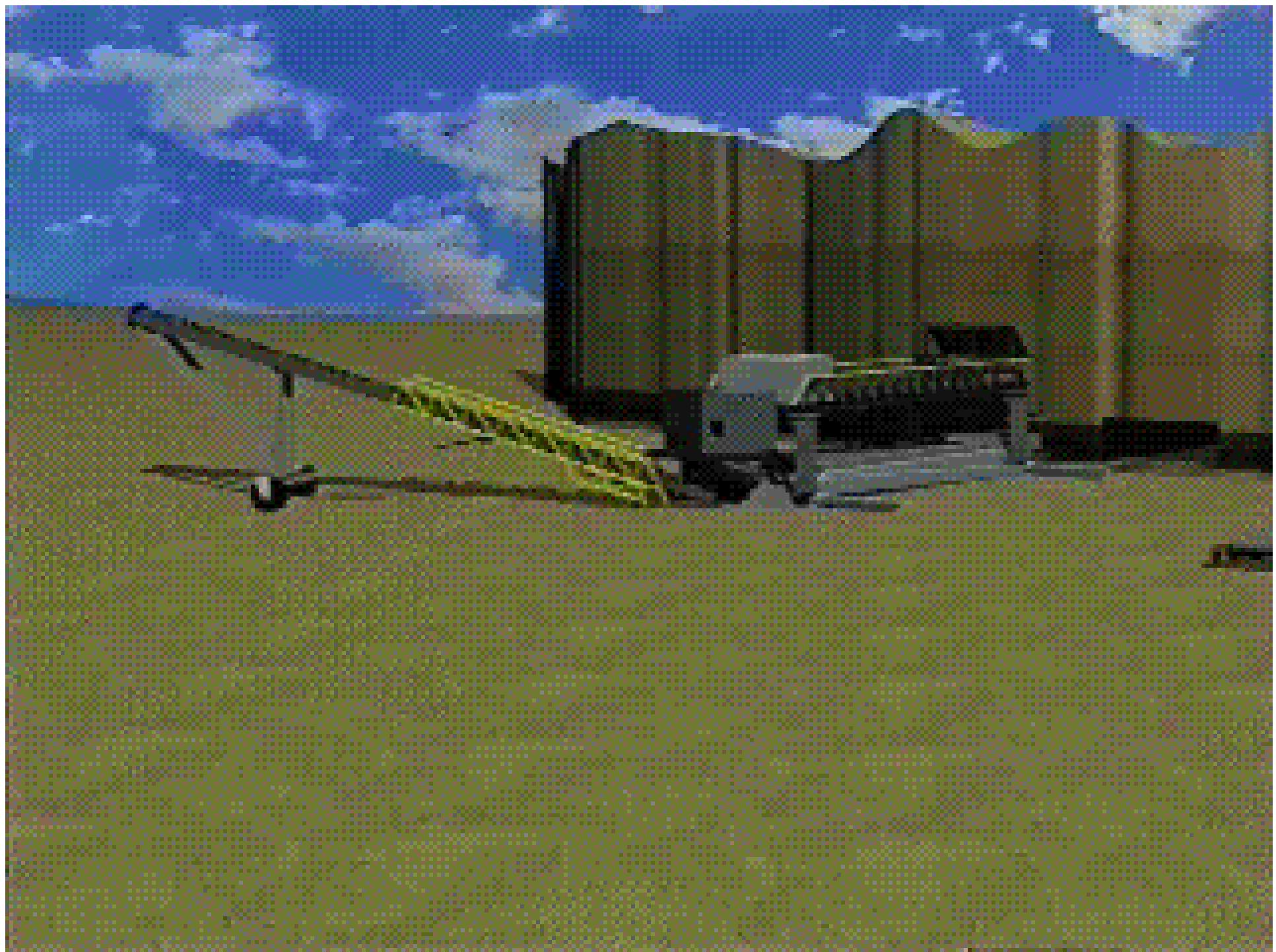


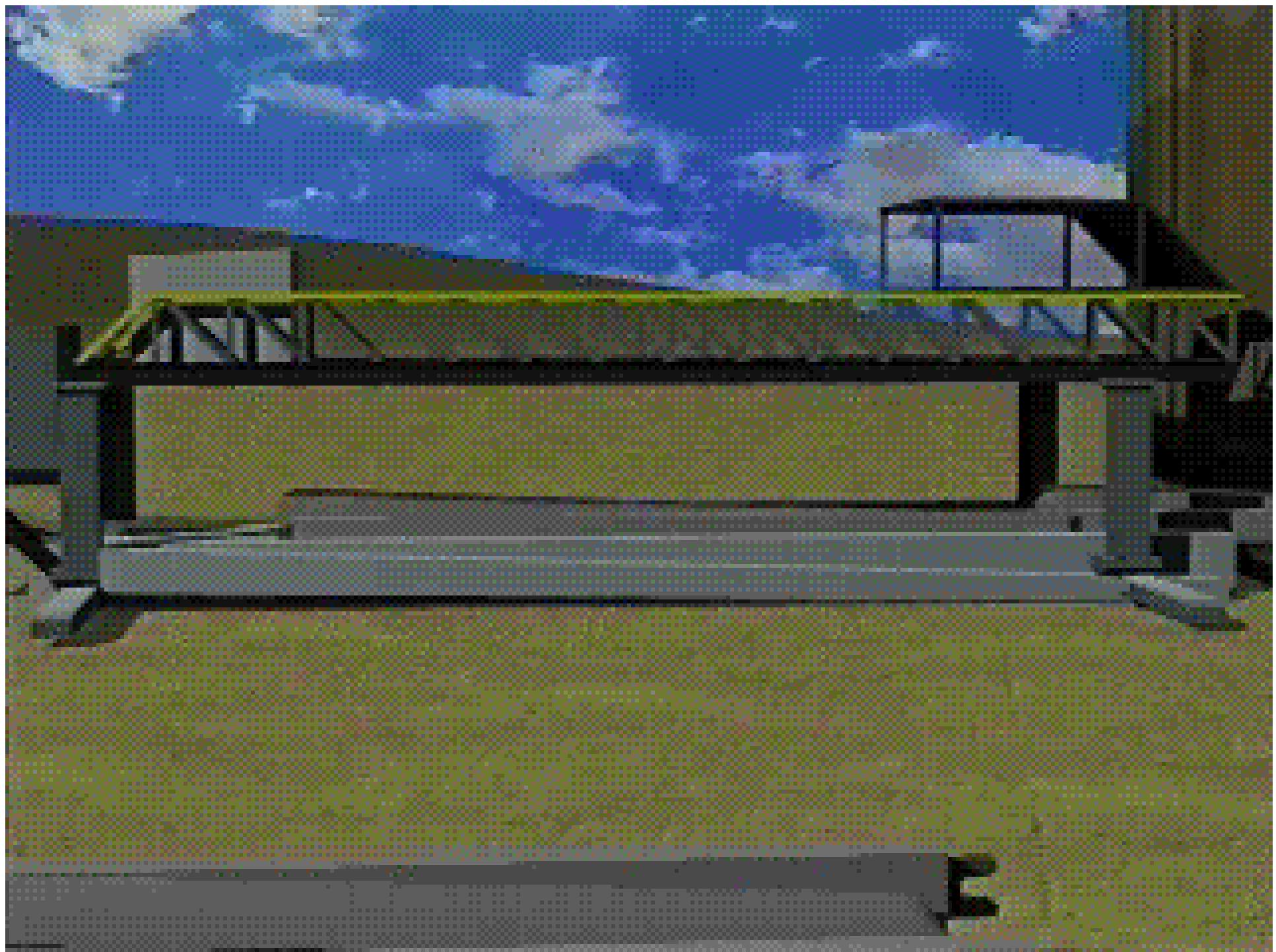
WHEEL LOADER

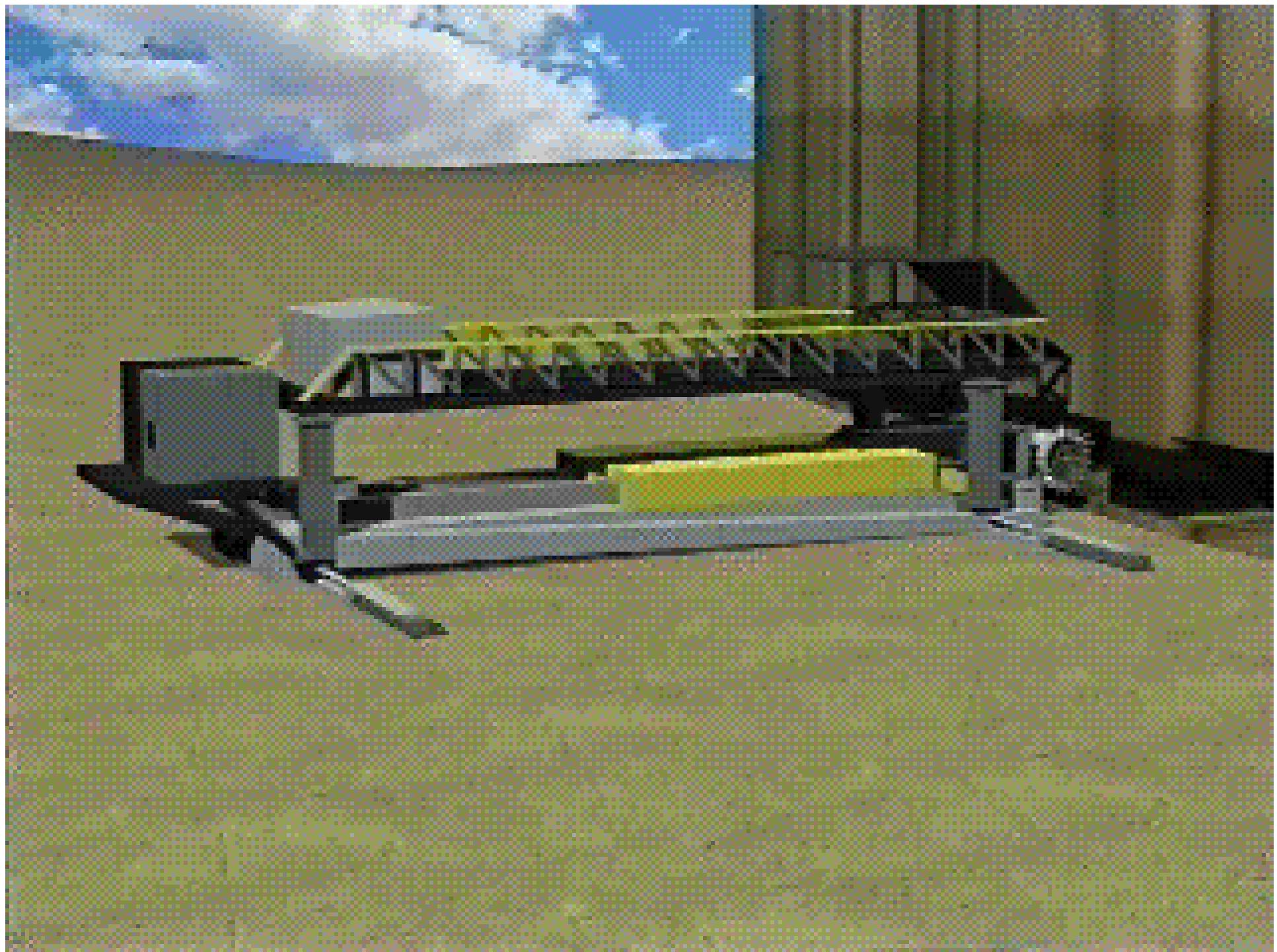


ADDCAR MINING PROCEDURE









STEEP DIP HIGHWALL MINING



ADDCAR HIGHWALL MINING SYSTEM



Mining Technologies, Inc.

Surface Mining....



.... Dragline Methods

History of Draglines



- ✓ First dragline built in 1904 by Page & Schnable
- ✓ Built for a specific need on the Chicago Drainage Canal project
- ✓ In 1912, Page Engineering Company incorporated when Page discovered building draglines more profitable than contracting



History, continued



- ✓ Up until 1912 no one had developed a means of propelling the machine
- ✓ In 1913 an engineer for Monighan Machine Company revolutionized dragline by placing two shoes, one on each side of the revolving frame
- ✓ The Model 1-T became the first walking dragline



History, continued

World's Largest Machines

- ✓ 1935 12 CY manufactured by Bucyrus Erie
- ✓ 1942 30 CY manufactured by Marion
- ✓ 1961 40CY manufactured by Ransom & Rapier (British)
- ✓ 1963 85 CY manufactured by Marion
- ✓ 1965 145 CY manufactured by Marion
- ✓ 1969 220 CY manufactured by Bucyrus Erie



History, continued

World's Largest Machines



- ✓ **BIG MUSKIE**
- ✓ Muskingum Mine of Central Ohio Coal Company (AEP)
- ✓ Operated until June 1991
- ✓ Attempting to preserve as a public historical facility



History, continued

- ✓ Today only two remaining manufacturers of draglines:
 - Bucyrus Erie
 - P & H



History of Dragline Operations in West Virginia

- ✓ Joe Hughes of Northeast Mining Company operated a 4 yard Page near Beaver Creek in Tucker County in 1963
- ✓ During late 1960's and 1970's several operations including:
 - Imperial Coal & Construction Co.
 - Grant County Coal Corp.
 - Byron Construction Company
 - Bitner Mining
 - Island Creek Coal



History of Dragline Operations in West Virginia

- ✓ 1983 Hobet Mining began operations with a BE 1570 - 80 CY dragline at Hobet 21 near Madison
- ✓ 1983 Taywood Mining operated a Marion 183M - 9 CY
- ✓ 1987 Hobet Mining installed Marion 8200 - 72 CY machine at the Hobet 07 operations (transferred to Dal-Tex in August 1996)
- ✓ 1989 Morrison Knudsen began contract mining operations at Cannelton with a Marion 8200 - 72 CY
- ✓ 1989 AOWV/Ruffner added Marion 8400 - 49 CY machine
- ✓ 1994 Catenary Coal Company installed a BE 2570 - 100 CY machine at the Samples Mine (upgraded 1998 to 118 CY)
- ✓ 1998 Evergreen Mining comissioned a BE 1570 - 75 CY machine in Webster County



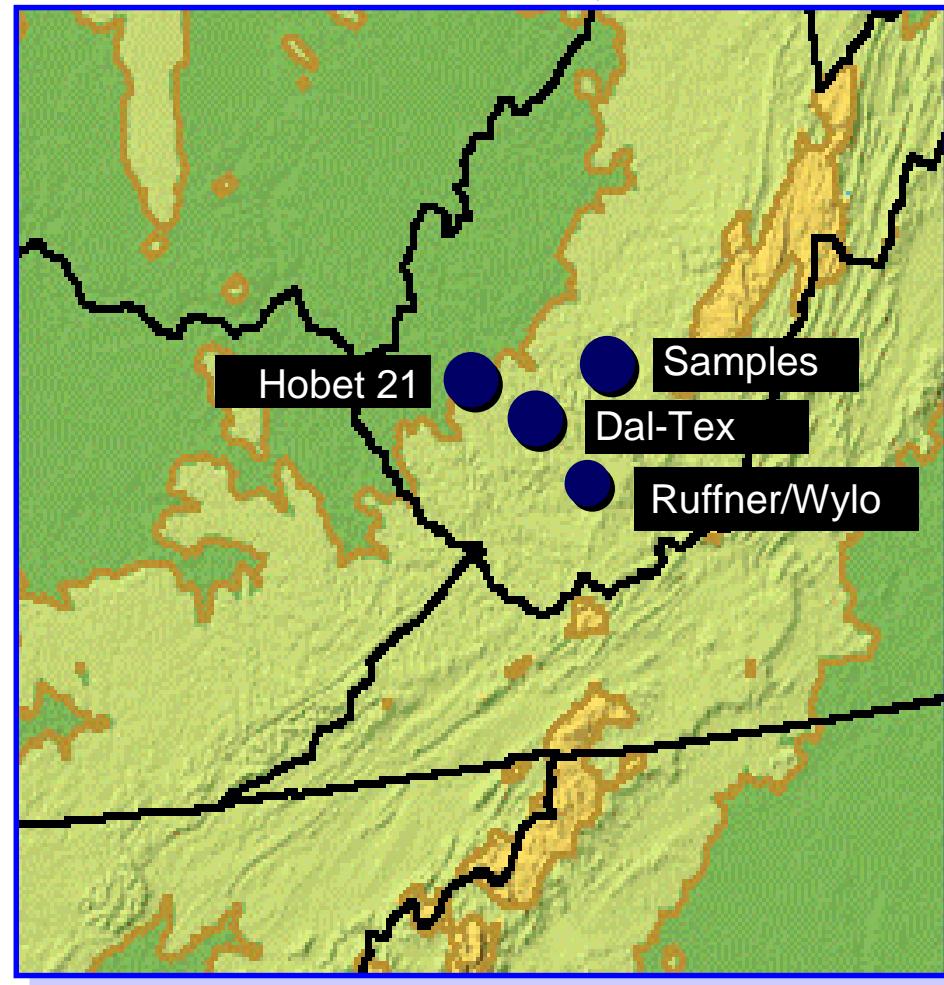
History of Draglines Operating in West Virginia

- ✓ 1999 - 6 draglines in operation:
 - BE 1570 at Hobet 21 Mine
 - Marion 8400 at AOWV/Ruffner Mine
 - Marion 8200 at Dal-Tex Mine
 - BE 2570 at Catenary/Samples Mine
 - Marion 8200 at Cannelton Mine
 - BE 1570 at Evergreen Mine



West Virginia Dragline Operations

Arch Coal, Inc.



Mine Planning..

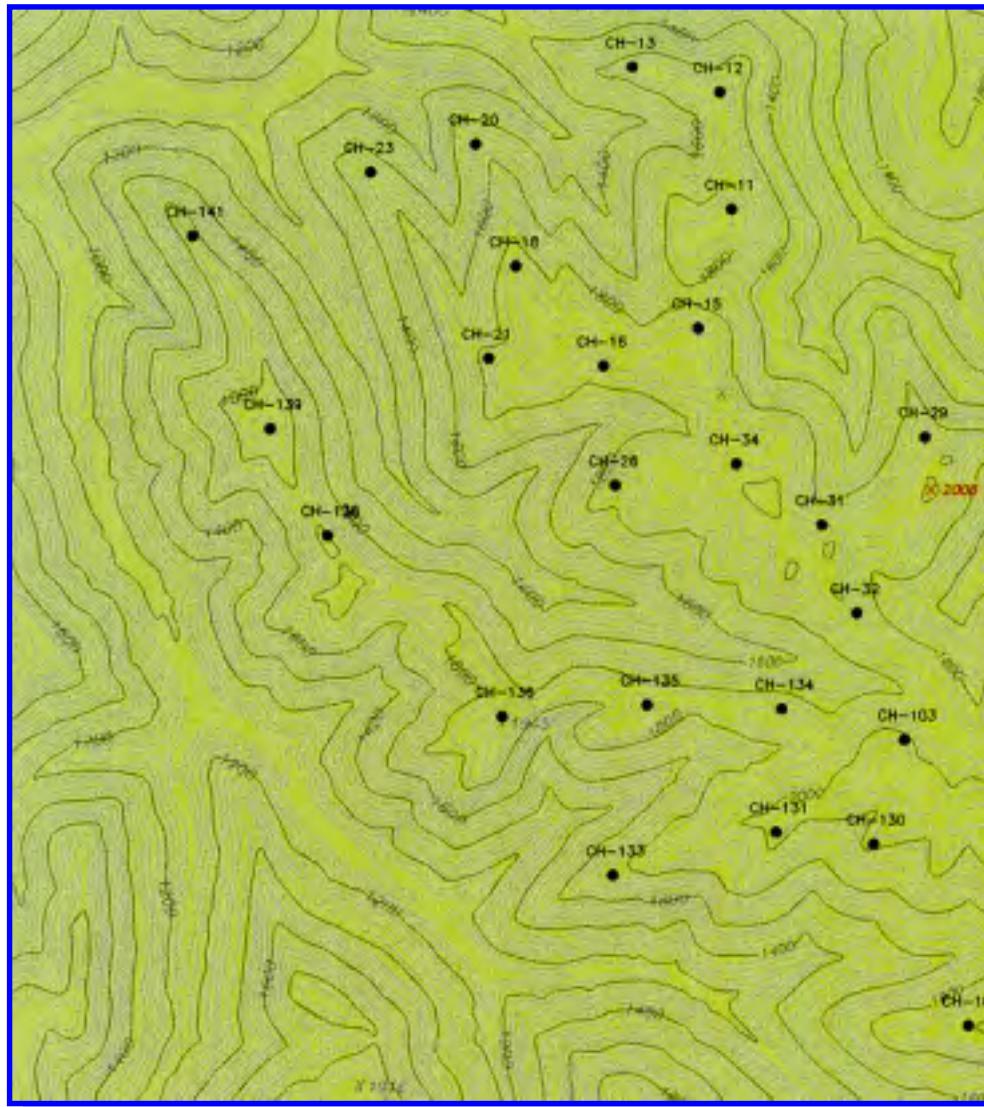


General Considerations in WV

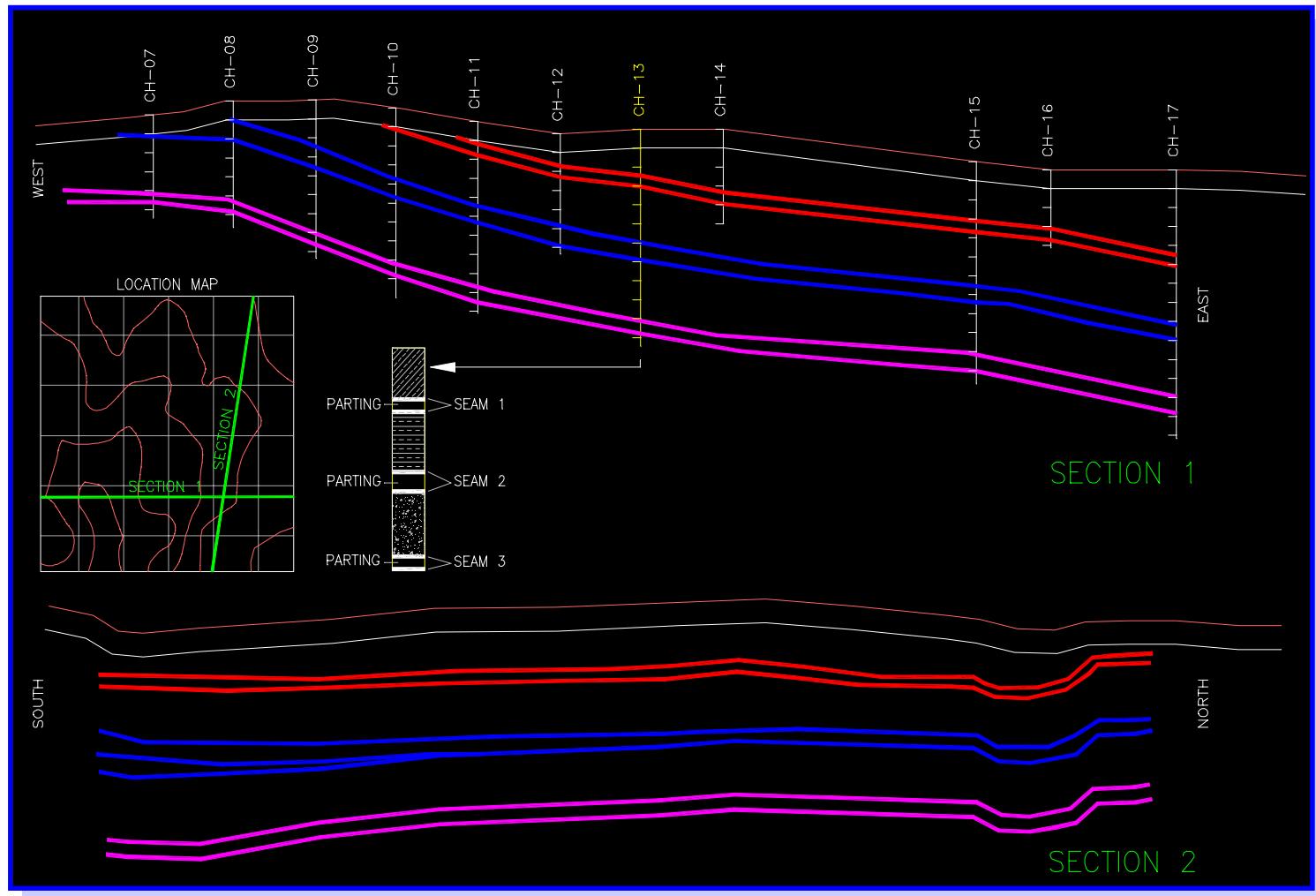
- ✓ Topographical constraints
- ✓ Pit geometry (length/width/bench height)
- ✓ Need for added mobility of machine
- ✓ Single vs. multiple seam
- ✓ Development requirements
- ✓ Contemporaneous reclamation
- ✓ Economics



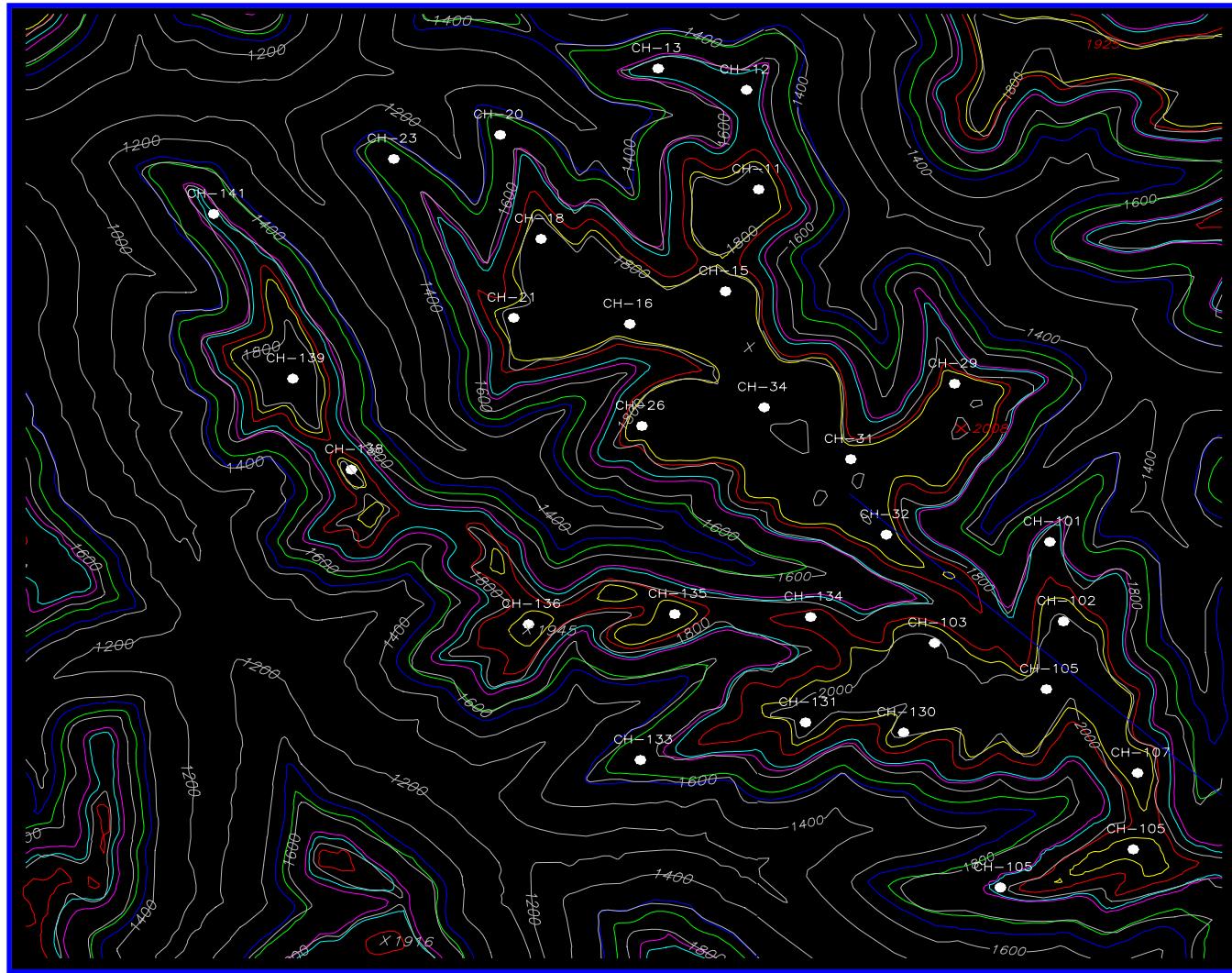
Topographic Map of Dragline Area



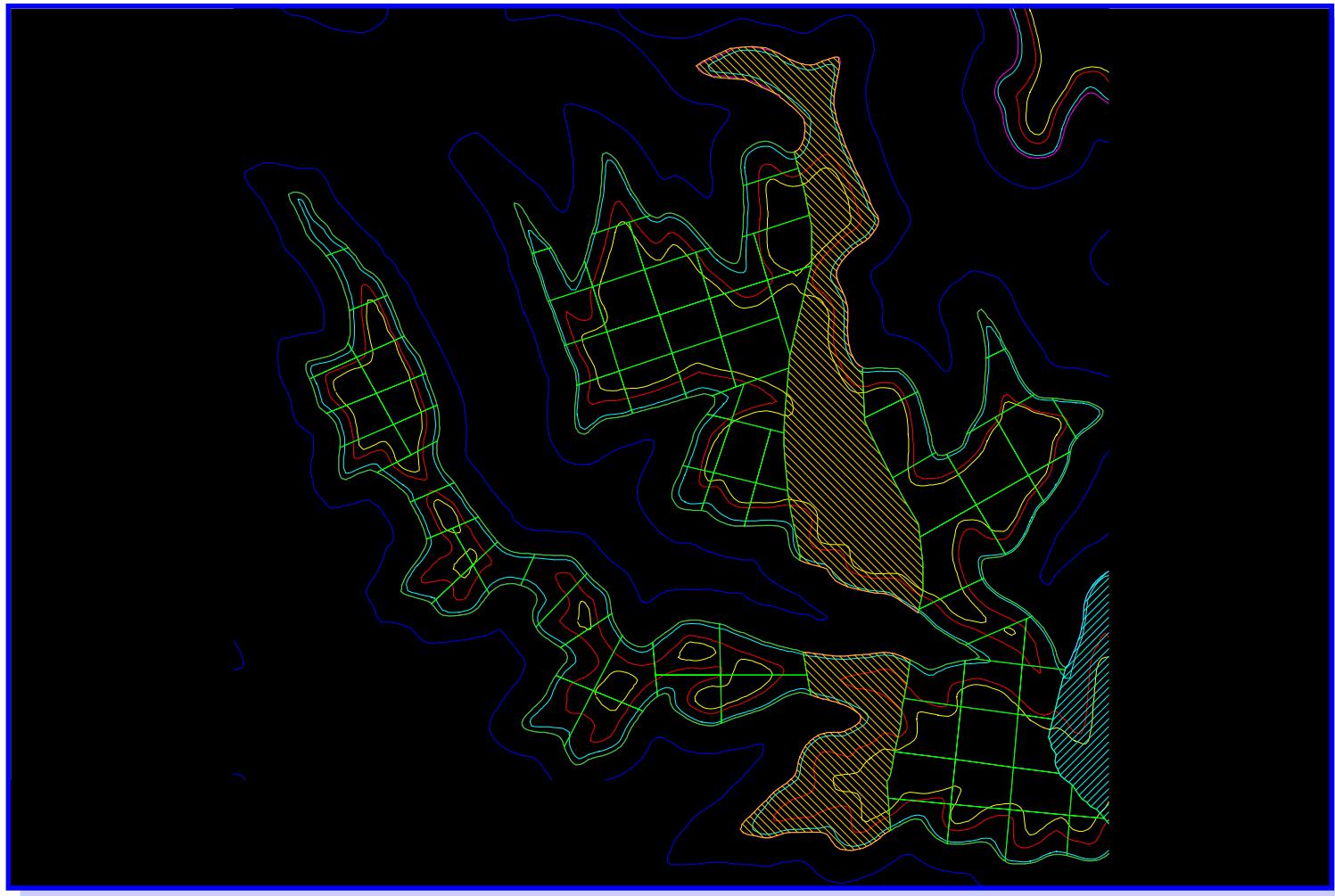
Coal Seam Correlation



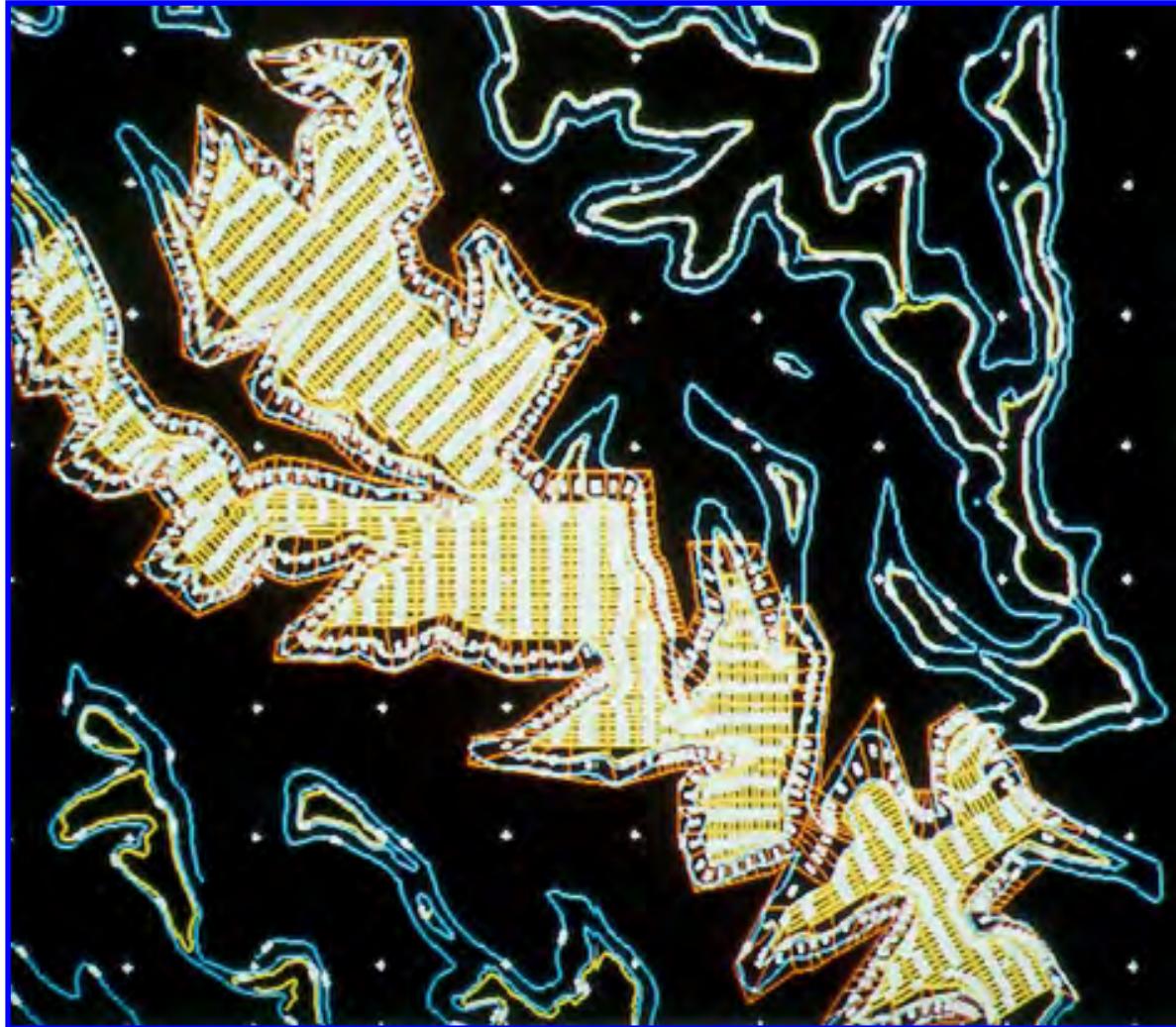
Coal Crops / Reserve Boundaries



Volumetric Gridding



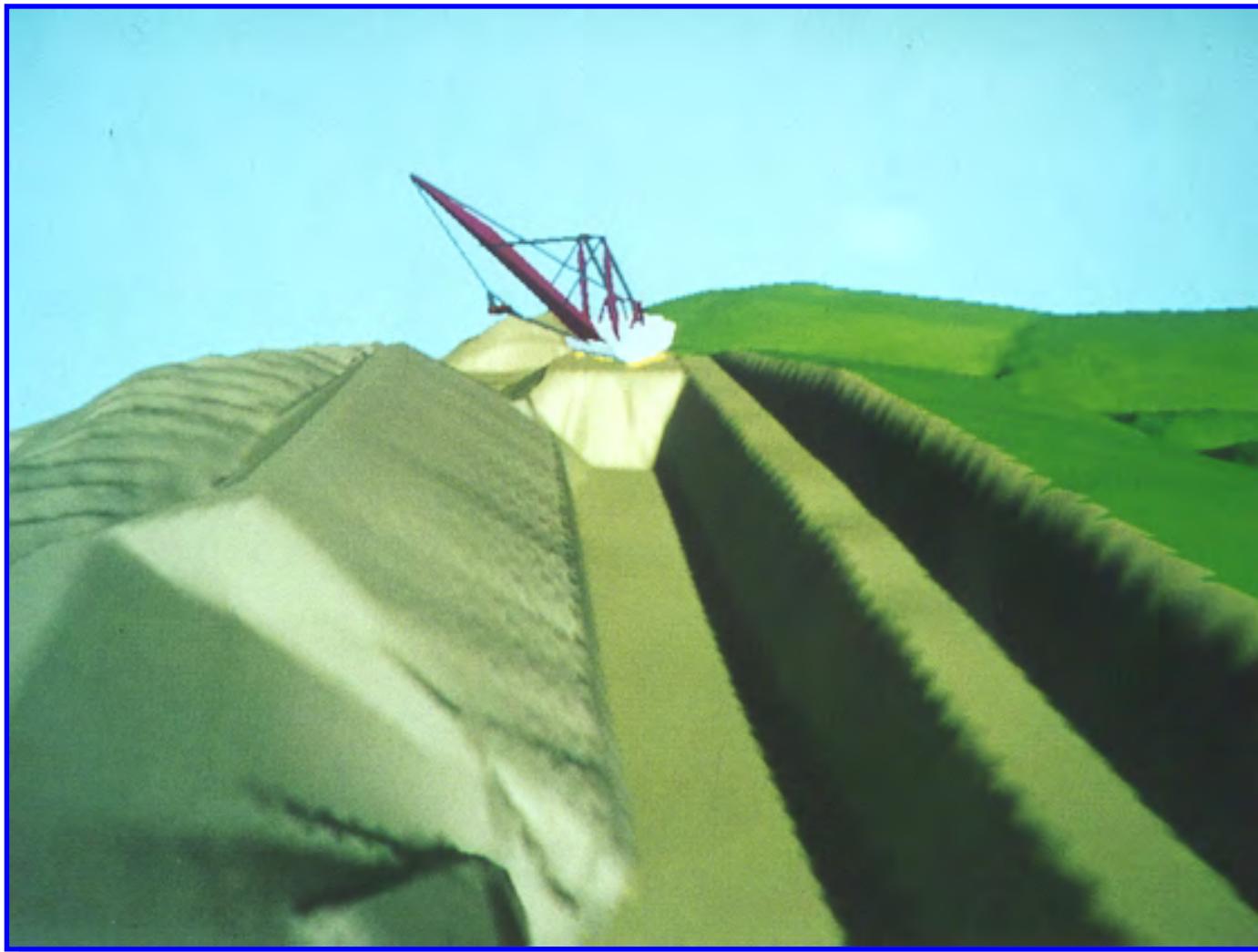
Mine Sequencing



3-Dimensional Modeling



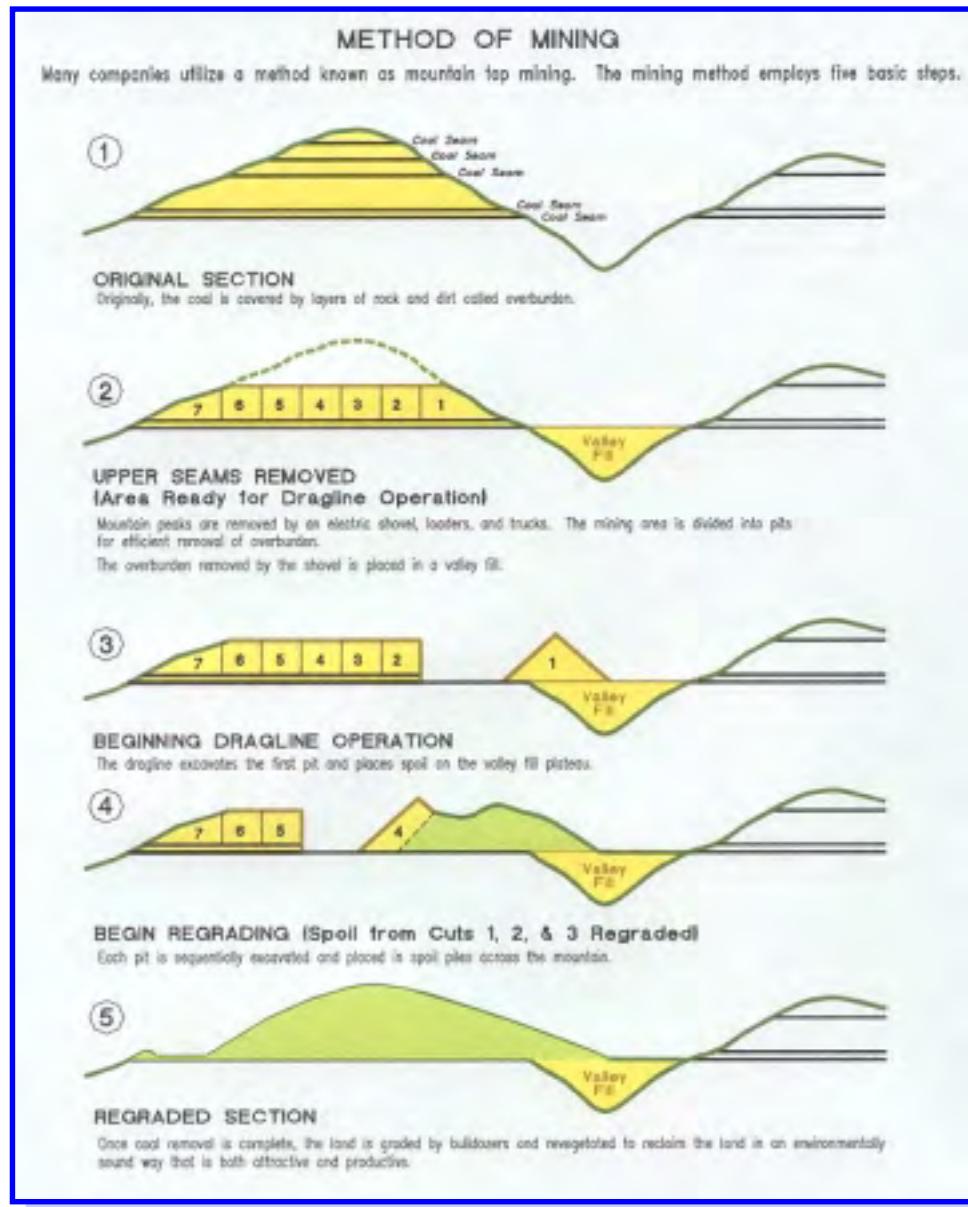
Pit Geometry



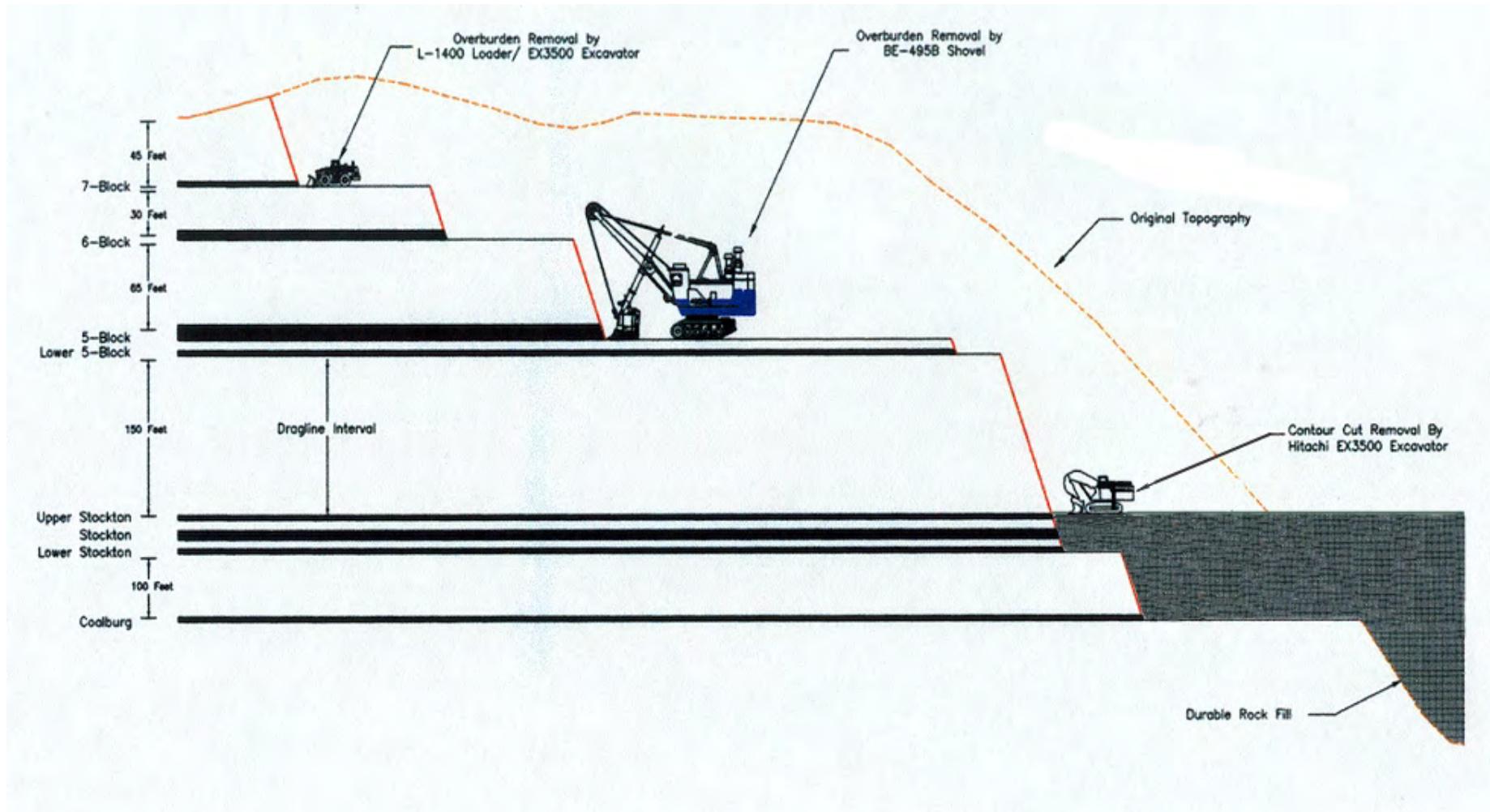
BE 2570 - Samples Mine



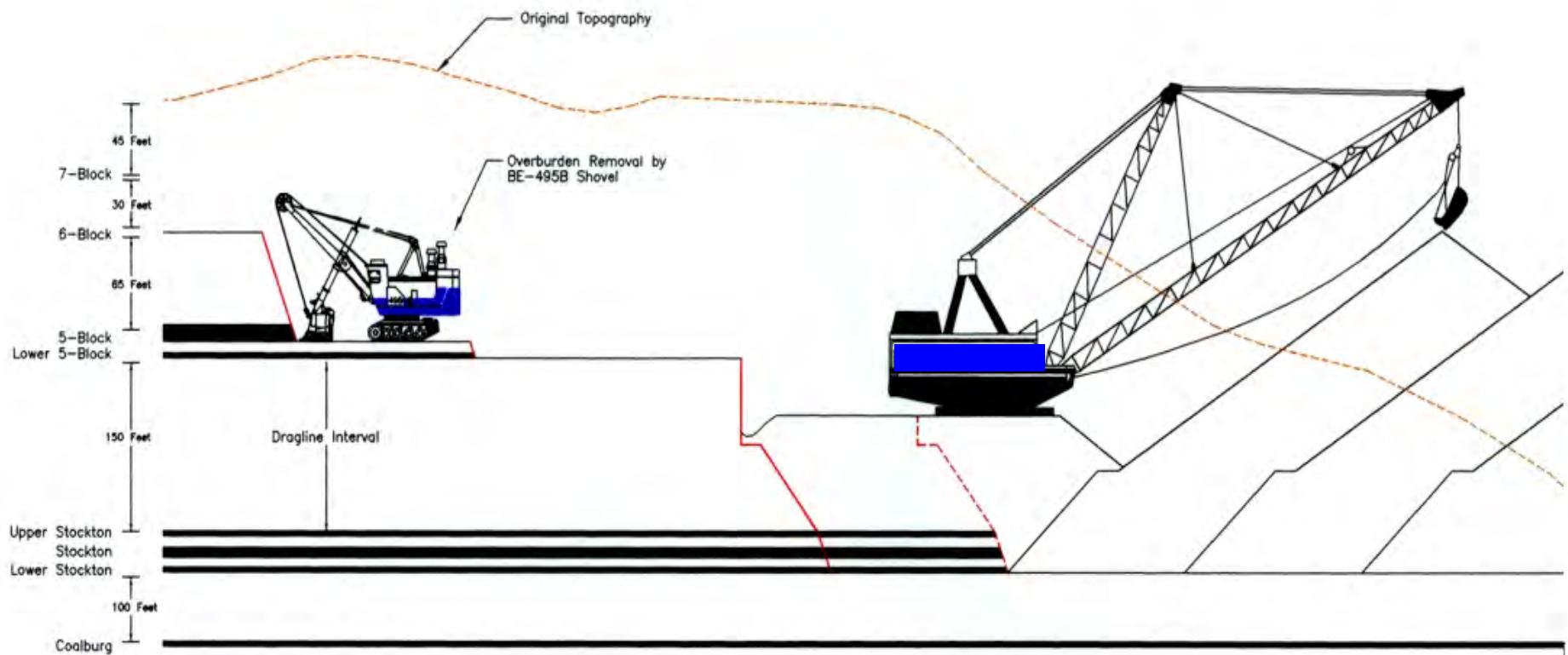
Schematic Showing Typical Dragline Operation



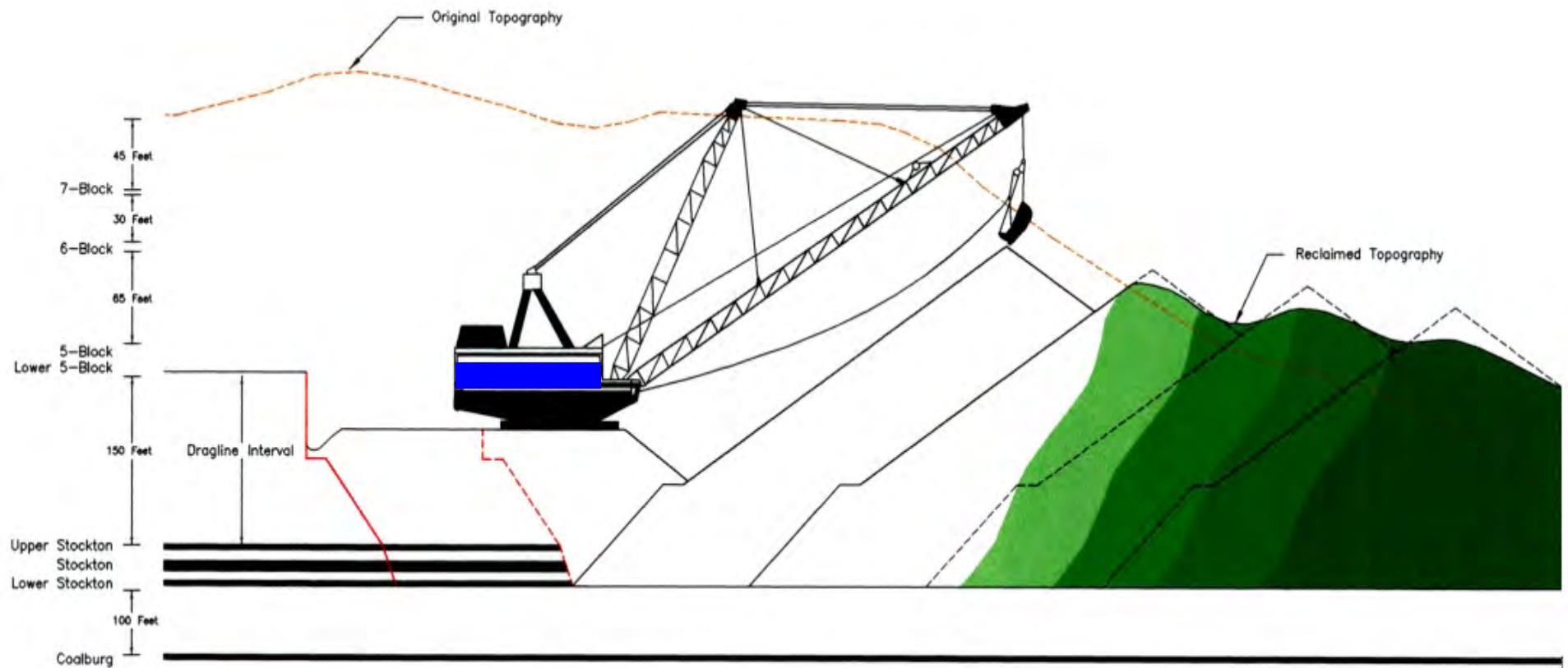
General Mining Sequence 'A'



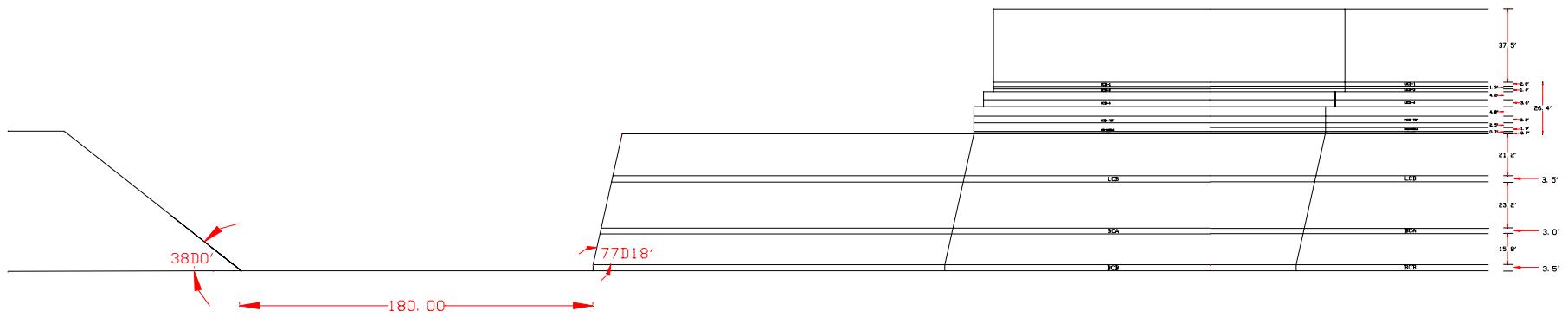
General Mining Sequence 'B'



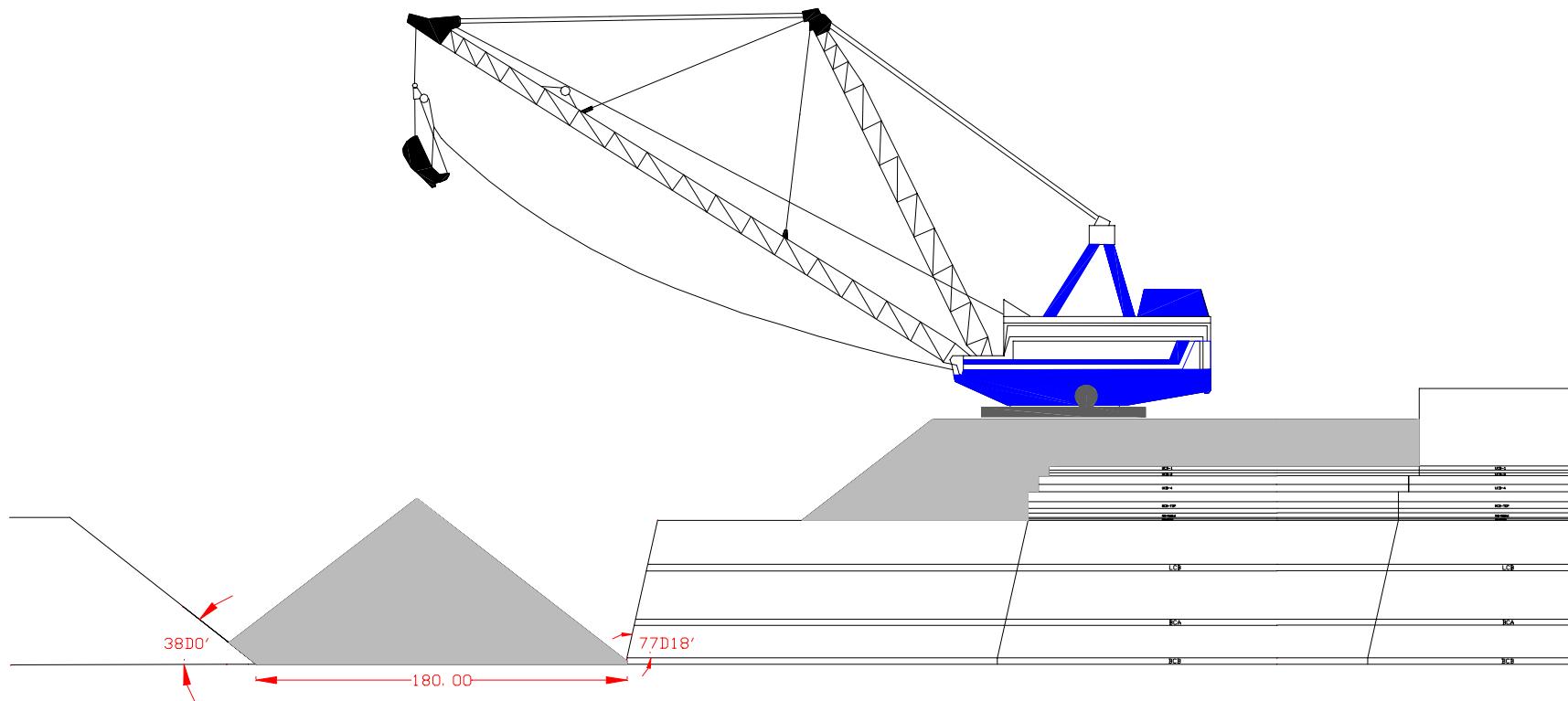
General Mining Sequence 'C'



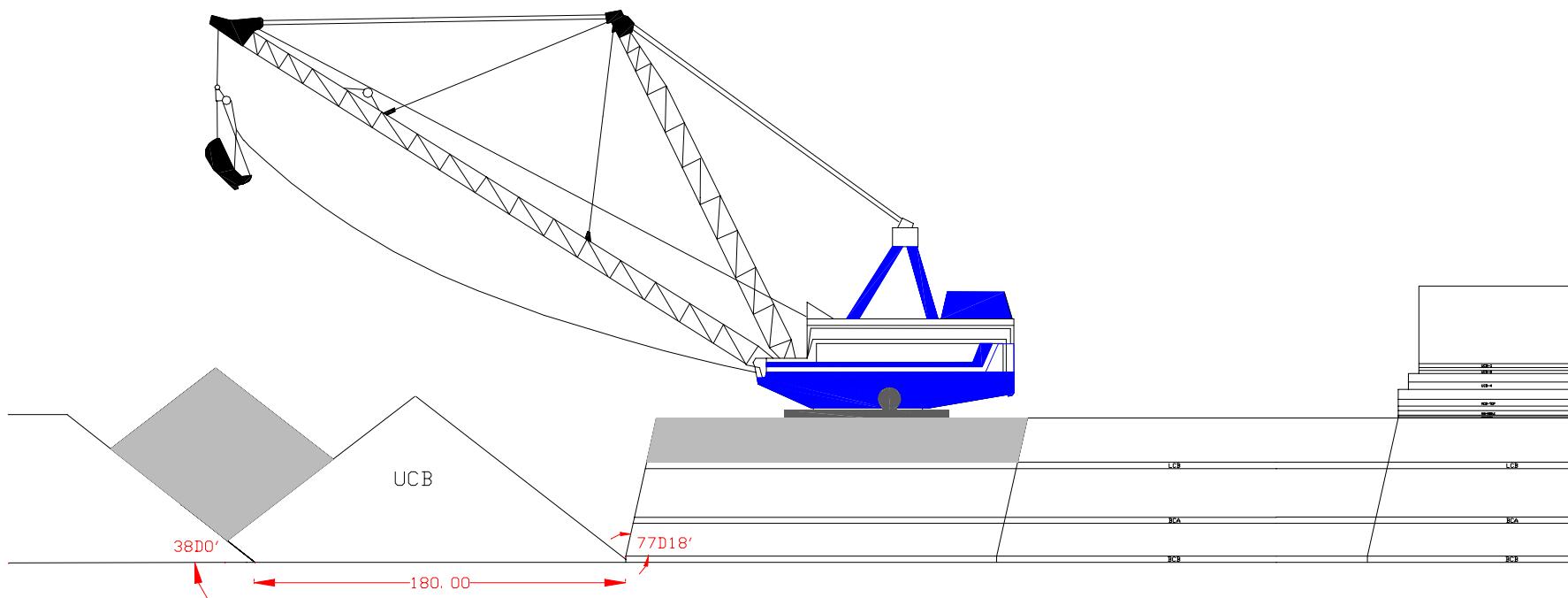
Typical Multi-Seam Dragline Sequence '1'



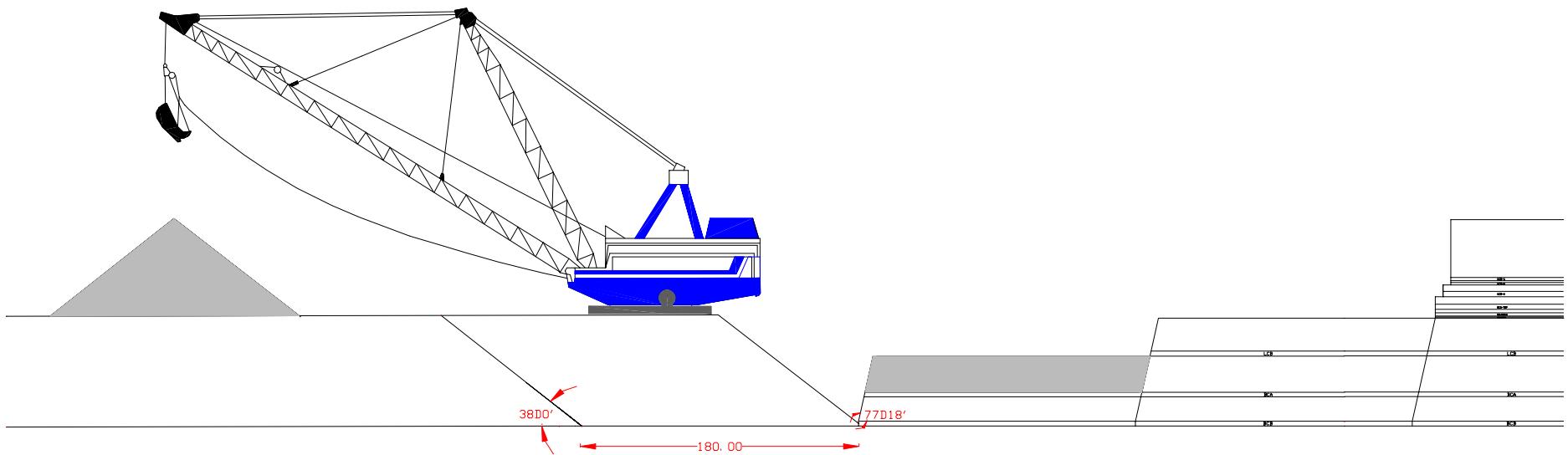
Typical Multi-Seam Dragline Sequence '2'



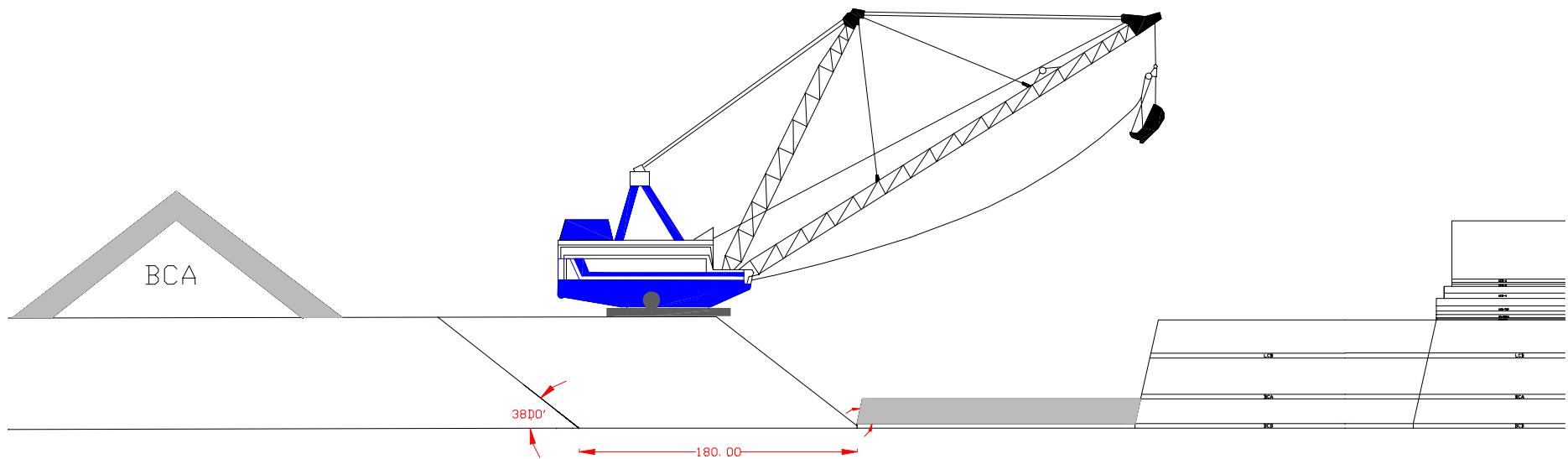
Typical Multi-Seam Dragline Sequence '3'



Typical Multi-Seam Dragline Sequence '4'



Typical Multi-Seam Dragline Sequence ‘5’



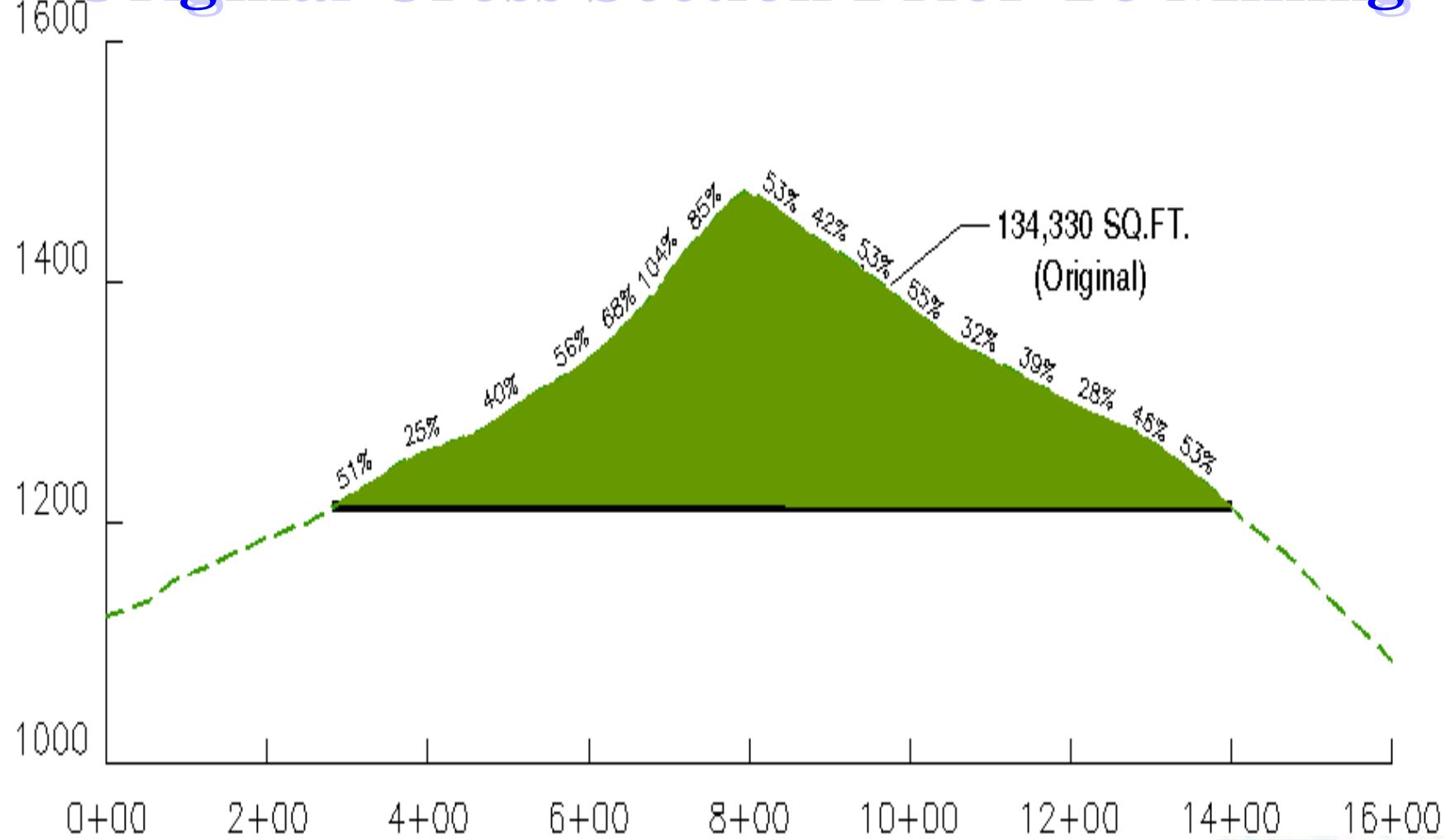
During Mining



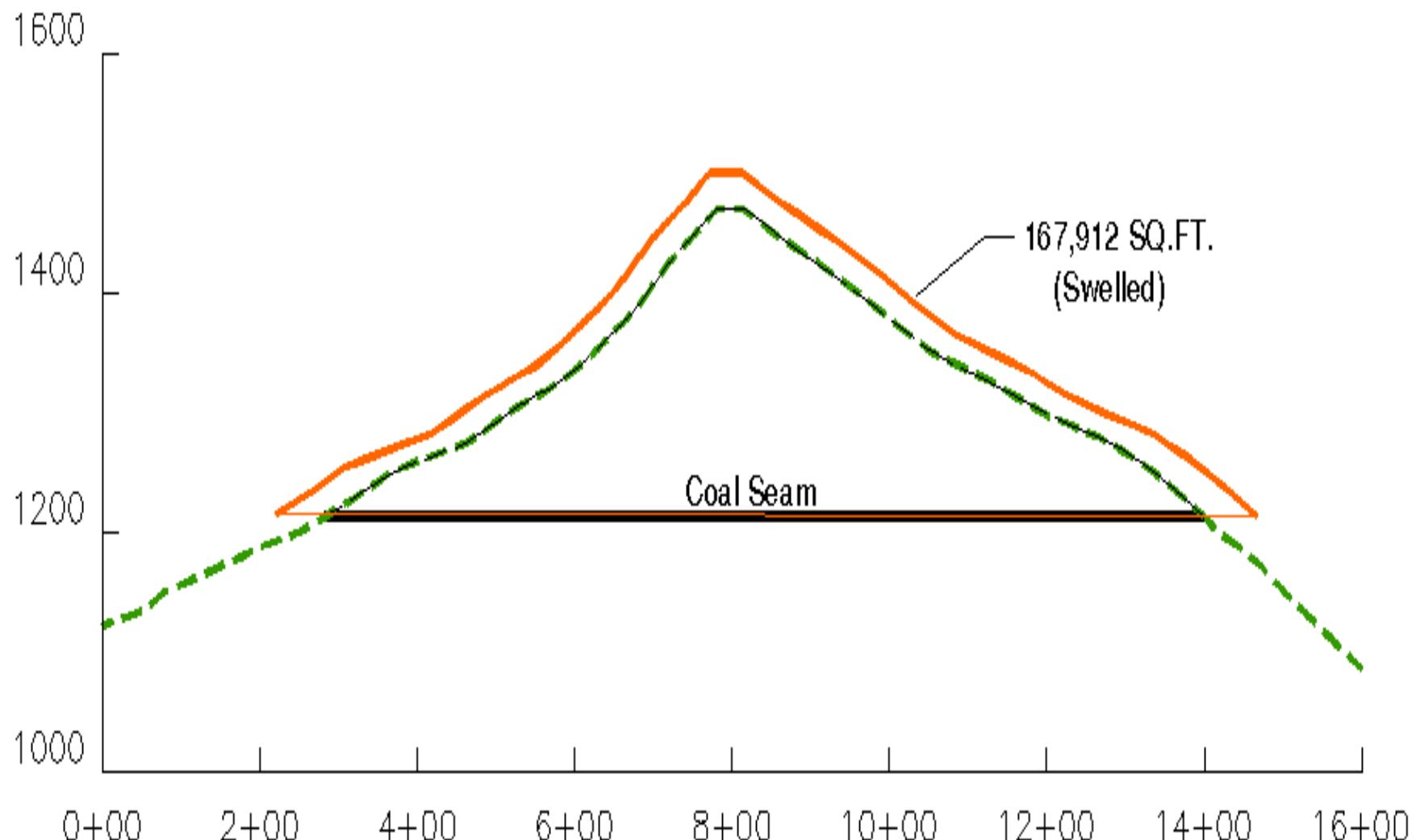
After Mining (1+ yrs. reclamation)



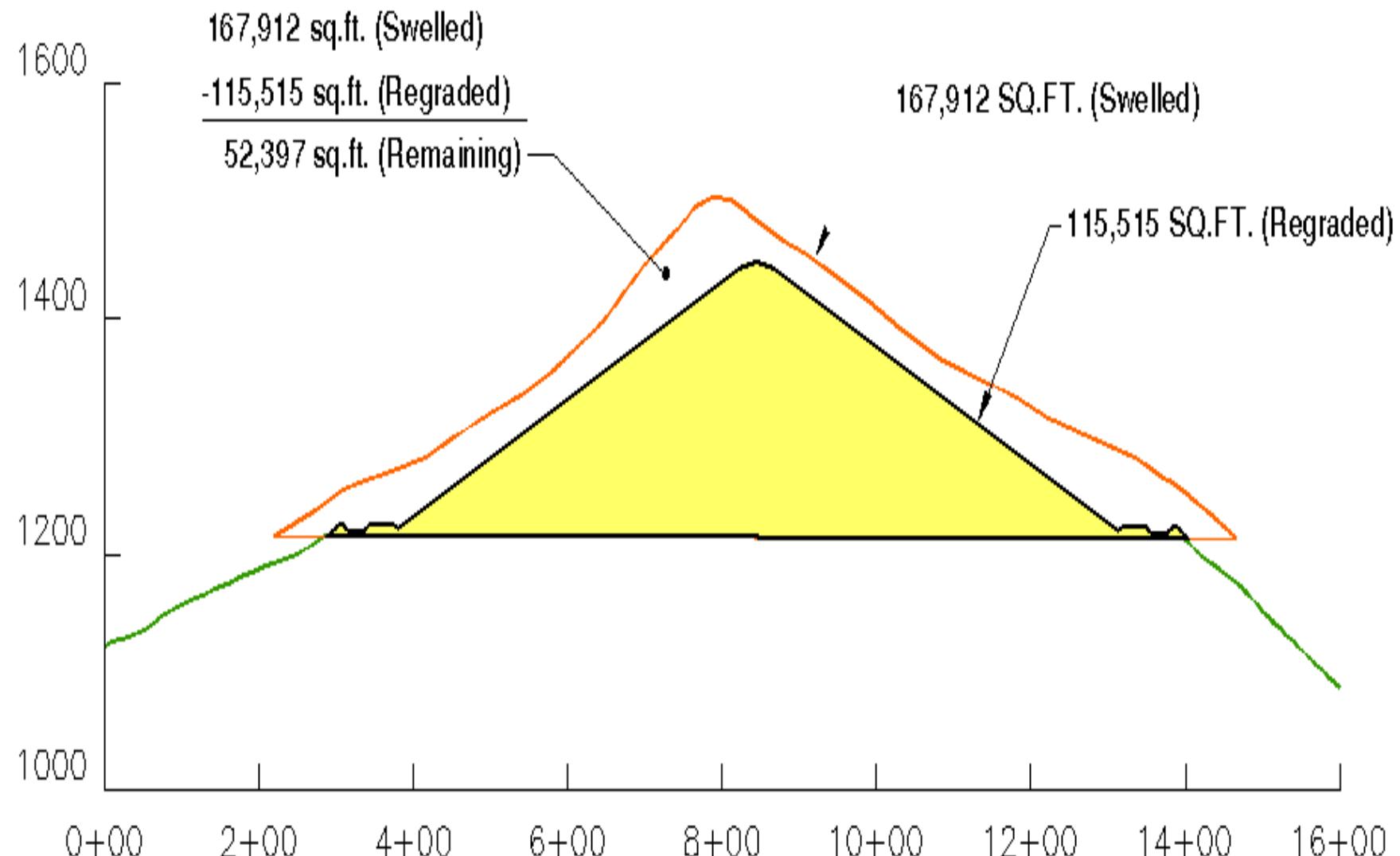
Concept of Excess Spoil Original Cross Section Prior To Mining



Original Material Swelled 125%



Regraded Cross Section After Reclamation

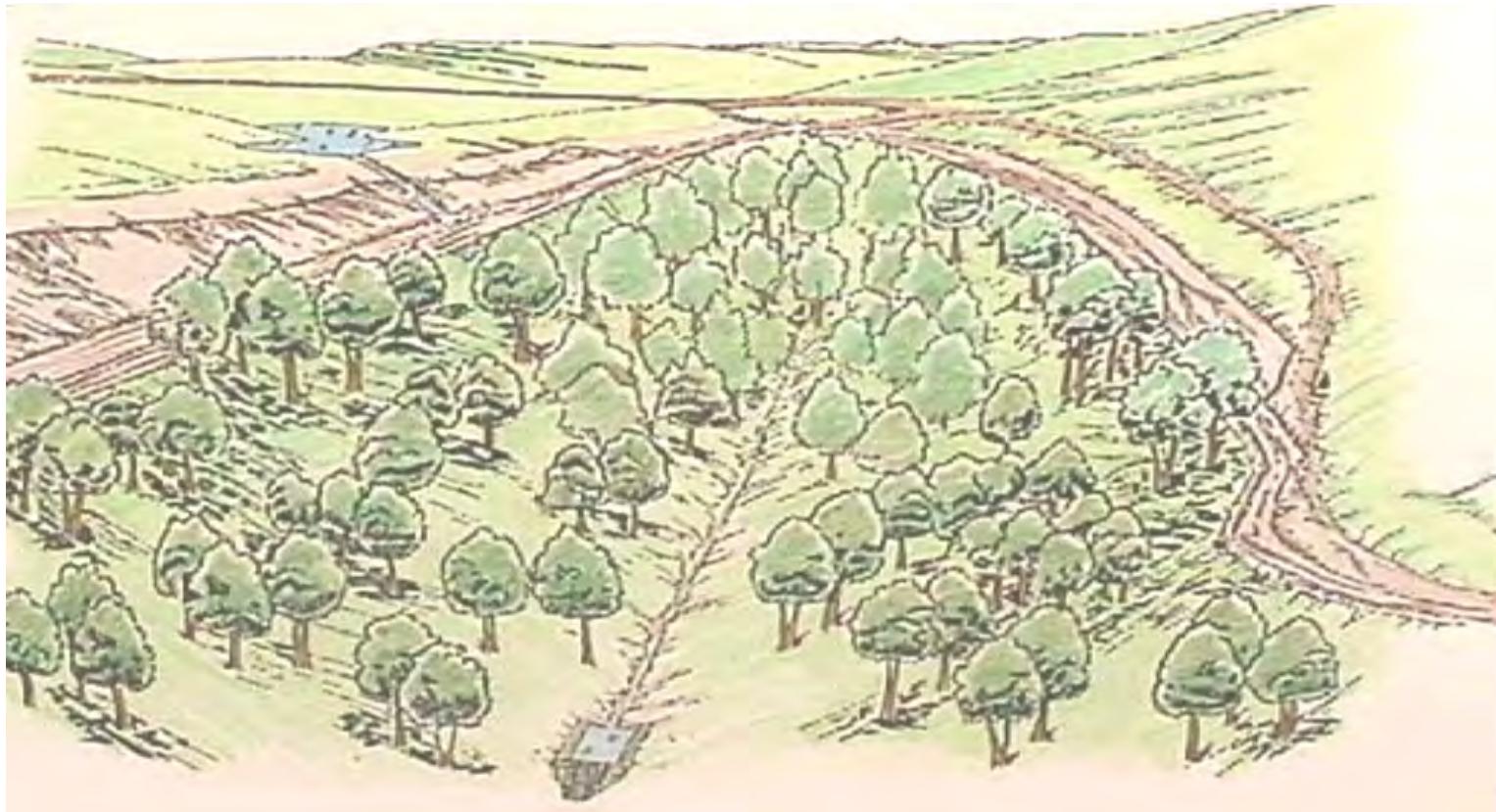


Concept of Excess Spoil Disposal Alternatives

- ✓ Two primary disposal alternatives:
 - 1 - Valley Fill (usually durable rock construction)
 - 2 - Backfill on mined-out area

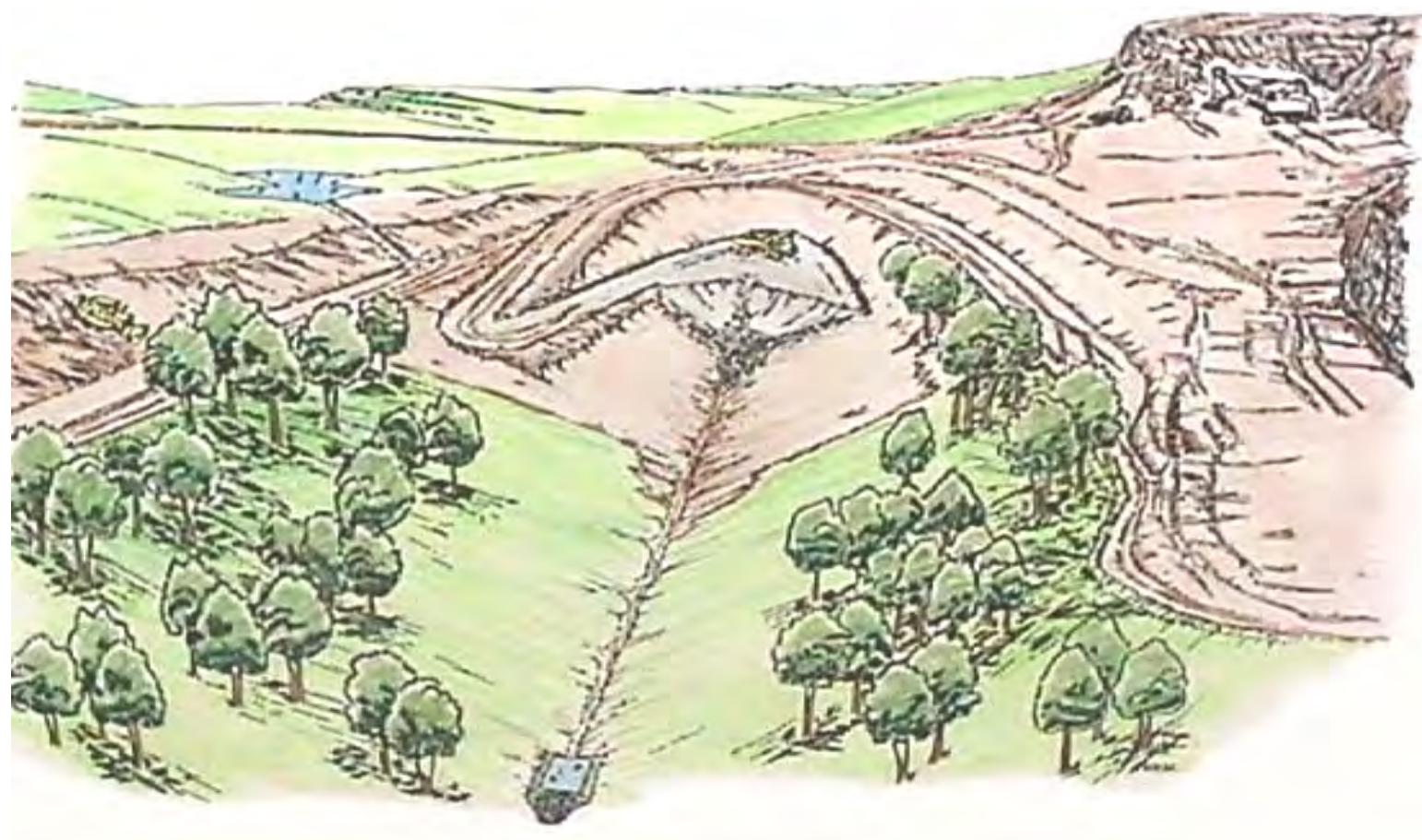


Durable Rock Valley Fill Construction



Phase 1
Sediment Pond Construction

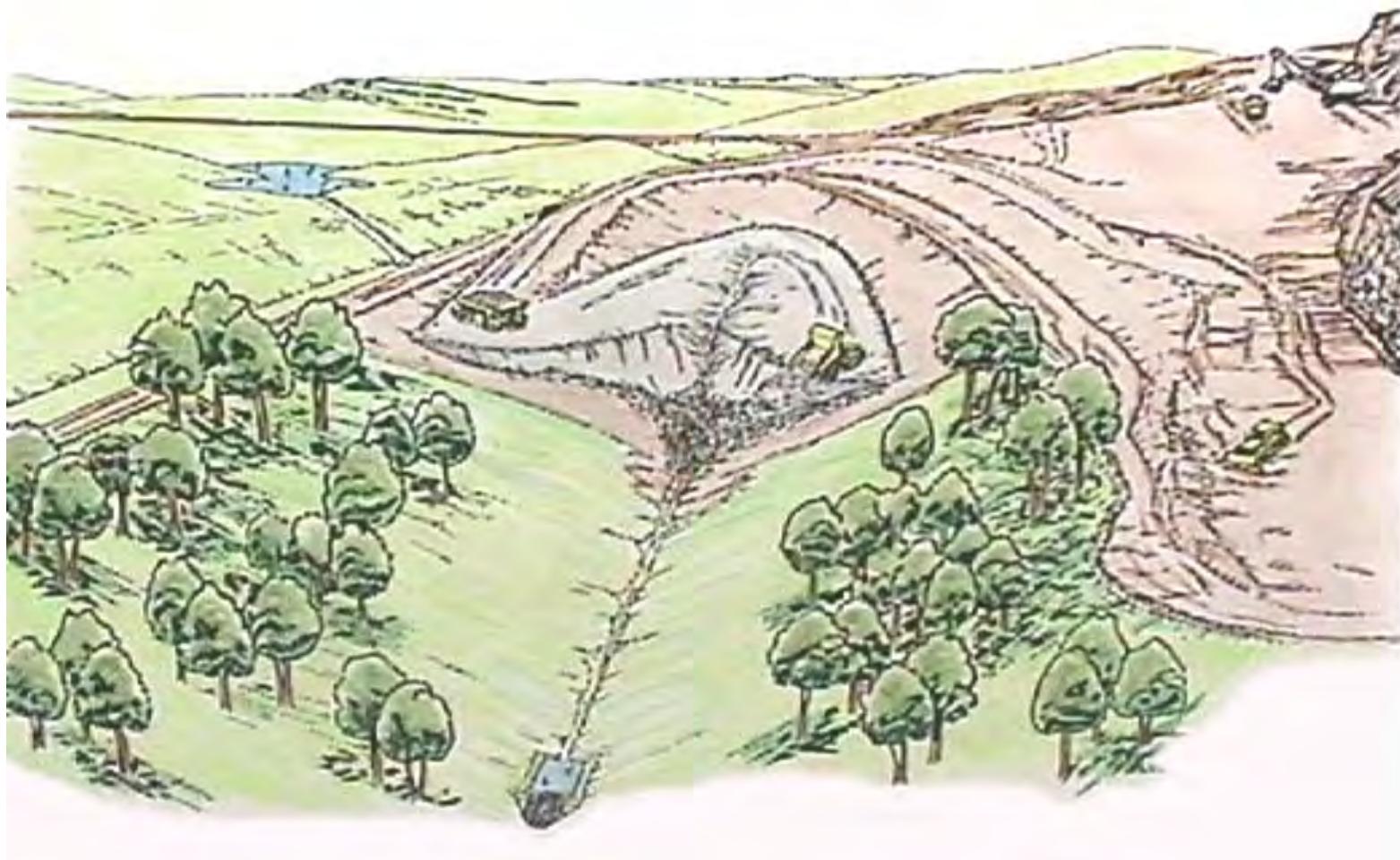




Phase 2

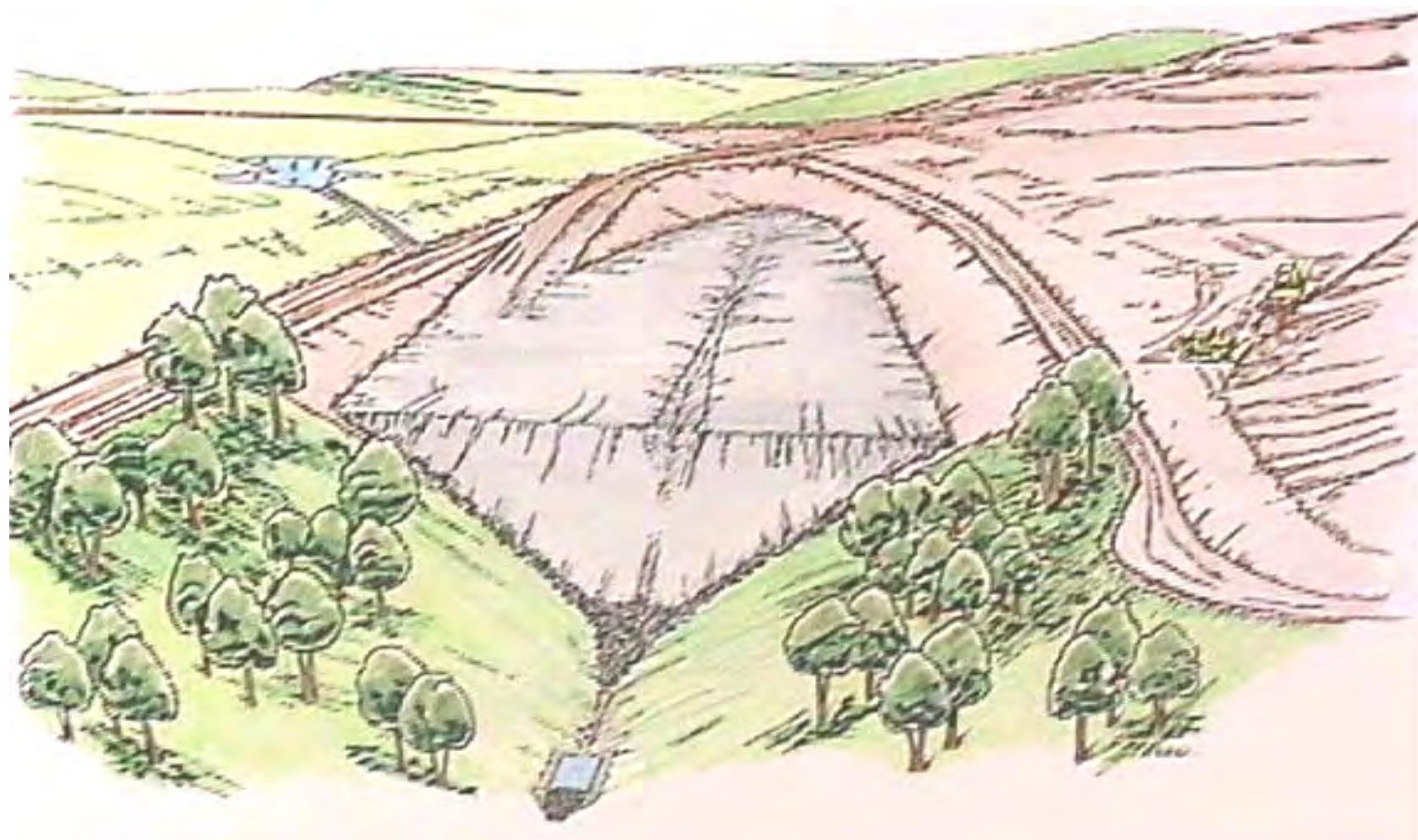
Initial Overburden Placement





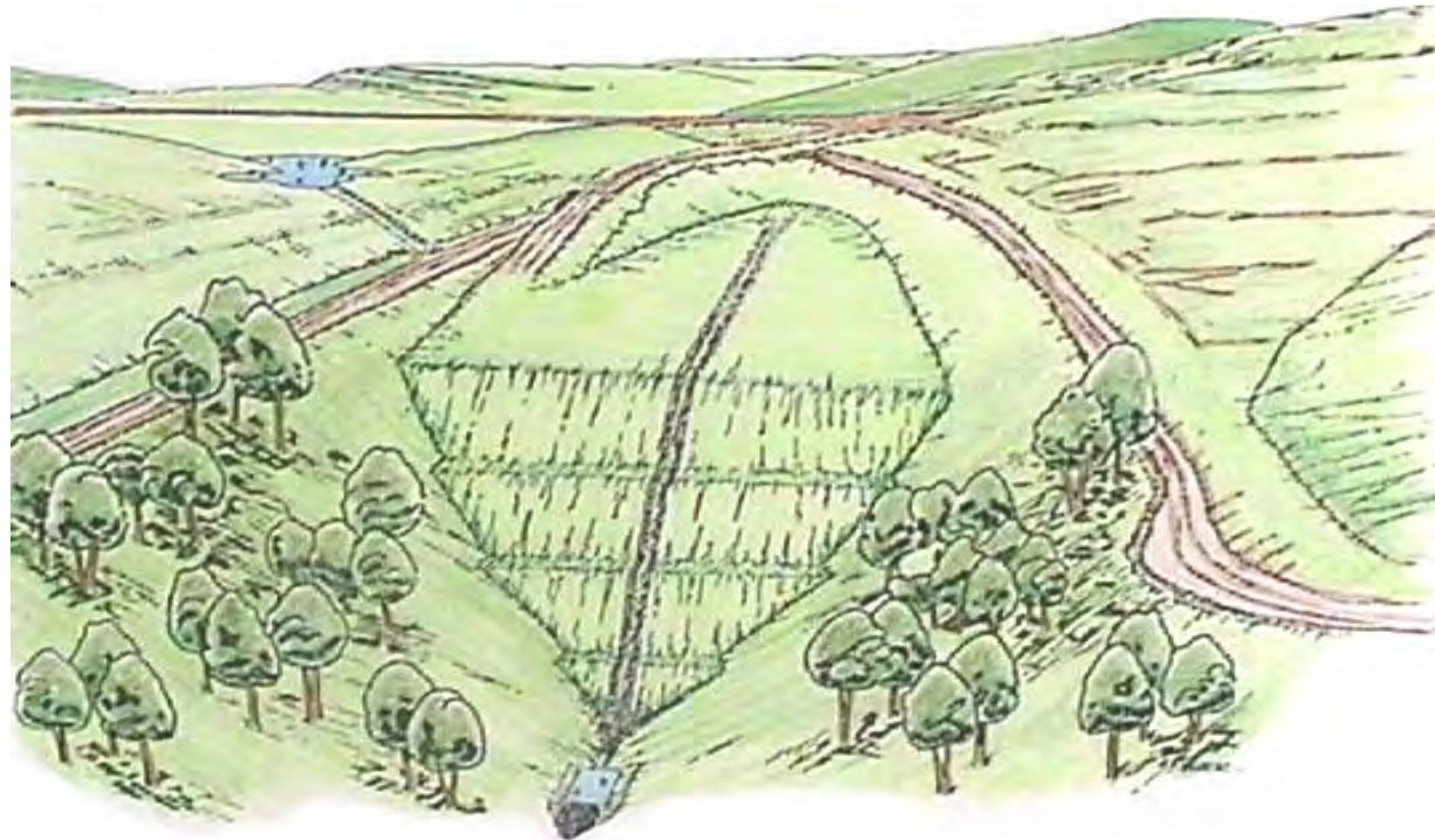
Phase 3 Continued Overburden Placement





Phase 4
Overburden Placement Completed
Surface Drainage Conveyances Constructed





Phase 5
Regrading / Revegetation Completed











Backfilling Operations



Drilling & Blasting Operations





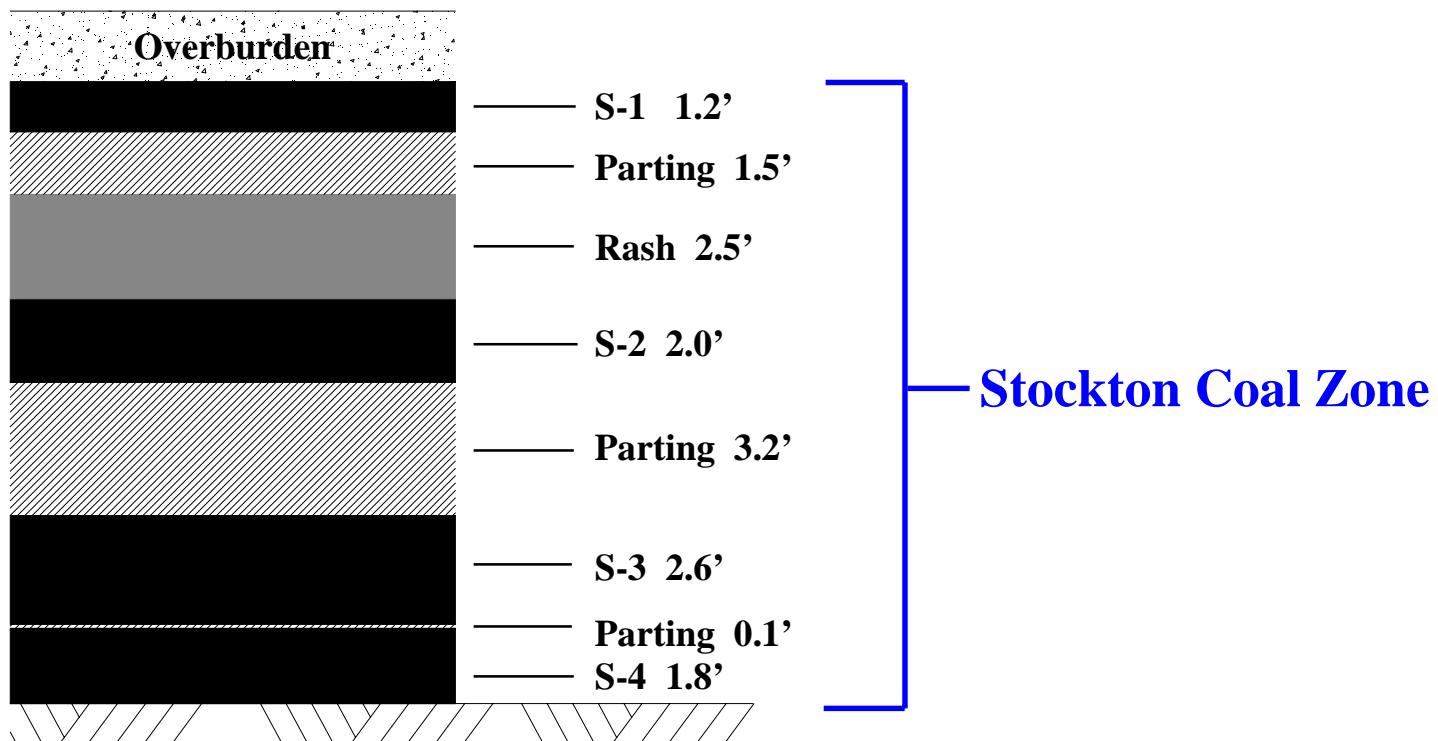


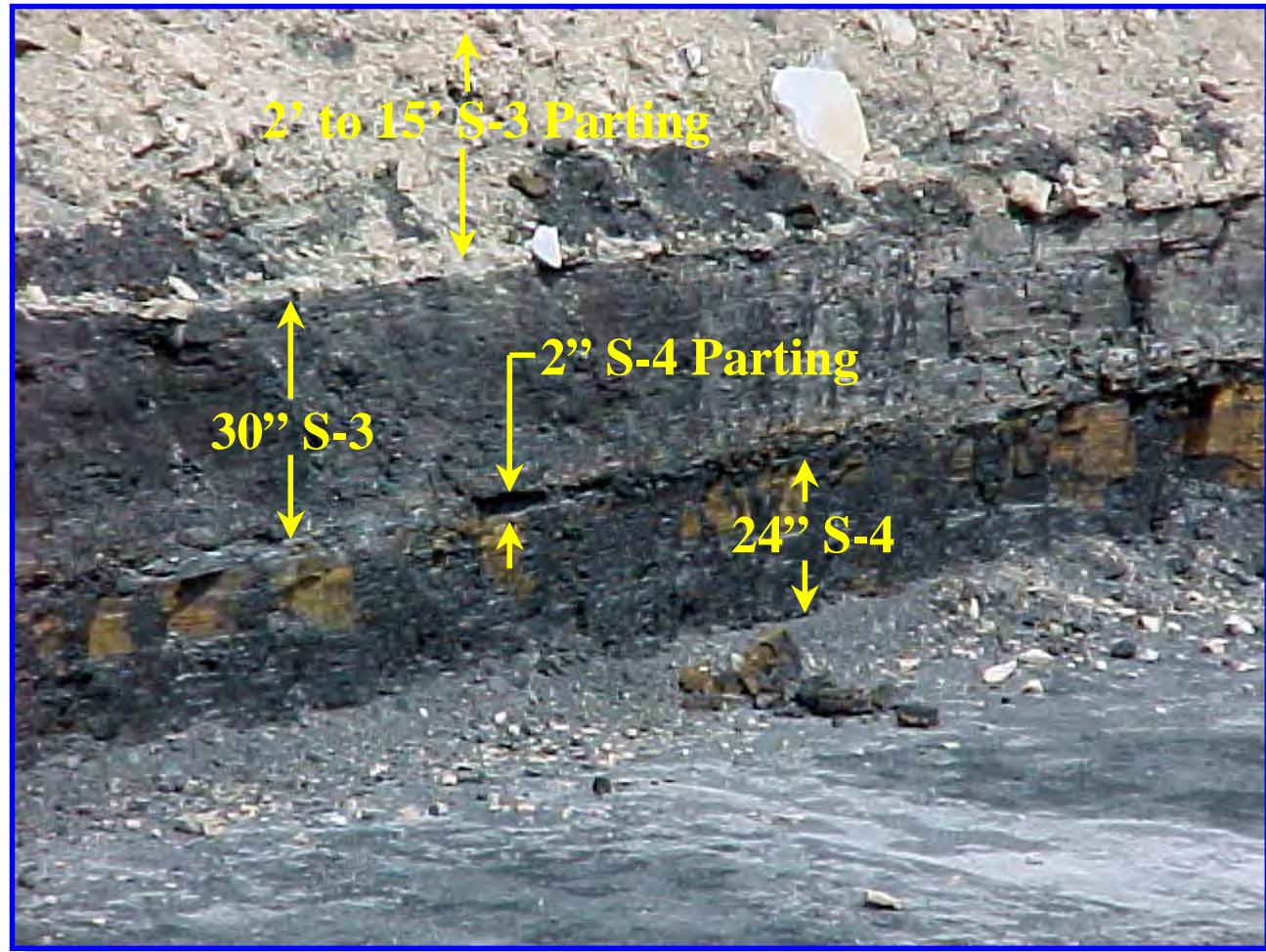
Coal Loading Operations





Typical Cross Section Stockton Coal Zone

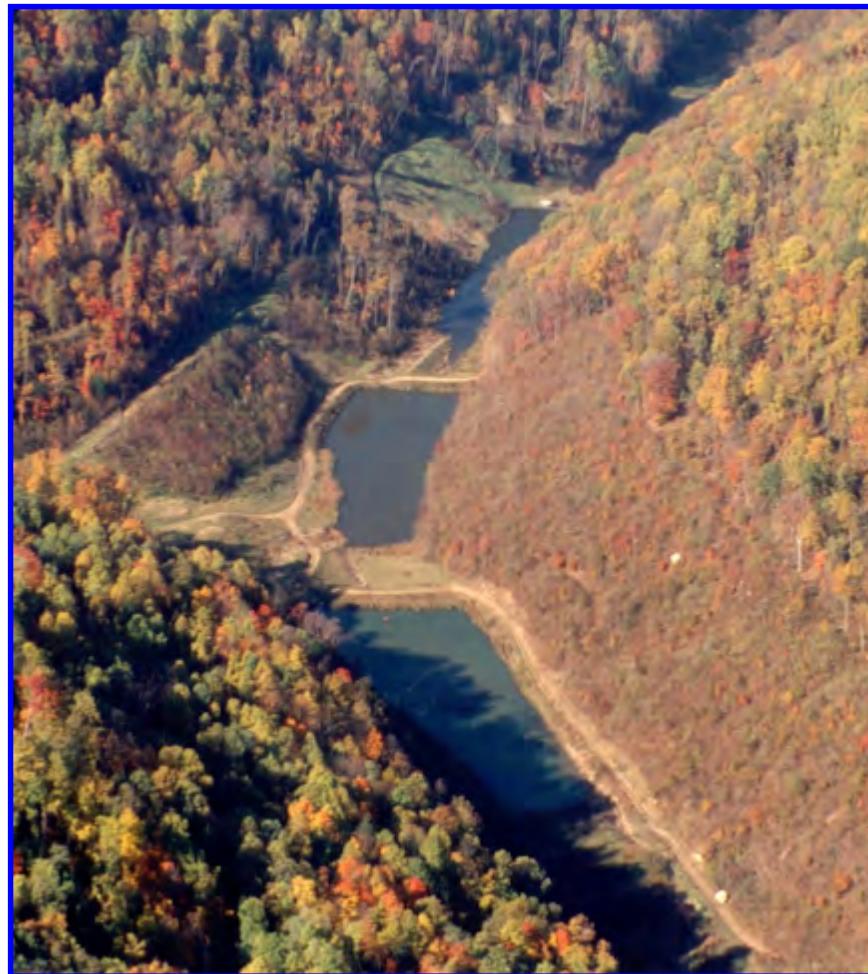




Environmental Considerations



Establishment of Drainage and Sedimentation Controls





Approximate Original Contour



Other...

✓ **Waste Management Plan**
Ground Water Protection Plan
Spill Prevention Control &
Countermeasure Plan



Fixing the Scars of the Past

- “Third Generation” Surface Mining

- ✓ Restoration of abandoned refuse sites eligible for AML funding at no cost to the state
- ✓ Creation of wetlands and passive water treatment sites
- ✓ Elimination of miles of pre-SMCRA highwalls
- ✓ Extinguishment or isolation of abandoned underground mine fires



Pre-SMCRA Highwalls and Deep Mine Entries





Abandoned Coal Refuse Dumps





Acid Mine Drainage



Reclaimed Pre-law Refuse Sites



Wetlands Construction



Related Benefits

- ✓ Resource recovery
- ✓ Can address prior environmental problems
- ✓ Provides opportunities for future use of resource due to infrastructure development



Russian Dragline - Circa 1998



Mining Technology

From Perception to Procedures



MORGAN WORLDWIDE
MINING CONSULTANTS

Introduction



- What is typical environmentalist
 - Target Practice
- Reason for presentation
 - To make sure that environmental issues are included in thought process
 - Environmental awareness not permit compliance
 - No NOVs does not a perfect mine make
- Right of mining
 - Legal land use
 - Critical part of economy and vital commodity

Why Opposition?



- Helplessness
- Feelings of Impotence
- Excluded from Process
- Dislike of change
- Fundamental beliefs

Participants in Process



- Stakeholders
 - Company
 - Industry Groups
 - Industry attorneys
 - Shareholder
 - Landowner
 - Mineral Owner
 - Employees
 - Customer
 - Regulator
 - Community
 - Environment

Industry Character



- Character of industry changing
 - Consolidation of industry
 - Less local involvement
 - Managers are mobile
 - Foreign ownership
- 1998 W.Va Tonnage 160 million tons
- Approx W.Va Value \$3.2 bn

Capability of Industry



- Access to capital
- Capability of constructing almost any configuration
- Very efficient movers of rock
- Ongoing operations and therefore momentum
- Complacency of acceptability of historic approach
- Focus on efficiency

Environmental / Citizen Character



- National issues / groups
- Political groups i.e. Green Party in Germany
- Presidential / National politics
- Local residents
- Troublemaking attorneys

Regulators

- Federal
 - U.S. EPA
 - U.S. Army Corps of Engineers
 - U.S. Fish and Wildlife
 - U.S. OSM
- State
 - WV DEP

Effects of Mining



- Mining is a short-term land use
 - Effects are both short-term and long term
 - Short term effects
 - On site
 - Removal of vegetation
 - Aesthetics
 - Hydrology

Effects (Cont.)

- Off site
 - Blasting
 - Noise
 - Dust
 - Visual
 - Traffic
 - Flow rates in streams
 - Water quality changes

Effects (Cont.)

- Long term effects
 - Change in topography
 - Filling of valleys
 - Changing grade and elevation of hillsides
 - Change in drainage patterns
 - Revised aesthetics
 - Vegetation

Key Issues



- Short Term Effect Mitigation
- AOC
- AOC Variances and Post Mining Land Use
- Minimizing Disturbed Area

Minimizing Disturbed Area

- Recognize volume is needed for excess spoil
- Objective to reduce area disturbed outside mineral extraction area
- Have rational approach to determining optimum
- Use previously disturbed areas first

Approach

- Calculate Excess Spoil (AOC Model)
- Select valleys for fill consideration
- Calculate equal increments of capacity moving down valley
- End calculation at logical toe
- Have top surface above elevation of primary mining horizon
- Select optimum capacity to meet excess spoil

Approach (Cont.)

- Use area calculated from optimization as “disturbed area bank” in acres
- Add accepted acreage to reflect sub optimum
- Allow operator to apply bank to whichever valleys they want, in whatever order
- Any Amendment or adjacent permit has to be similarly optimized
- Variances always have an associated change in disturbed area from optimum

FETC Coal Briefing
June 23, 1999

Overview:

Introductory Comments

Thank you for the invitation to speak here today. We at EIA appreciate the opportunity to learn more about the activities of our fellow agencies and our customers and to see how our information and forecasting products and services can contribute to their planning.

I will be discussing , initially, EIA's [Annual Energy Outlook](#), with particular emphasis on coal and the market trends that will affect the time period through 2020. Then, I will cover a report that examines the potential impacts of the Kyoto Protocol.

The goal is to provide a mid-term framework for examining the some of the issues confronting the coal industry that will be discussed during this symposium.

Quick Overview of EIA and the AEO

EIA is the independent data collection and analysis arm of the DOE--it currently has approximately 370 FTE

The projections in the [Outlook](#) are based on the National Energy Modeling System--NEMS, a large-scale integrated energy model that EIA developed in the 1992-1993 period. Each year the model is updated with the latest data and modified as necessary to examine emerging issues.

NEMS provides detailed projections of energy supply, demand, and prices of all major energy sources through 2020. Its integrated structure permits the development of baseline and scenario forecasts that are can be used to examine the impacts of government policy on a wide-range of issues.

- The AEO99 reference case is based on data as of July 31, 1998 and assumes, for baseline purposes, that Federal, State, and local laws and regulations that were in effect at that time will remain unchanged through 2020.

It does not attempt to anticipate the nature or approval of future policy or legislative initiatives. As such, the Kyoto Protocol targets have not been included in the reference case forecasts. However, in the second section of this presentation, I will provide some model results regarding the range of possible impacts.

AEO & Short-Term Issues

- The AEO focuses on the mid-term--through 2020. As such, events of a more short-term nature such as weather, natural disasters, strikes, and facility outages are not factored into our trend projections. EIA short-term forecasts would change, but such events do not influence our view of the mid-term.

Oil Prices-Three Cases

World oil prices are projected to rise gradually from current levels \$22.73 per barrel in constant 1997 dollars. Non-OPEC production gains and improved exploration and drilling technology are keeping costs in check despite rising global demand.

Oil prices have been particularly volatile over the last 2 years -- the low prices in 1998 were the result of abundant supply and weak worldwide demand.

If we convert the reference case projection to current or nominal dollars (See Inset Graph)--the price per barrel rises to \$43.30 in 2020.

The AEO includes high and low oil price cases that reflect uncertainties regarding future levels of OPEC production. Prices range from \$14.57 to \$29.35 in 2020.

Natural Gas Prices

Prices at the wellhead grow at a rate of 0.8 percent annually.

The wellhead price in 2020 is \$2.68 per MCF in 1997 dollars.

The moderate price growth coupled with lower capital costs, strong gains in generating efficiency, and certain environmental advantages have made natural gas a formidable competitor to coal for use in electric generation. In fact, natural gas consumption for electricity generation grows at a rate of 4.5 percent annually.

Before discussing our coal forecast, I would like to review the major trends and uncertainties in electricity markets ---the primary customer for coal.

Electricity Generation by Fuel (Figure 74)

- Coal-fired power plants are expected to remain the dominant source of electricity through 2020-- but to decrease in overall share of total generation from 53 percent to 49 percent in 2020.
- In percentage terms, natural gas generation increases the most, from 14 percent of the total to 33 percent in 2020, overtaking nuclear generation by 2003..
- Nuclear generation is projected to increase until 2000 and then decline as older units are retired.
- Electricity sales grow at 1.4 percent annually, compared to a 2.1 percent growth rate for the gross domestic product.

Electricity Generation and Cogeneration Capacity Additions (Figure 69)

- Over 1200 new plants, with an average capacity of 300 megawatts, are projected to be built by 2020, to meet demand growth and to offset retirements of old units.
- 88 percent of the new capacity is projected to be combined-cycle or combustion turbine technology fueled by natural gas or both oil and gas.

Electricity Generation Costs (Figure 72)

- Technology choice decisions for new generating capacity are made to minimize leveled costs while meeting local and Federal emissions constraints.
- In head to head competition for new capacity, highly-efficient advanced combined-cycle plants have lower leveled generation costs than new, conventional coal plants, despite a higher fuel cost component..
- The capital and O&M cost component for combined-cycle plants is one-third that for coal-fired plants.
- In 2020, new combined-cycle plants have leveled costs of generation that are 6 mills (6-tenths of a cent) lower than new coal-fired plants.

New Legislation Reduces NOx Emissions from Powerplants

- AEO99 includes the impacts of legislation for the control of NOx by electric generators, including the second phase of the Clean Air Act Amendments of 1990 and the Ozone Transport Rule, scheduled for the 2003 summer season--(May 1 through September 30).

SIP Call NOx Control Costs

- The compliance technologies available include combustion controls (including low-NOx burners), selective noncatalytic reduction, and selective catalytic reduction. Co-firing a coal plant with natural gas is also an option.
- The capital investment for these control technologies is expected to total about \$8 billion.
- The total annualized cost for the technologies, including operating costs, is \$2 billion.

SIP Call NOx Control Costs Relative to Sales Revenue

- The total annualized costs for NOx controls (bottom line of the graph)-are relatively small compared to annual revenue from electricity sales (which exceed \$200 billion) -- less than 1 percent.

Electricity Price Projections: AEO99 - Fig 1A

- Real electricity prices (all sectors average) are projected to decline 0.9 percent a year between 1997 and 2020, from 6.9 cents per kilowatthour to 5.6 cents a kilowatthour.
- The projections reflect the ongoing restructuring of the electricity industry to a competitive wholesale market. The following regions are assumed to have competitive retail pricing: the Mid-Atlantic Council (Pennsylvania, Delaware, New Jersey, and Maryland), the Mid-America Interconnected Network, California, New York, and New England.
- As of April 1999, 21 states had enacted legislation or promulgated regulations establishing retail competition programs. Most of the remaining states have the matter under active consideration.

Coal Consumption for Electricity and Other Uses: AEO99 - Fig 114

- Domestic coal demand rises by 245 million tons in the forecast, from 1030 million tons in 1997 to 1275 million tons in 2020.
- Throughout the forecast, electricity generation accounts for approximately 90 percent of domestic coal demand.
- The growth in coal consumption for electricity generation is the result of higher utilization of existing equipment (rising from 67 to 79 percent) and additions of new capacity in later years -- 32 gigawatts of new capacity .

Non-Electricity Coal Consumption: AEO99 - Fig 115

- An increase of 12 million tons in industrial steam coal consumption is offset by a 9 million ton reduction in coking coal consumption.
- Increases in steam coal consumption are primarily in the chemical and food-processing industry, as well as cogeneration.
- Coking coal consumption declines as a result increased use of electric arc furnaces, process efficiencies, and increased imports of semi-finished steels.

U.S. Coal Exports: AEO99 - Fig 116

- U.S. coal exports rise slowly in the forecast from 84 million tons in 1997 to 93 million in 2020, as a result of higher demand for steam coal imports in Europe and Asia. U.S. exports of metallurgical coal in 2020 are 3 million tons lower than the 1997 level.
- The recent worldwide financial crisis has introduced some changes in international markets, affecting trade patterns and prices. In international markets, coal prices are negotiated in U.S. dollars. Currency devaluations against the U.S. dollar and contracting markets have placed strong downward pressures on U.S. sales. Australia and South Africa have lowered prices substantially in key markets.

Coal Production by Region: AEO99 - Fig 107

- Total coal production grows at a rate of 0.9 percent, reaching 1358 MMT in 2020.
- The western share of coal production is growing steadily and will soon exceed that mined east of the Mississippi River. The reference case projects that this share will increase to approximately 57 percent in 2020.

- Production of low cost, low-sulfur subbituminous coal from the Powder River Basin is projected to grow at an annual rate of 2.5 percent annually, compared to a national growth rate of 0.9 percent.

Coal Distribution by Sulfur Content: AEO99 - Fig 117

- Phase 2 of the Clean Air Act Amendments, which begins in 2000, tightens annual sulfur dioxide emissions limits on large, higher emitting plants and also set restrictions on smaller, cleaner plants.
- Low sulfur coal is projected to increase gradually in market share from 40 percent in 1997 to 51 percent in 2020. (Low sulfur coal produces less than 1.2 pounds of SO₂ per MMBtu).

Coal Minemouth Prices: AEO99 - Fig 108

- Minemouth coal prices are projected to decline by \$5.40 per ton in constant 1997 dollars, from \$18.14 per ton in 1997 to \$12.74 per ton in 2020. This decline reflects a continuation in productivity improvements over the forecast period as well as a continuing shift to the lower priced, low Btu coal of the Powder River Basin.
- Over the forecast period, assumptions regarding productivity growth account for approximately 60 percent of the projected price decline, while regional shifts in production account for the remaining 40 percent.

Labor Productivity by Region: AEO99 - Fig 109

Historical Trend

- Measured in tons per miner hour, U.S. coal mining productivity has risen continuously since 1977, increasing at an average rate of 6.2 percent per year. On average, each U.S. coal miner produced more than three times as much coal per hour in 1997 as in 1977. On the positive side, these gains have allowed coal to remain competitive with other fuels over the period, despite increasing environmental costs at coal-fired power plants.
- On the other hand, employment in the U.S. coal industry has plummeted, declining from 225 thousand miners in 1977 to 81.5 thousand miners in 1997.

Forecast Period

- Over the forecast period, labor productivity improvements are assumed to continue, but to decline in magnitude. This is based on the expectation that further penetration of

productive mining technologies such as longwall units at underground mines and large capacity surface mining equipment at surface mines will gradually level off.

- In the *AEO99* reference case, labor productivity rises at an average rate of 2.3 percent per year over the forecast period. By region, productivity rises at a slightly faster pace West of the Mississippi River, reflecting further concentration of western production in the Powder River Basin (PRB). In 1997, the average productivity for PRB mines was approximately 35 tons per miner hour. This compares with an average of 6.04 tons per miner hour for all U.S. coal mines.

(Note to speaker--the average value shown is correct. It is heavily influenced by the substantially greater number of hours required for eastern coal production.)

Labor Cost Component of Minemouth Prices: AEO99- Fig 110

- The contribution of wages to minemouth coal prices fell from 31 percent in 1970 to 17 percent in 1997, and is projected to decline to 15 percent by 2020.
- Improvements in labor productivity have been, and are expected to remain, the key to lower mining costs.

Average Minemouth Coal Prices in 3 Mining Cost Cases: AEO99 - Fig 111

- Two alternative **Mining Cost Cases** were run to show how minemouth coal prices and regional coal distribution patterns vary with changes in mining costs.
- In the *AEO99* reference case projections, productivity increases by 2.3 percent a year through 2020, while wage rates are constant in 1997 dollars. The national minemouth coal price declines by 1.5 percent a year to \$12.74 per ton in 2020.
- In the low mining cost case, productivity increases by 3.8 percent a year, and real wages decline by 0.5 percent a year. The average minemouth price falls by 2.4 percent a year to \$10.42 per ton in 2020. Eastern coal production is 17 million tons higher in the low case than in the reference case in 2020, reflecting the higher labor intensity of mining in eastern coalfields.
- In the high mining cost case, productivity increases by 1.2 percent a year, and real wages increase by 0.5 percent a year. The average minemouth price of coal falls by 0.8 percent a year to \$14.94 per ton in 2020 (17.3 percent higher than in the reference case). Eastern production in 2020 is 52 million tons lower in the high labor cost case than in the reference case.

Carbon Emissions by Fuel: AEO99 - Fig 120

- Petroleum products are the leading source of carbon emissions from energy use. In 2020, petroleum accounts for 42 percent of the total 1,975 million metric tons of carbon emissions in the reference case. About 81 percent of this amount (from petroleum) results from transportation use.
- Coal is the second leading source of carbon emissions, accounting for 34 percent. Most of the increase in coal emissions originates from electricity generation.
- Of the fossil fuels, natural gas consumption and emissions increase most rapidly through 2020, at average annual rates of 1.7 percent.
- The use of renewable fuels and nuclear generation, which emit little or no carbon, mitigates the growth of emissions.

Carbon Emissions from Electricity by Fuel: AEO99 - Fig 121

- Although electricity produces no carbon emissions at the point of use, electricity generation currently accounts for 36 percent of total carbon emissions.
- Retirements of nuclear capacity will result in a 43 percent decline in nuclear generation.
- To compensate for the loss of nuclear capacity and to meet rising demand, generation from fossil fuels will raise electricity related carbon emissions by 213 million metric tons, or 40 percent from 1997 levels
- Coal, which accounts for about 52 percent of generation in 2020 (excluding cogeneration), produces 81 percent of electricity-related carbon emissions.
- In 2020, natural gas accounts for 30 percent of electricity generation but only 18 percent of electricity-related carbon emissions. Per unit of generation, natural gas produces only half the carbon emissions of coal.

Carbon Emissions in 3 Macro Cases: AEO99 Data

- To reflect the uncertainty in forecasts of economic growth, AEO99 includes high and low economic cases in addition to the reference case. The cases incorporate different growth rates for population, labor force, and labor productivity.
- GDP increases at an annual rate of 2.6 percent in the high growth case, 2.1 percent in the reference case, and 1.5 percent in the low growth case.

- In the reference case, carbon emissions increase at a rate of 1.3 percent annually. Carbon emissions respond to the different rates of economic growth and result in a spread of 300 million metric tons by 2020--approximately 150 above and below the reference case projection of 1975 million metric tons.

U.S Coal Production in 3 Macro Cases

- The strong correlation between economic growth and electricity use accounts for the variation in coal demand across the economic growth cases.
- The difference in coal production between the two economic growth cases in 2020 is 166 million tons, with coal use for generation accounting for 144 million tons.

Carbon Emissions in 3 Tech Cases: AEO99- Fig 32

- The AEO99 reference case includes continued improvements in technology for both energy consumption and production.
- As a result of continued improvements in the efficiency of end-use and electricity generation, total energy intensity in the reference case declines at an average annual rate of 1 percent between 1997 and 2020.
- We ran two sensitivity cases to examine the effects of different assumptions regarding the rate of technological improvement.
- The low tech case assumes that all future equipment choices are from the equipment and vehicles available in 1999. New generating technologies are assumed not to improve over time. Aggregate efficiencies still improve over the forecast period as new equipment is chosen to replace older stock and the capital stock expands.
- The high tech case incorporates a set of technological assumptions developed in consultation with experts in technology engineering, including higher efficiencies, more rapid market penetration, and lower costs.
- In contrast to the 1 percent rate of energy intensity decline in the reference case, there is a decline of 0.8 percent in the low tech case and 1.3 percent in the high tech case.
- The lower energy consumption in the high tech case lowers carbon emissions from 1975 million metric tons to 1848 million metric tons in 2020. In the 1999 technology case, emissions increase to 2105 million metric tons.

- To achieve greater reductions in energy consumption or carbon emissions, it is likely that either market policies (for example higher energy prices) or non-market policies (for example, new standards) may be required.

Carbon Emissions (7 Cases): Kyoto Report- Figure ES1

- The Kyoto Protocol, which was negotiated in late 1997 to address concerns about climate change, calls for developed nations to reduce greenhouse gas emissions relative to 1990 levels.
- In 1998, at the request of the Committee on Science of the U.S. House of Representatives, the EIA analyzed the Kyoto Protocol, focusing on U.S. energy use and prices and the economy in the 2008-2012 time frame. The NEMS model provided the modeling platform that was used to develop the results.
- The analysis included a reference case (similar to the AEO98 reference case) and 6 cases that represent a range of emission reduction targets that could result under different assumptions regarding emissions trading and the accounting for sinks related to agriculture, forestry, and land use.
- Each case was analyzed to estimate the energy and economic impacts of achieving an assumed level of reductions relative to the 1990 level.
- In each of the carbon reduction cases, the target is achieved on average for each of the years in the first commitment period, 2008 through 2012.
- The reference case carbon emissions level is 1791 in 2010; whereas the (1990 -7 percent) averages 1250 million metric tons in the commitment period, or 96 million metric tons less than 1990 and 542 million metric tons than the reference case.

Carbon Prices (7 Cases) : Kyoto Report - Figure ES2

- There are three ways to reduce energy-related carbon emissions: reduce demand for energy services, adopt more energy-efficient equipment, and switch to less carbon-intensive or noncarbon fuels.
- To reduce emissions, a carbon price is applied to the cost of energy.
- The carbon price is applied to each of the energy fuels relative to its carbon content at the point of consumption.

- The carbon prices projected to be necessary to achieve the carbon reduction targets range from \$67 per metric ton (\$1996) in the 1990 + 24 percent case to \$348 per metric tons in the 1990 minus 7 percent case.
- Delivered coal prices are affected more by carbon prices than other fuel prices. They are between 153 and 800 percent higher.
- The various cases show prices for electricity between 20 and 86 percent higher in all end-use sectors.

Electricity Generation by Fuel (9 Percent Case): Small Kyoto Report - Page 6

- Over one-third of all primary energy consumed by the United States goes into producing and delivering electricity.
- More than one-half of all U.S. electricity generated in 1997 was produced from coal- a fuel that emits more carbon dioxide per unit of electricity generated than any other fuel.
- And, unlike many other end uses, there are a range of fuel options for electricity generation.
- Thus, electricity production and consumption is likely to be a major focus in meeting Kyoto targets --including fuel switching away from more carbon-intensive generation.
- In the 1990 + 9 percent case, for example coal generation drops to 48 percent of the reference case levels and then continues to decline reaching to 25 percent of the 2020 reference case level

U.S. Coal Production (7 Cases): Kyoto Report- Fig 105

- In the carbon reduction cases, U.S. coal production begins a slow decline early in the next decade, accelerates rapidly downward through 2010, and then continues to drop slowly through 2020.
- The projected declines in coal production result primarily from sharp cutbacks in the use of steam coal for electricity generation.
- Coal production levels in 2010 range from a reference case level of 1287 million tons to 624 million tons in the 1990+9 percent case to 313 million tons in the 1990-7 percent case.

- EIA estimates that coal mine employment in 2010 would drop from 68,500 in the reference case (which reflects the effect of continuing gains in productivity and a further shift to western coal) to 42,500 in the 1990+ 9 percent case and 25,500 in the 1990-7 percent case.

Closing Comments

I have presented the mid-term projections views of EIA today and covered a range of topics and issues.

Energy projections are subject to much uncertainty.

Many events that shape energy markets cannot be anticipated such as new legislation, political disruption, and technological breakthroughs.

Many of the key uncertainties have been addressed through alternative cases that were discussed today.

I would be happy to answer any questions that you might have.

**Presented to Mining Technology Symposium
Morgantown, WV**

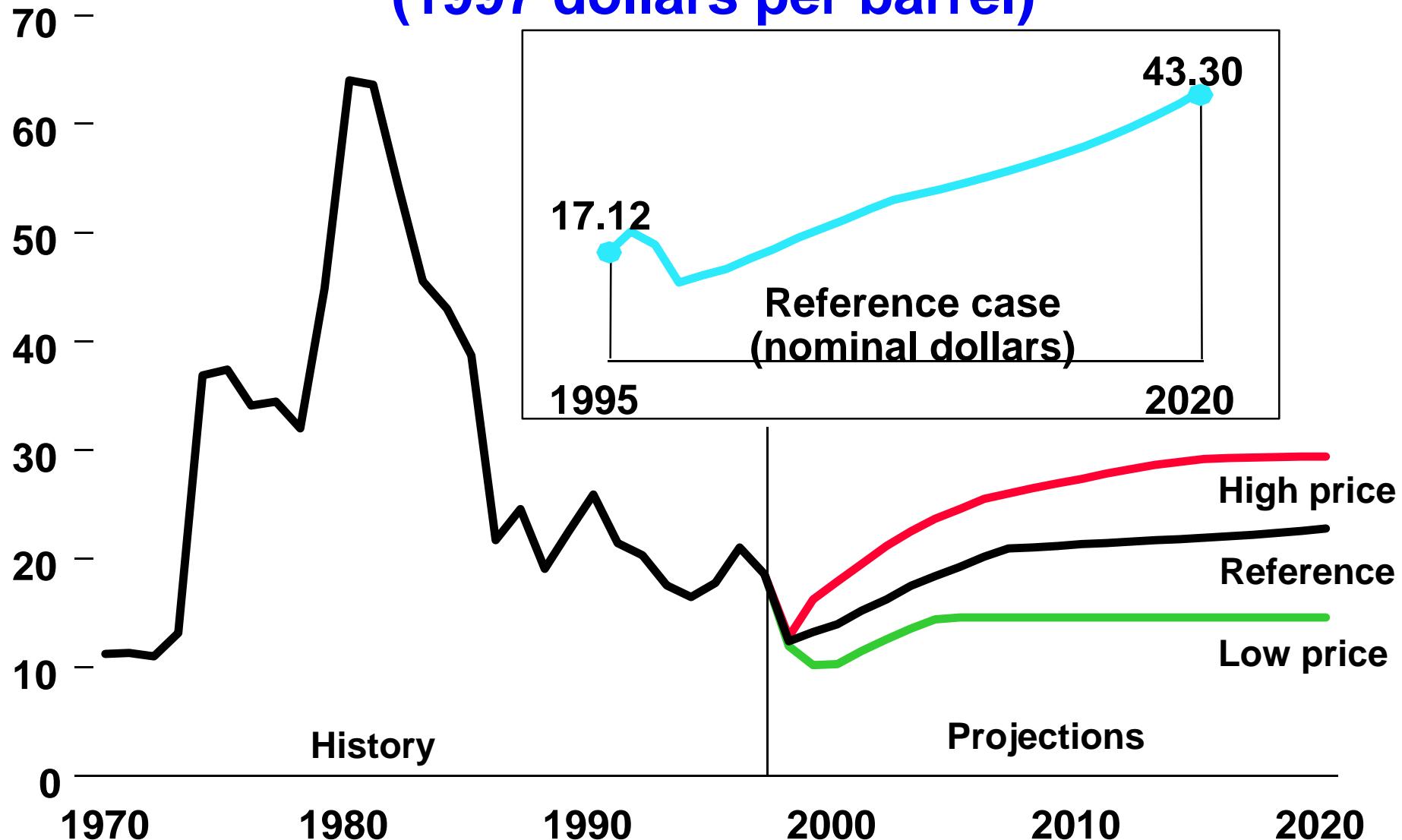
June 23, 1999

The Outlook for U.S. Coal Markets Through 2020

**Mary J. Hutzler
U.S. Energy Information Administration
Washington, D.C.**

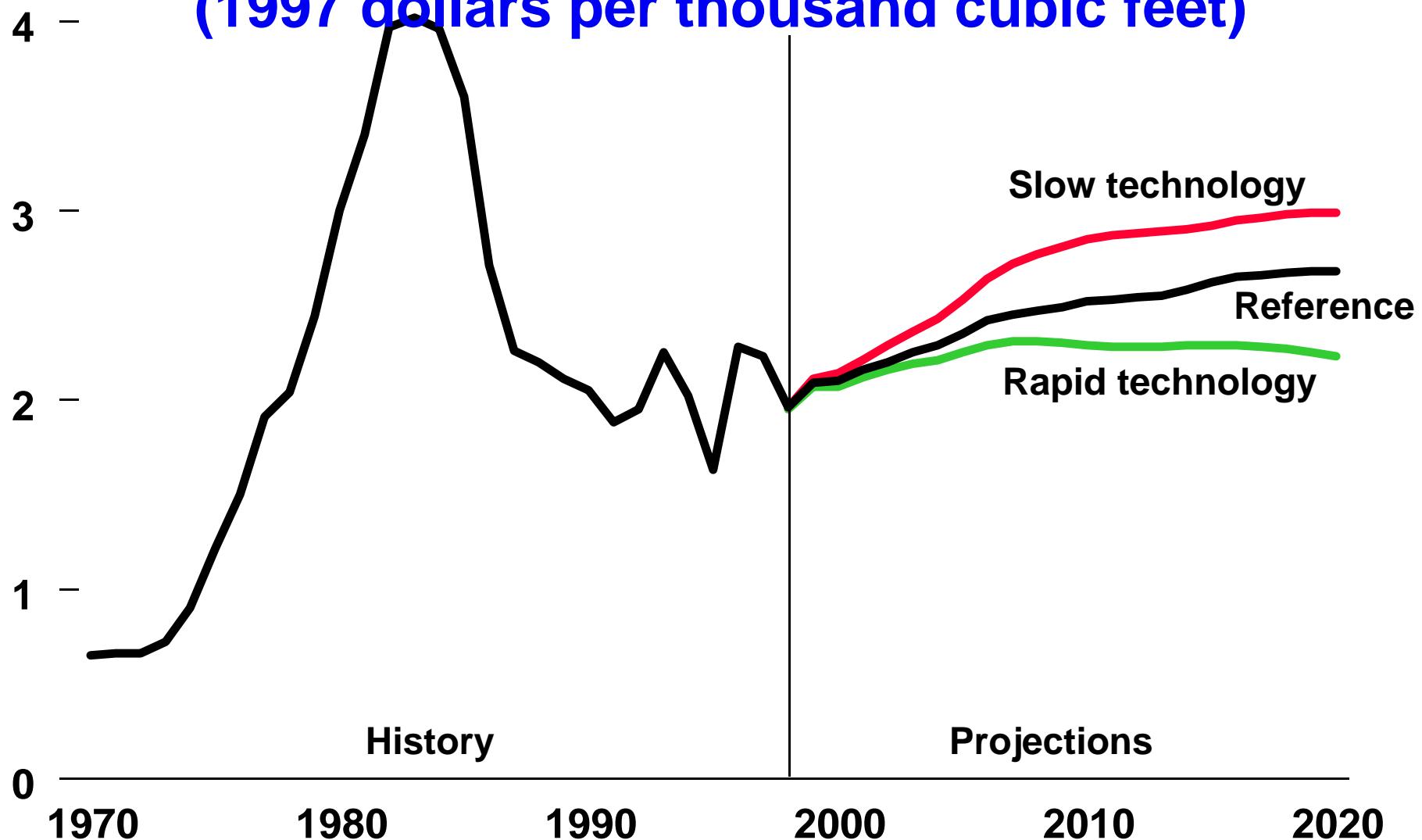
World Oil Prices in Three Cases, 1970-2020

(1997 dollars per barrel)

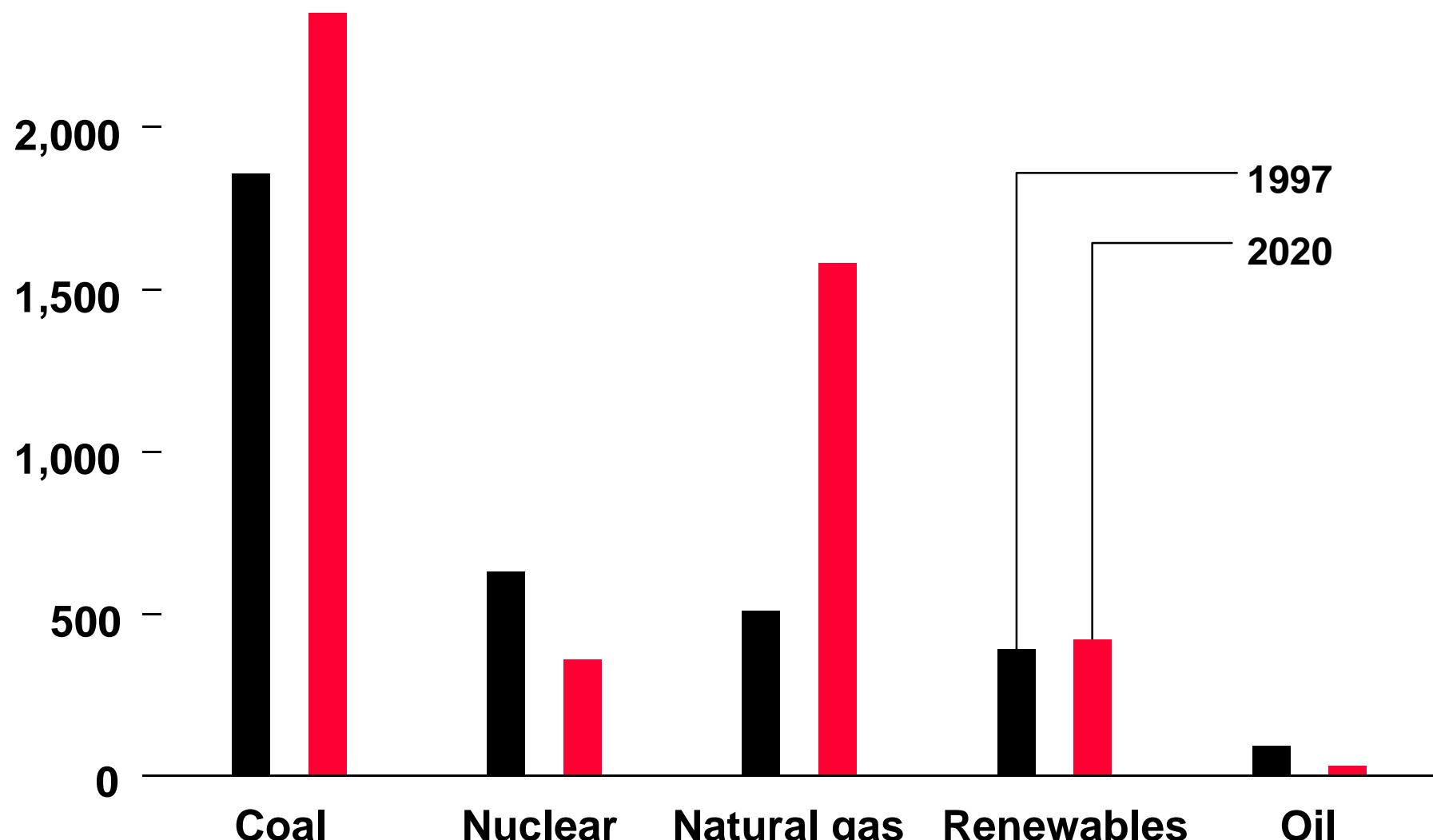


Lower 48 Natural Gas Wellhead Prices in Three Cases, 1970-2020

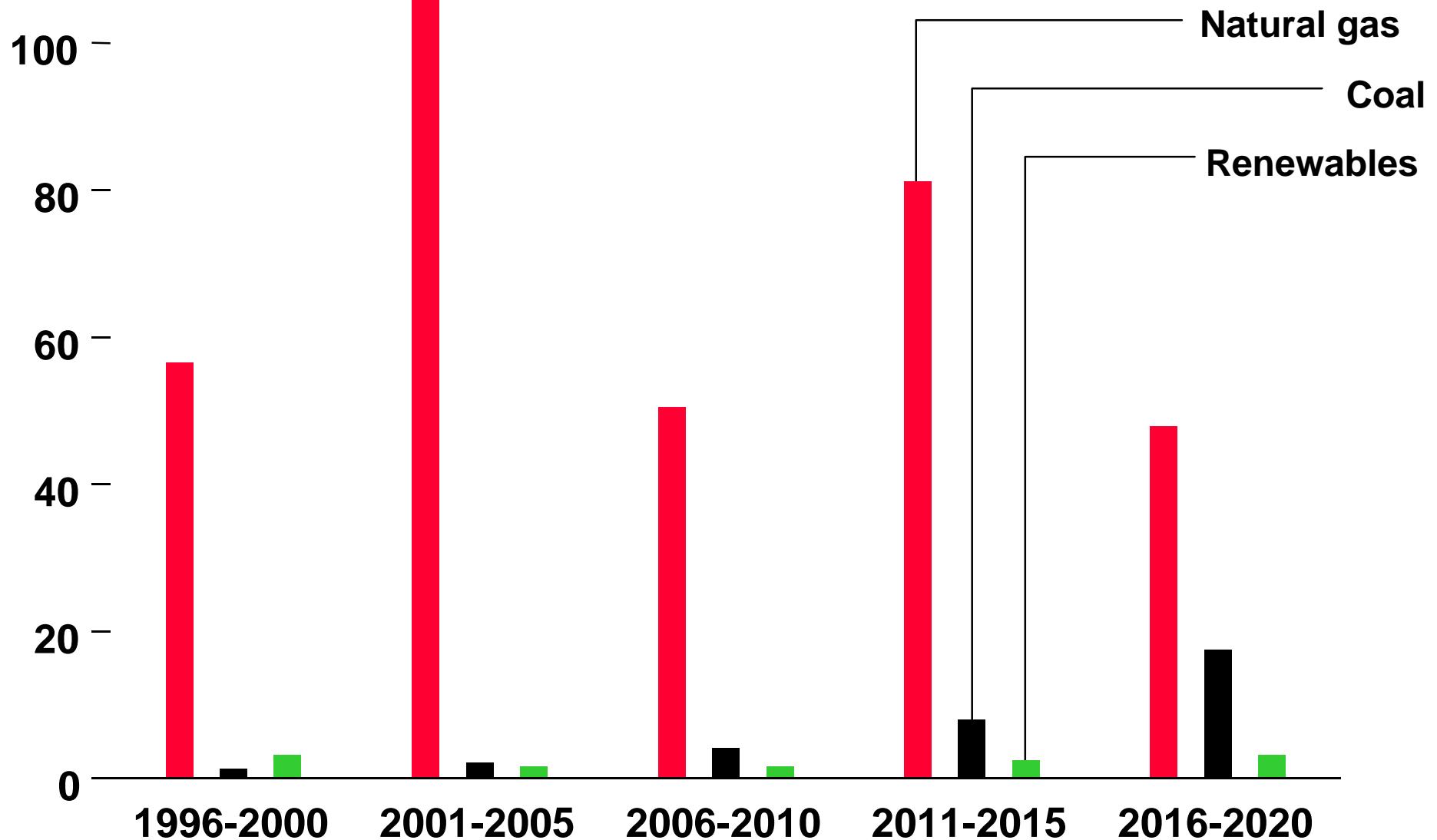
(1997 dollars per thousand cubic feet)



Electricity Generation by Fuel, 1997 and 2020 (billion kilowatthours)

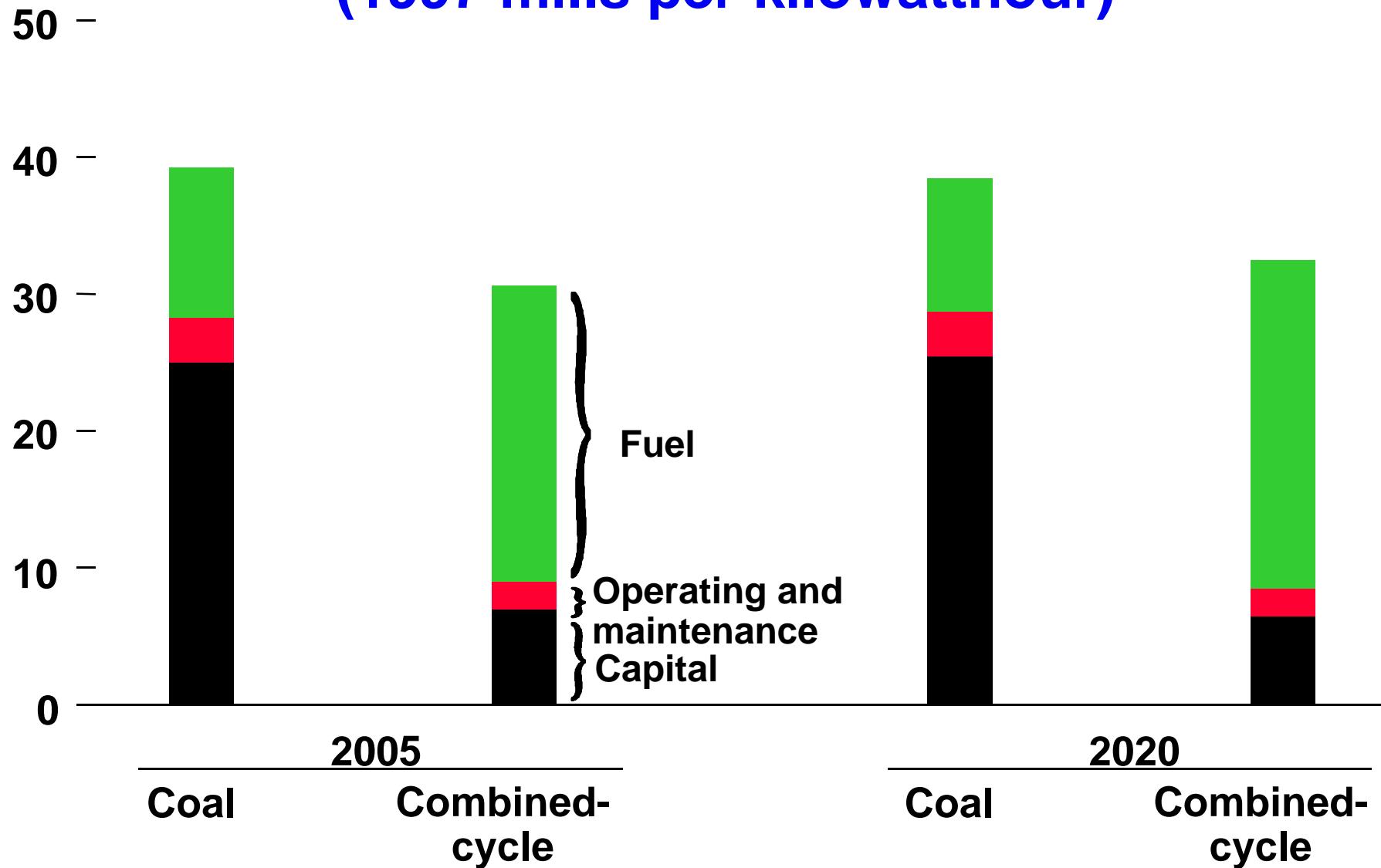


Electricity Generation and Cogeneration Capacity Additions by Fuel Type, 1996-2020 (gigawatts)

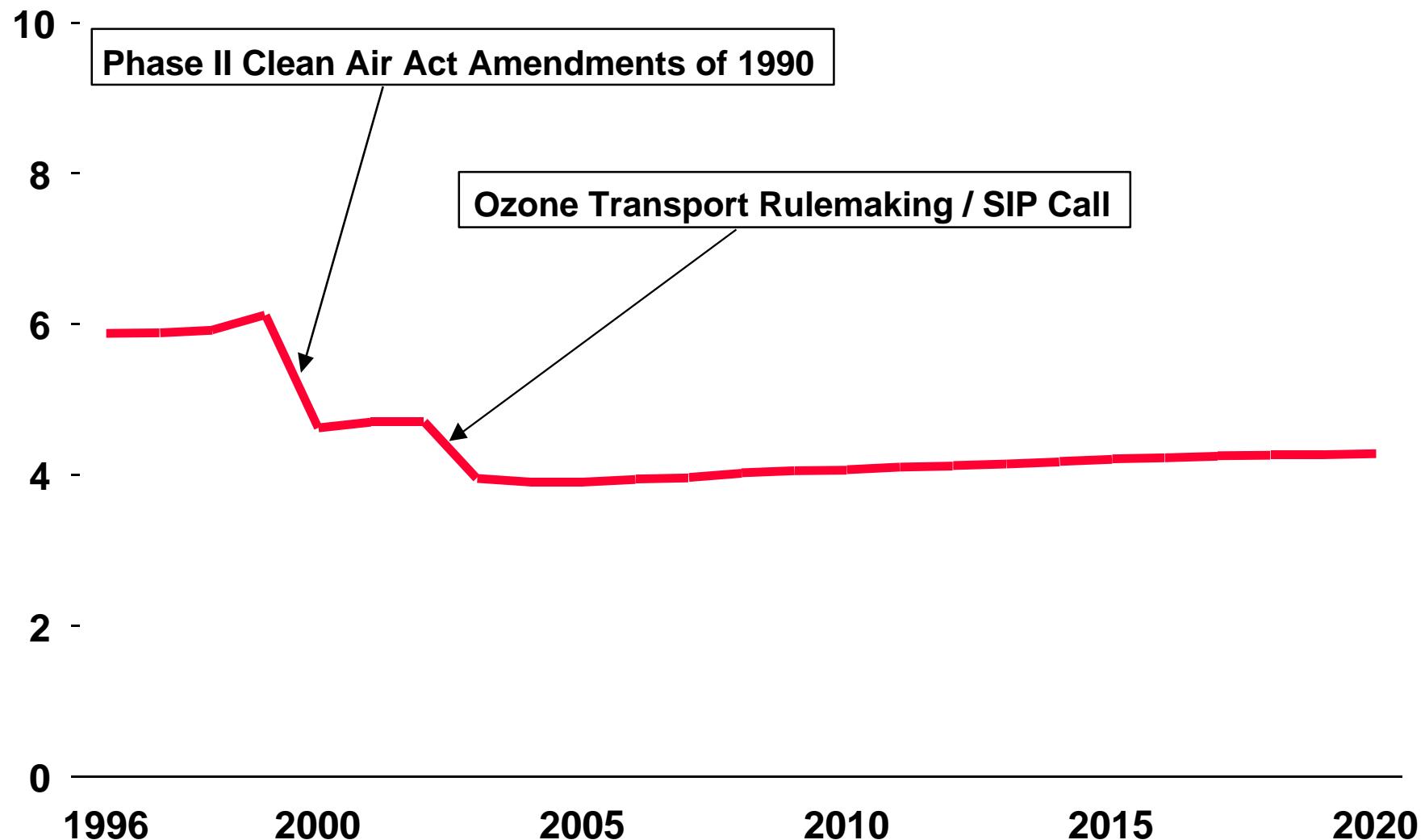


Electricity Generation Costs, 2005 and 2020

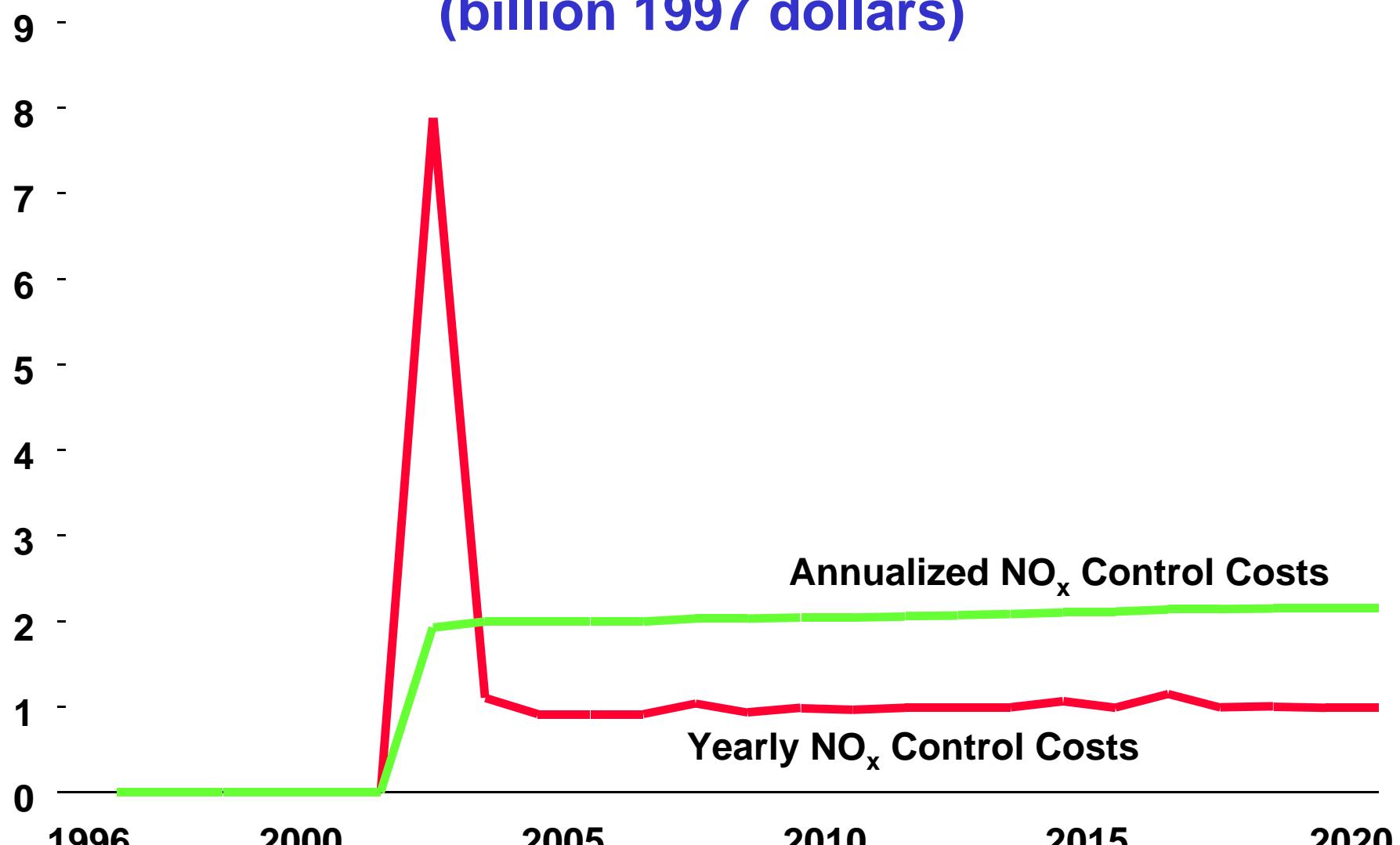
(1997 mills per kilowatthour)



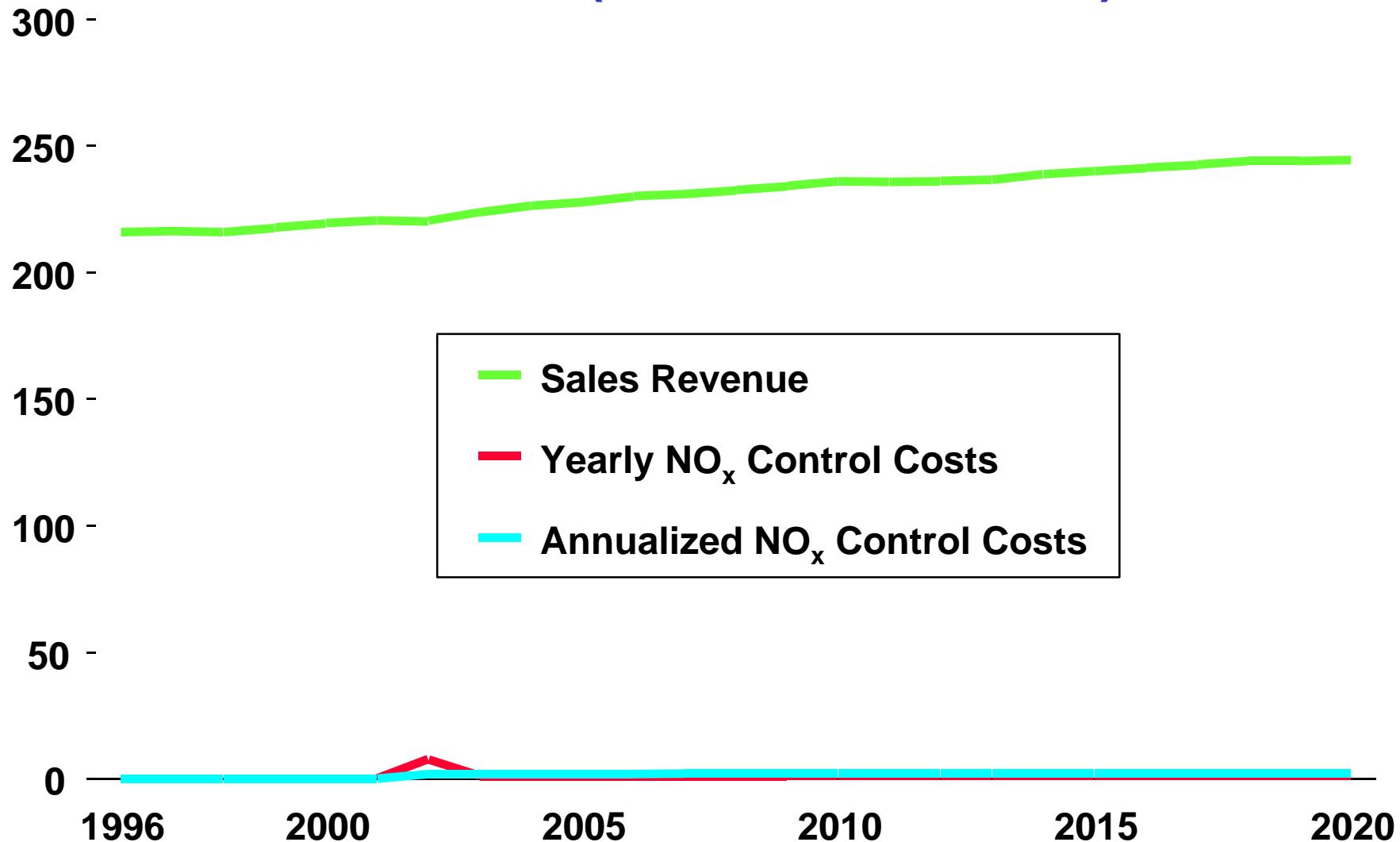
New Legislation Reduces NO_x Emissions from Powerplants, 1996-2020 (million tons)



SIP Call NO_x Control Costs, 1996-2020 (billion 1997 dollars)

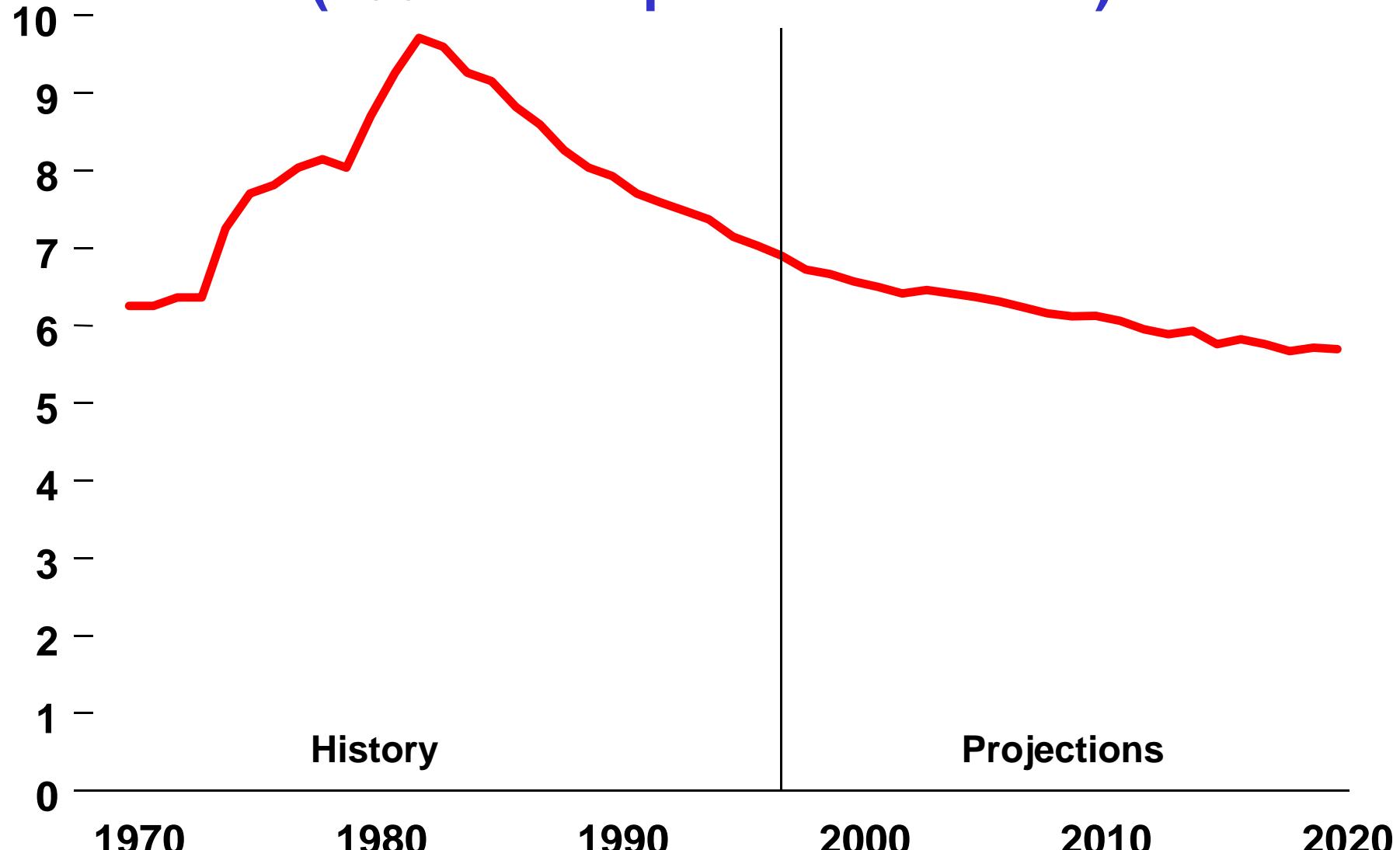


SIP Call NO_x Control Costs Relative to Sales Revenue, 1996-2020 (billion 1997 dollars)

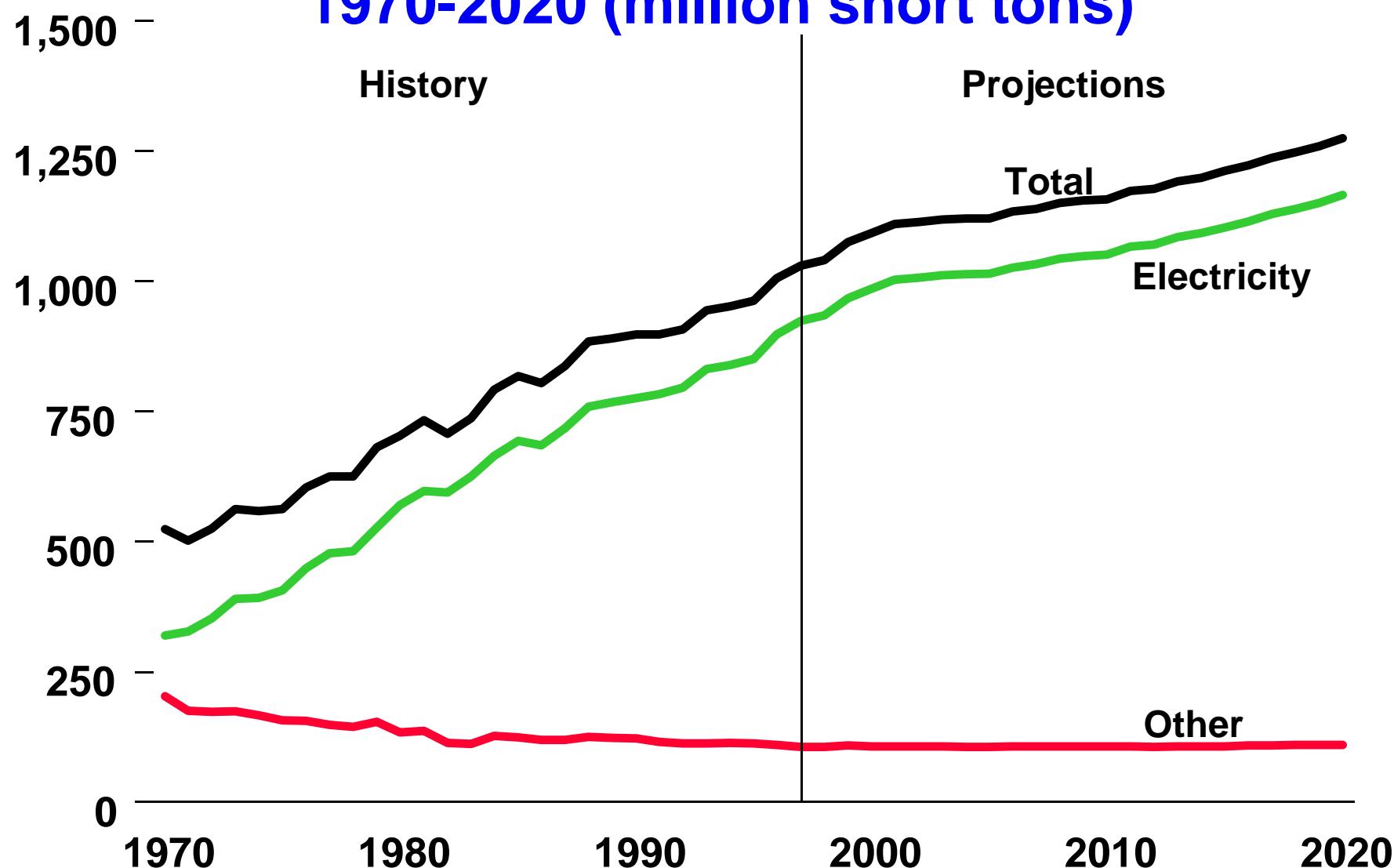


Electricity Price Projections, 1970-2020

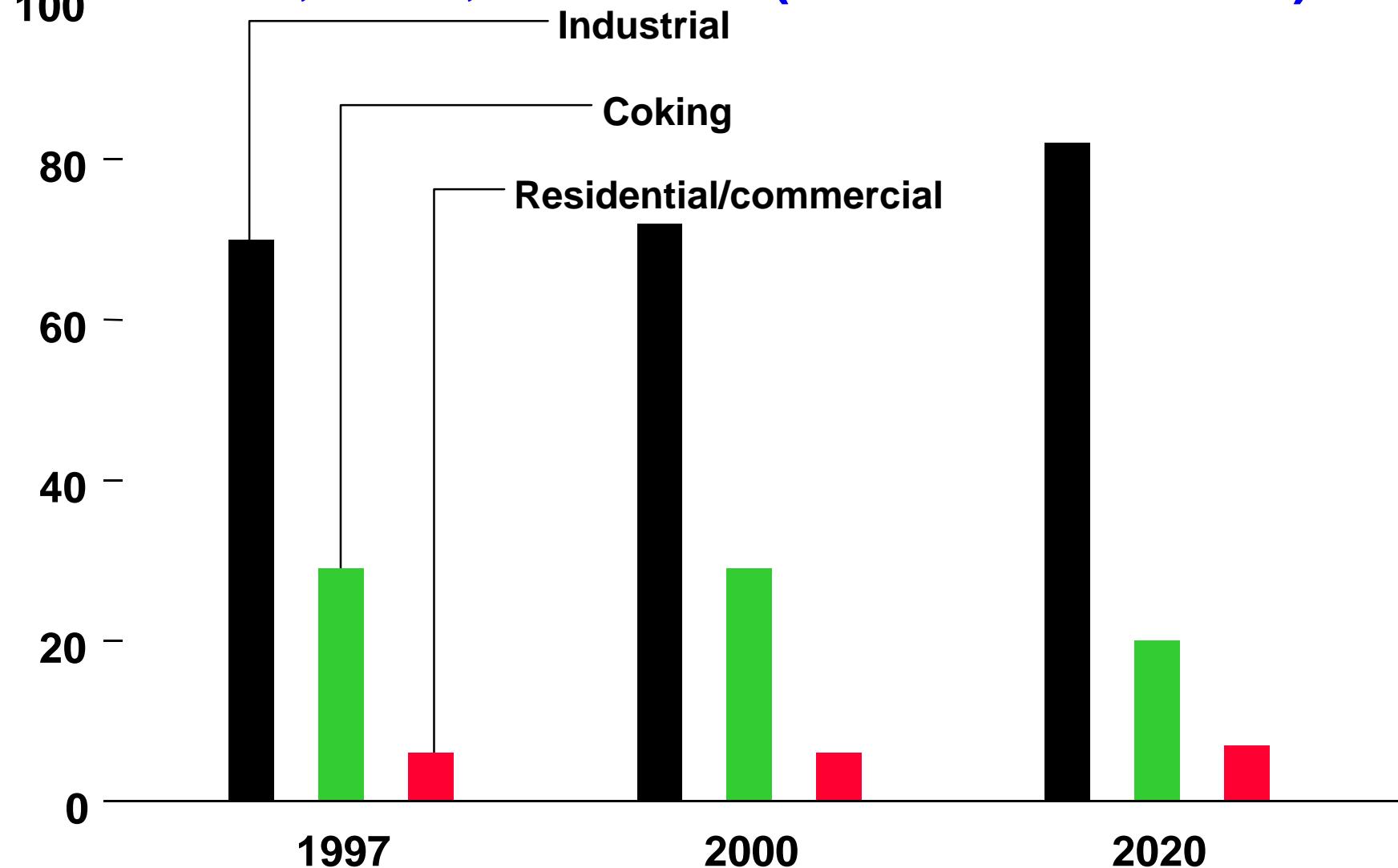
(1997 cents per kilowatthour)



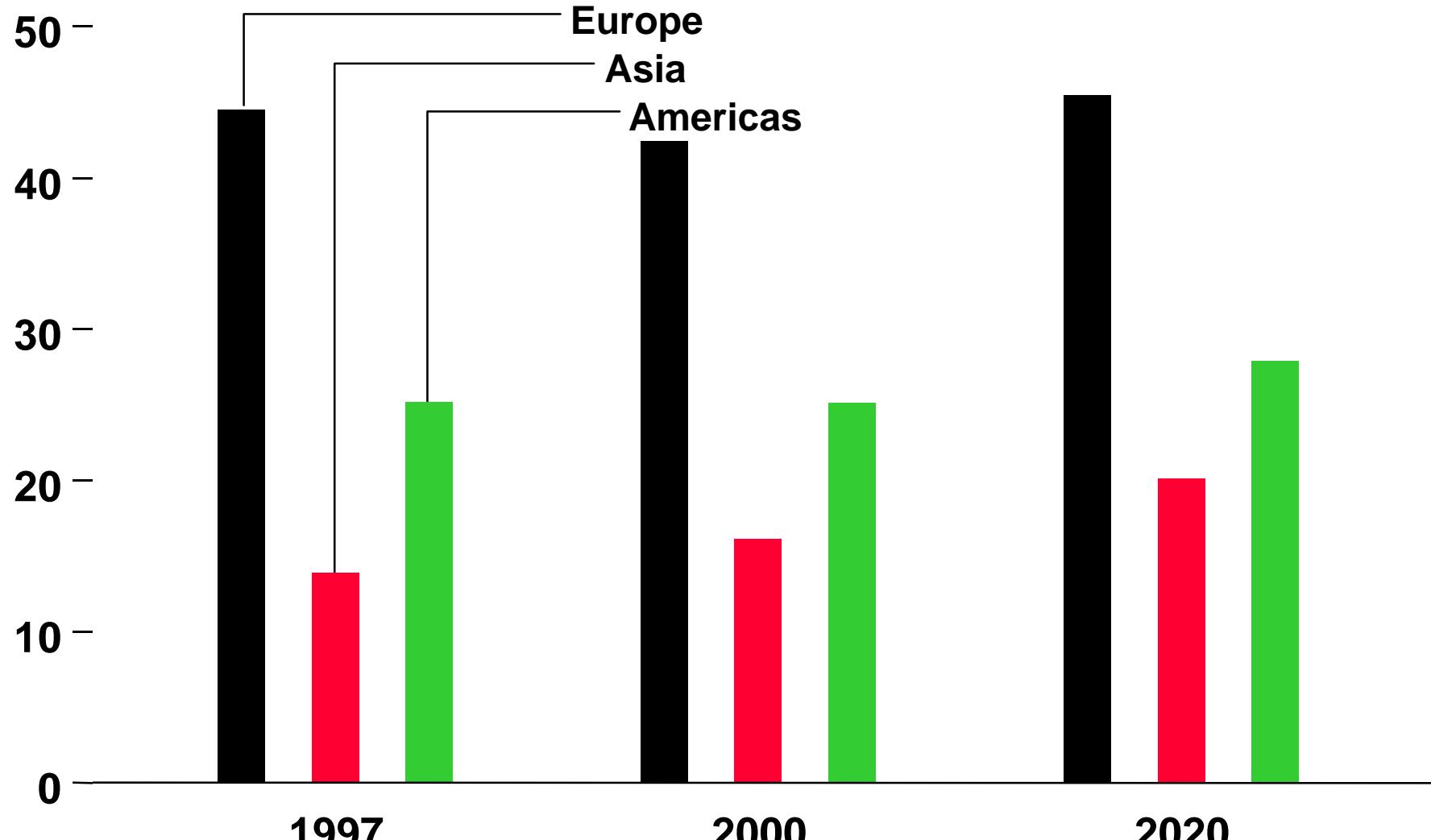
Electricity and Other Coal Consumption, 1970-2020 (million short tons)



Non-Electricity Coal Consumption by Sector, 1997, 2000, and 2020 (million short tons)

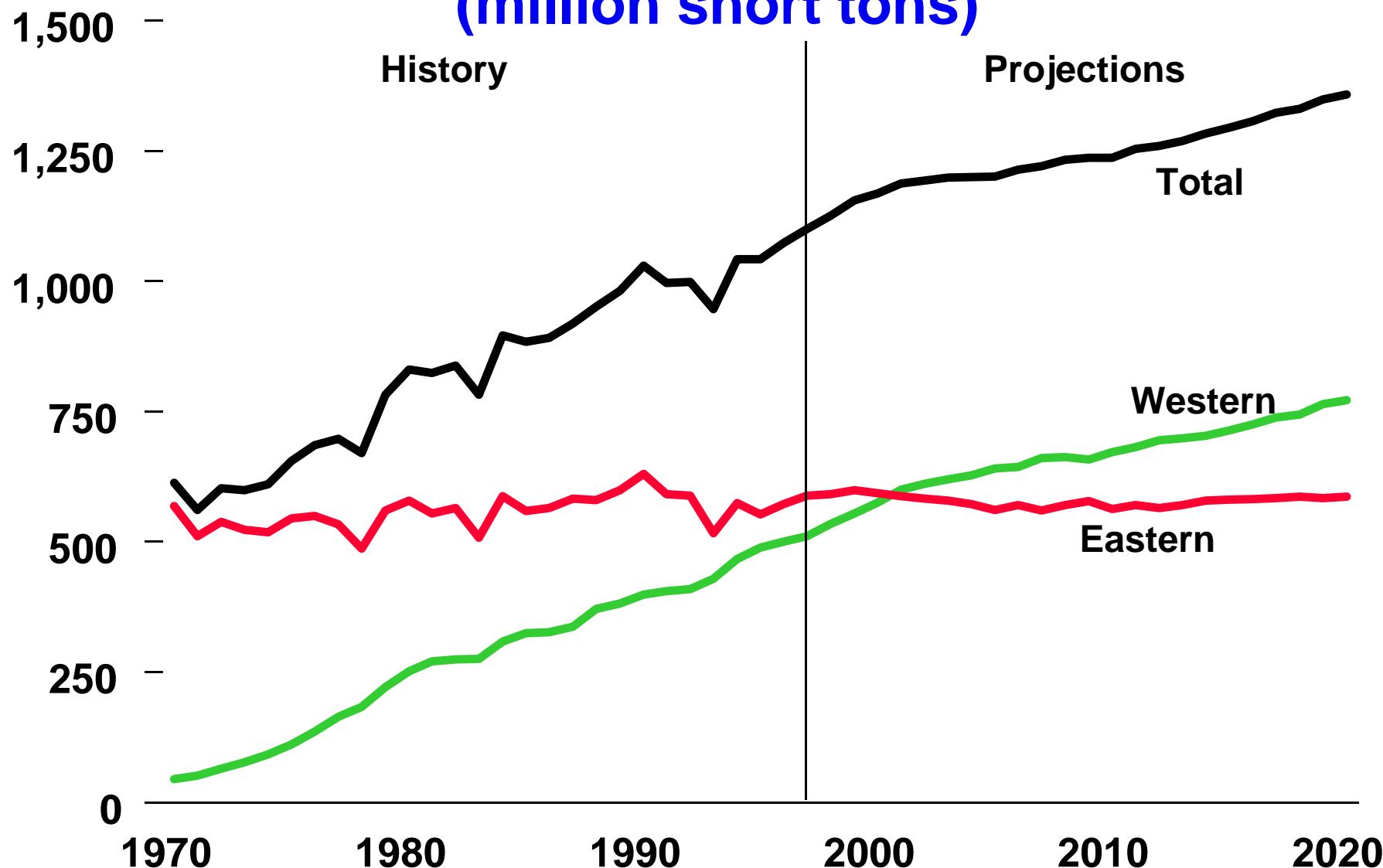


U.S. Coal Exports by Destination, 1997, 2000, and 2020 (million short tons)

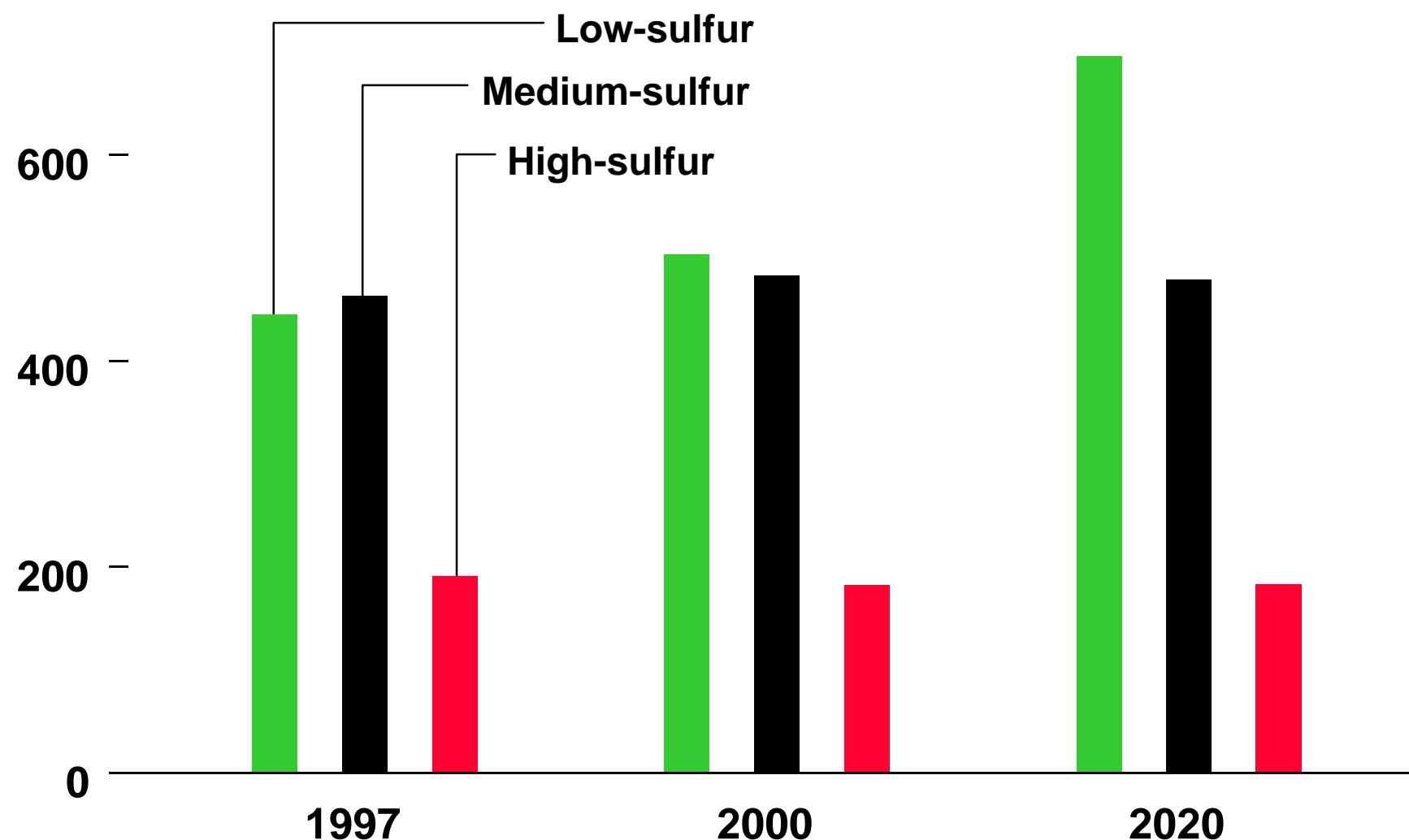


Coal Production by Region, 1970-2020

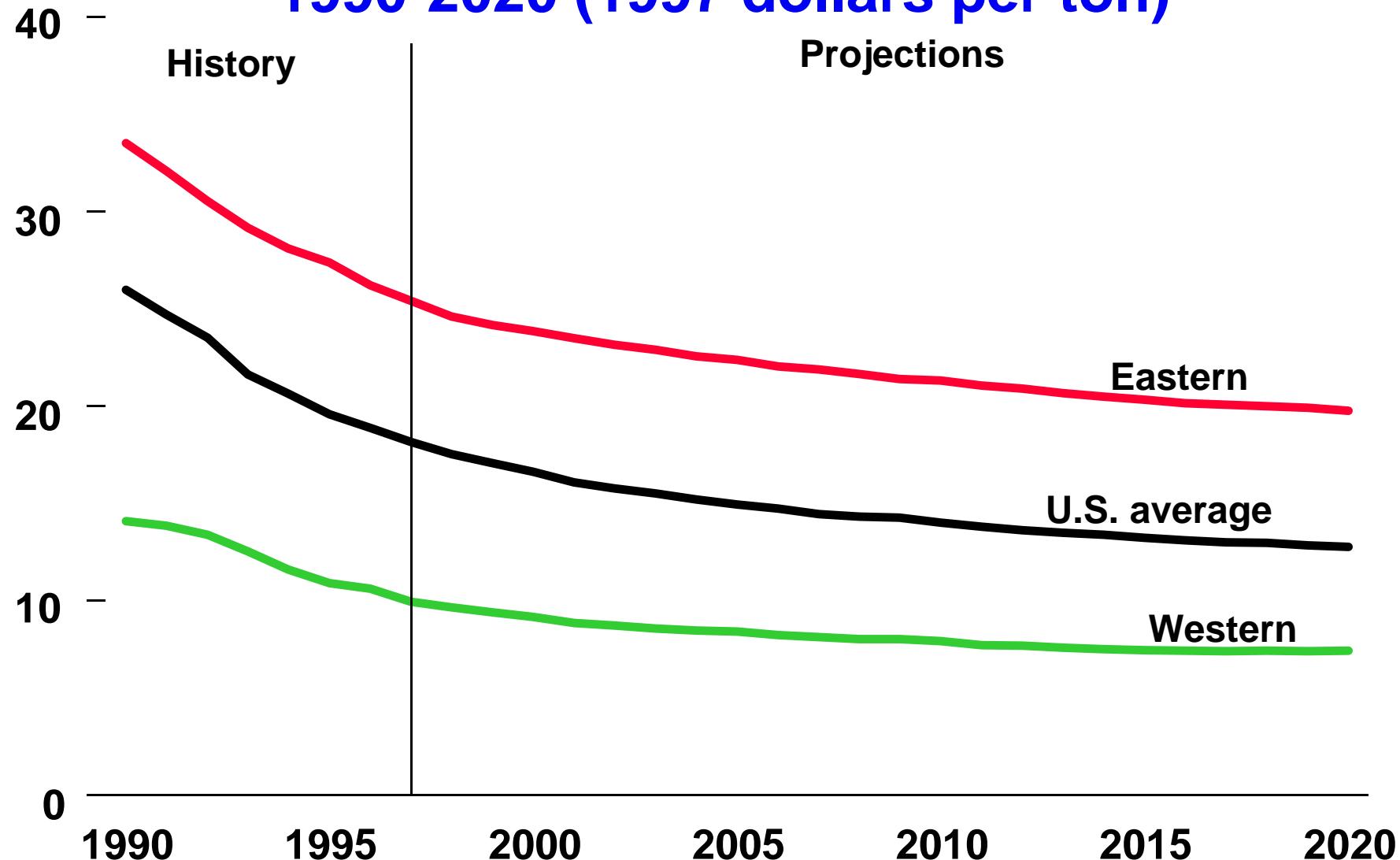
(million short tons)



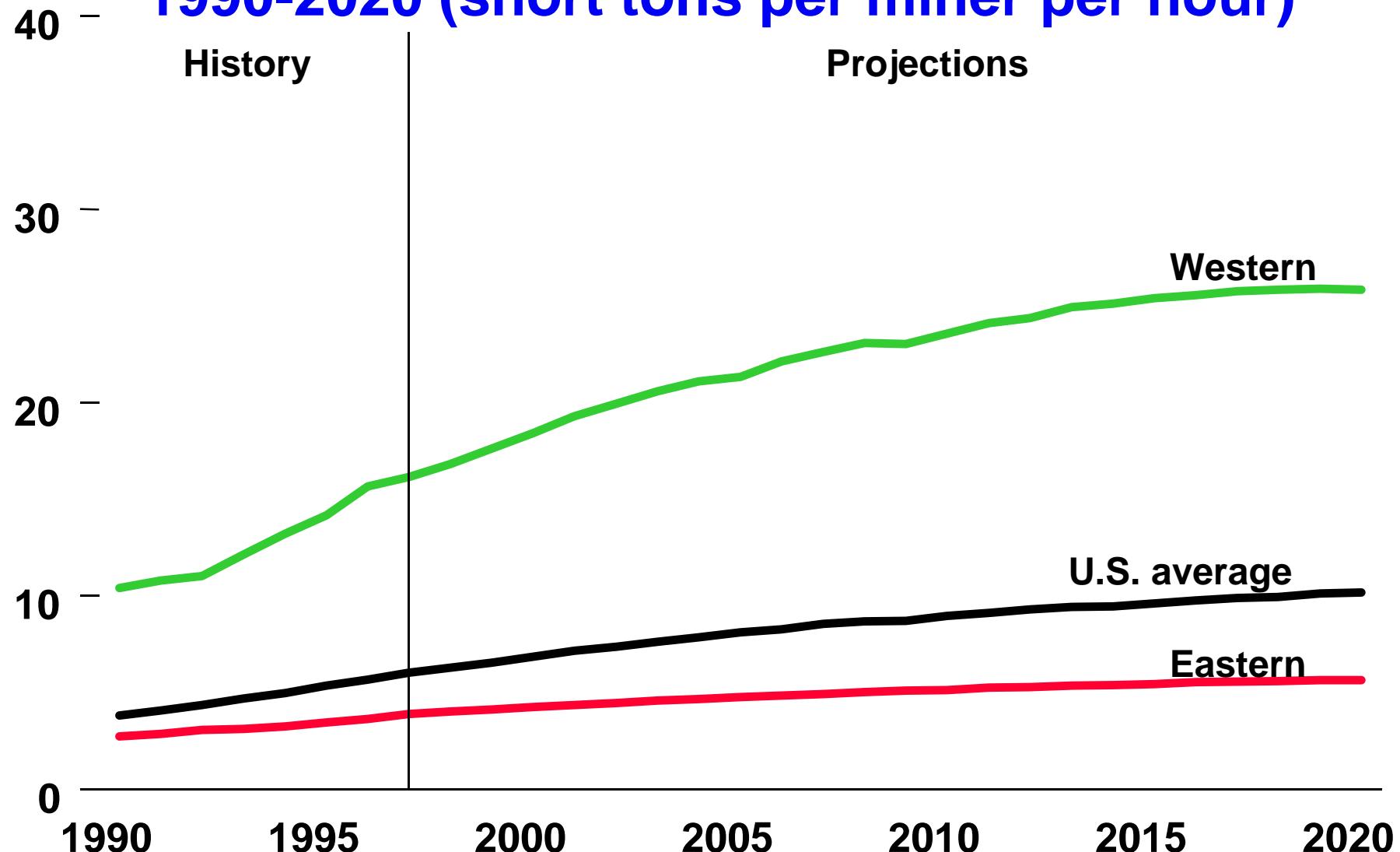
Coal Distribution by Sulfur Content, 1997, 2000, and 2020 (million short tons)



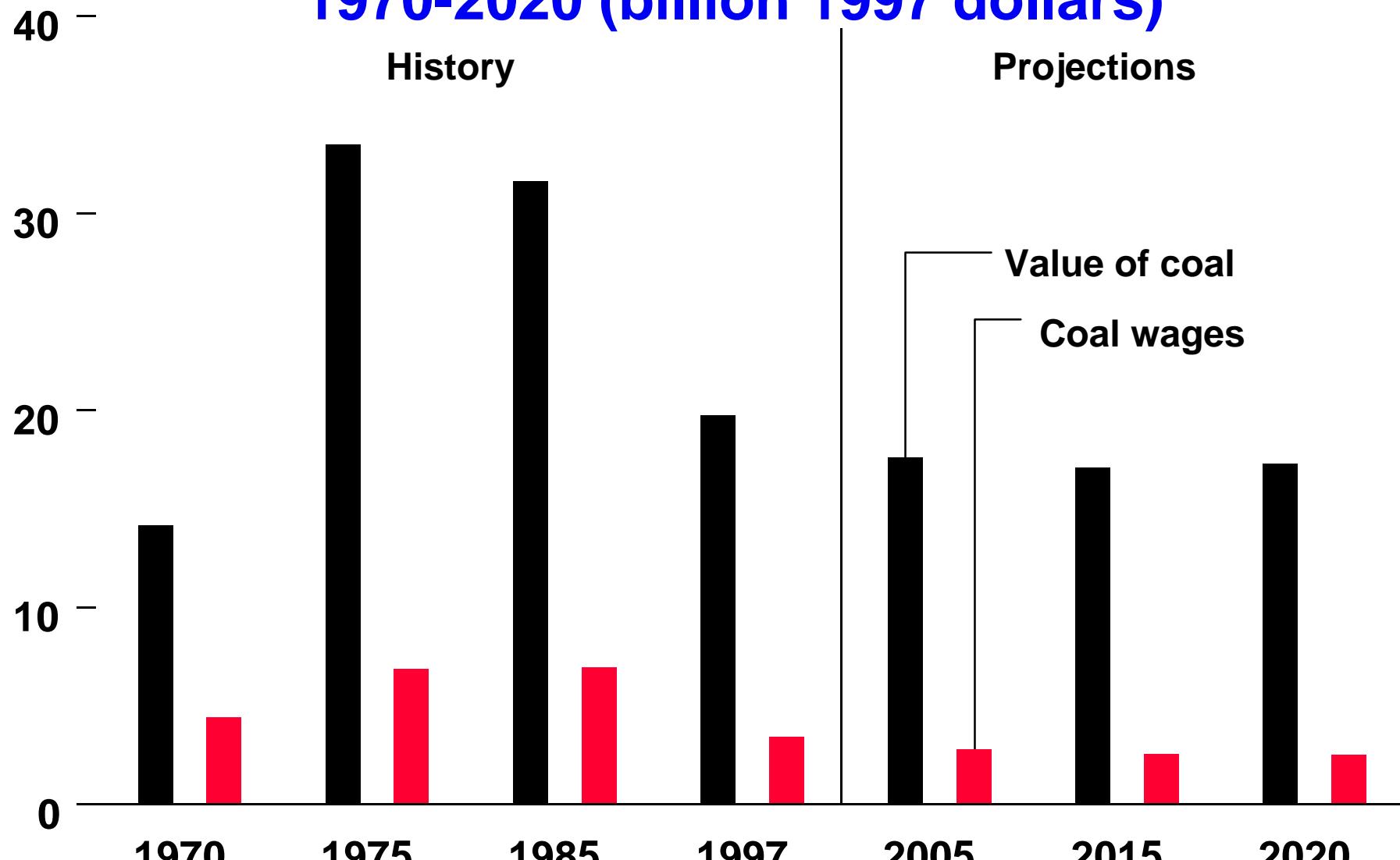
Average Minemouth Price of Coal by Region, 1990-2020 (1997 dollars per ton)



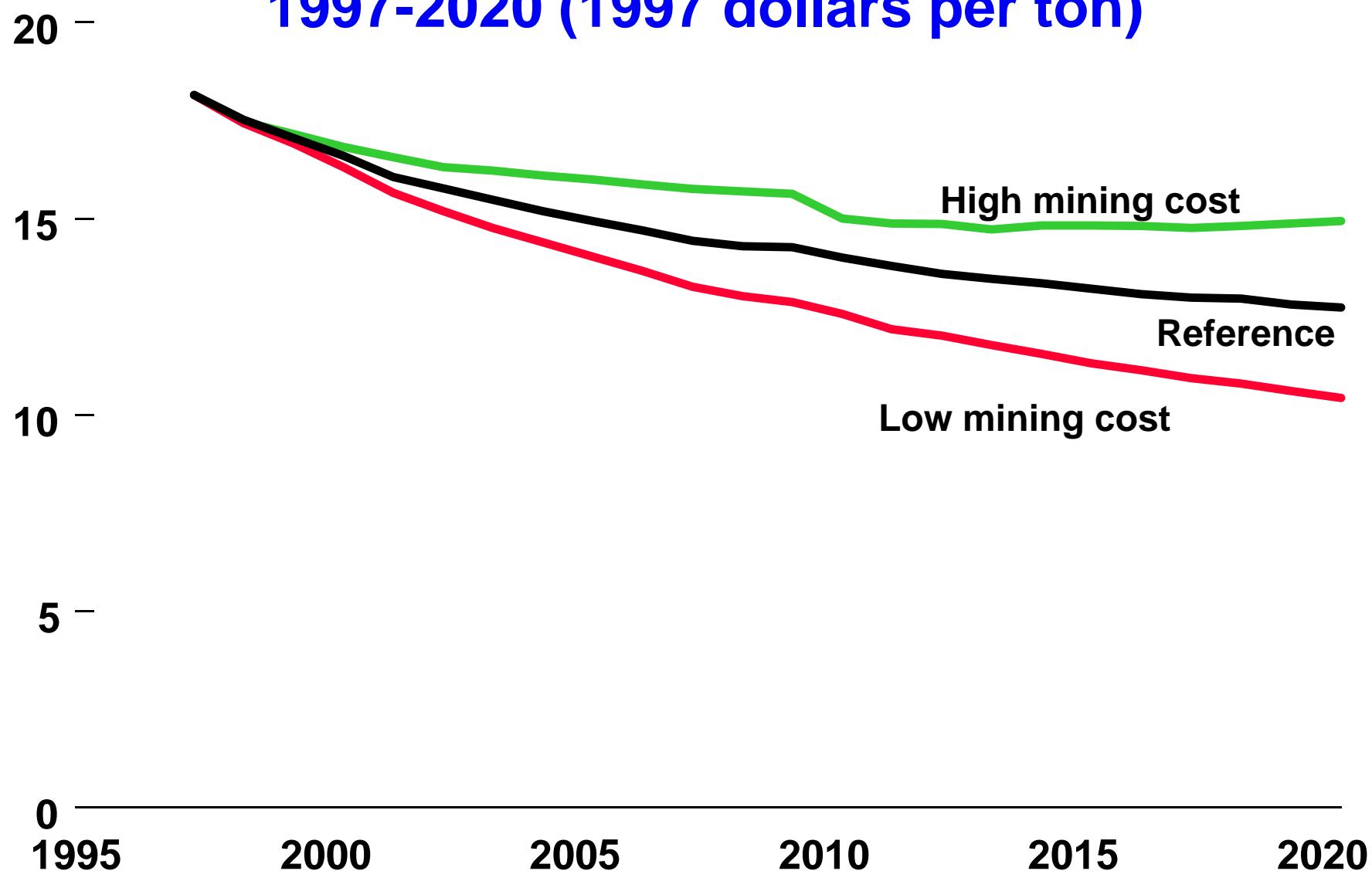
Coal Mining Labor Productivity by Region, 1990-2020 (short tons per miner per hour)



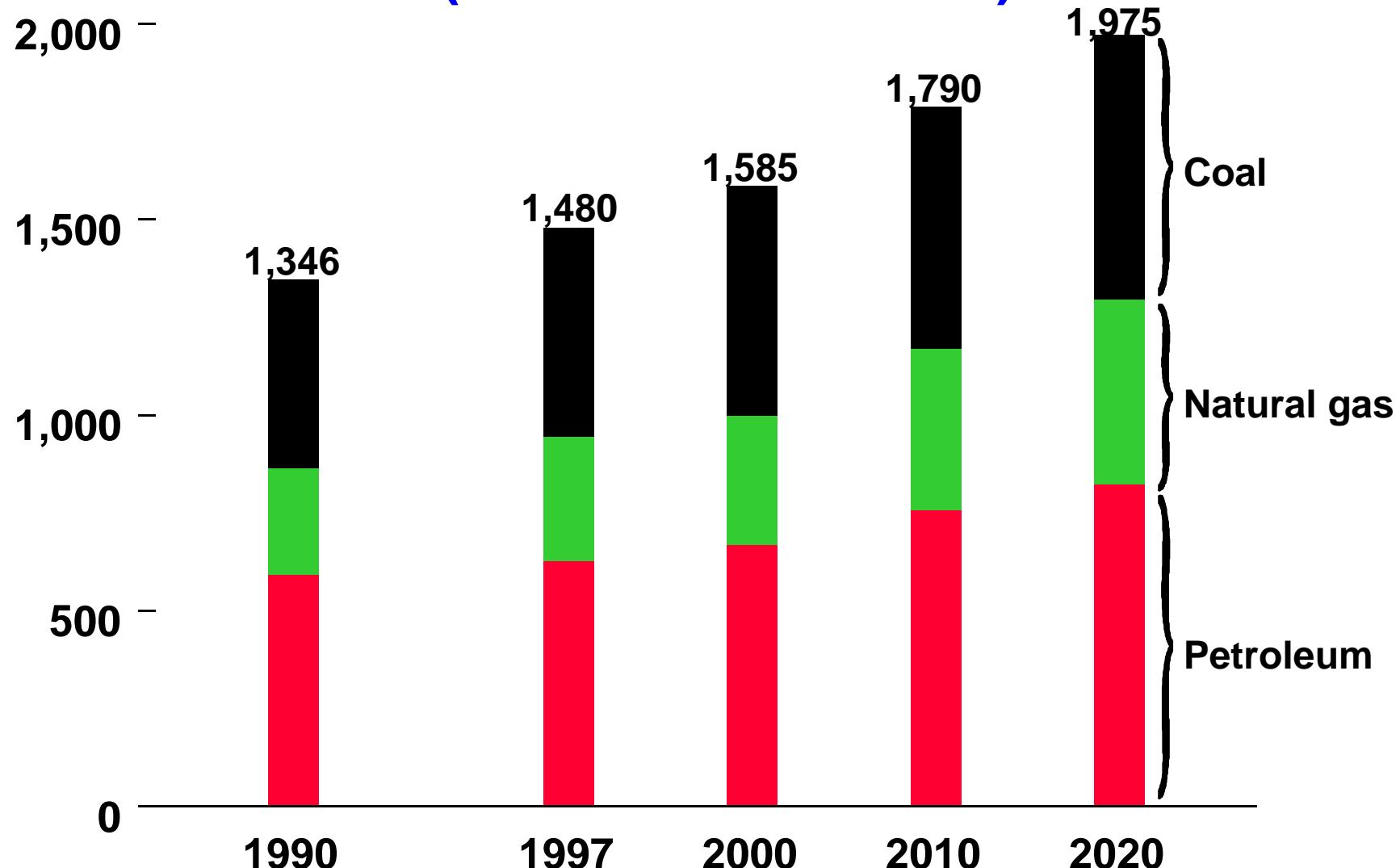
Labor Cost Component of Minemouth Coal Prices, 1970-2020 (billion 1997 dollars)



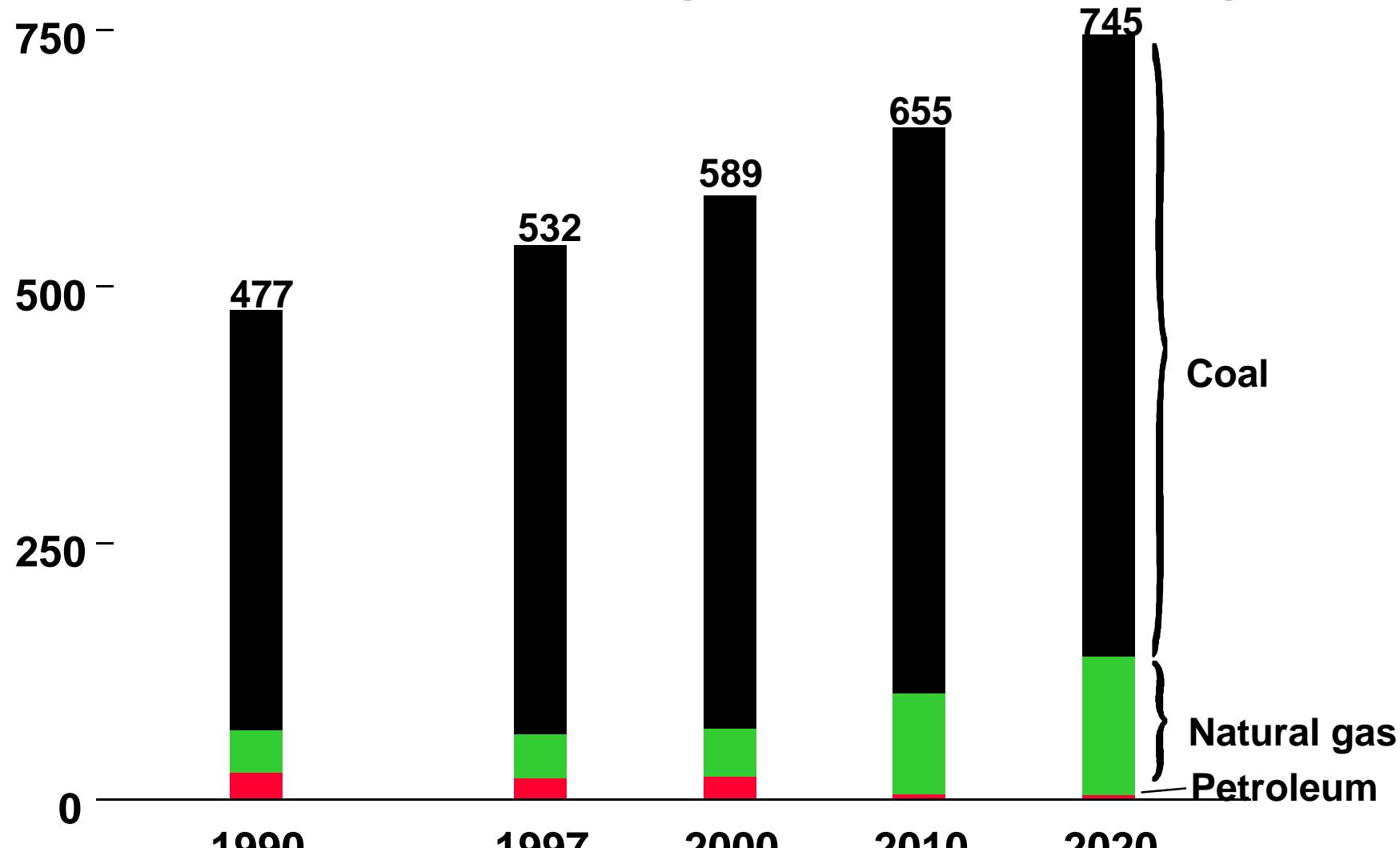
Average Minemouth Coal Prices in Three Cases, 1997-2020 (1997 dollars per ton)



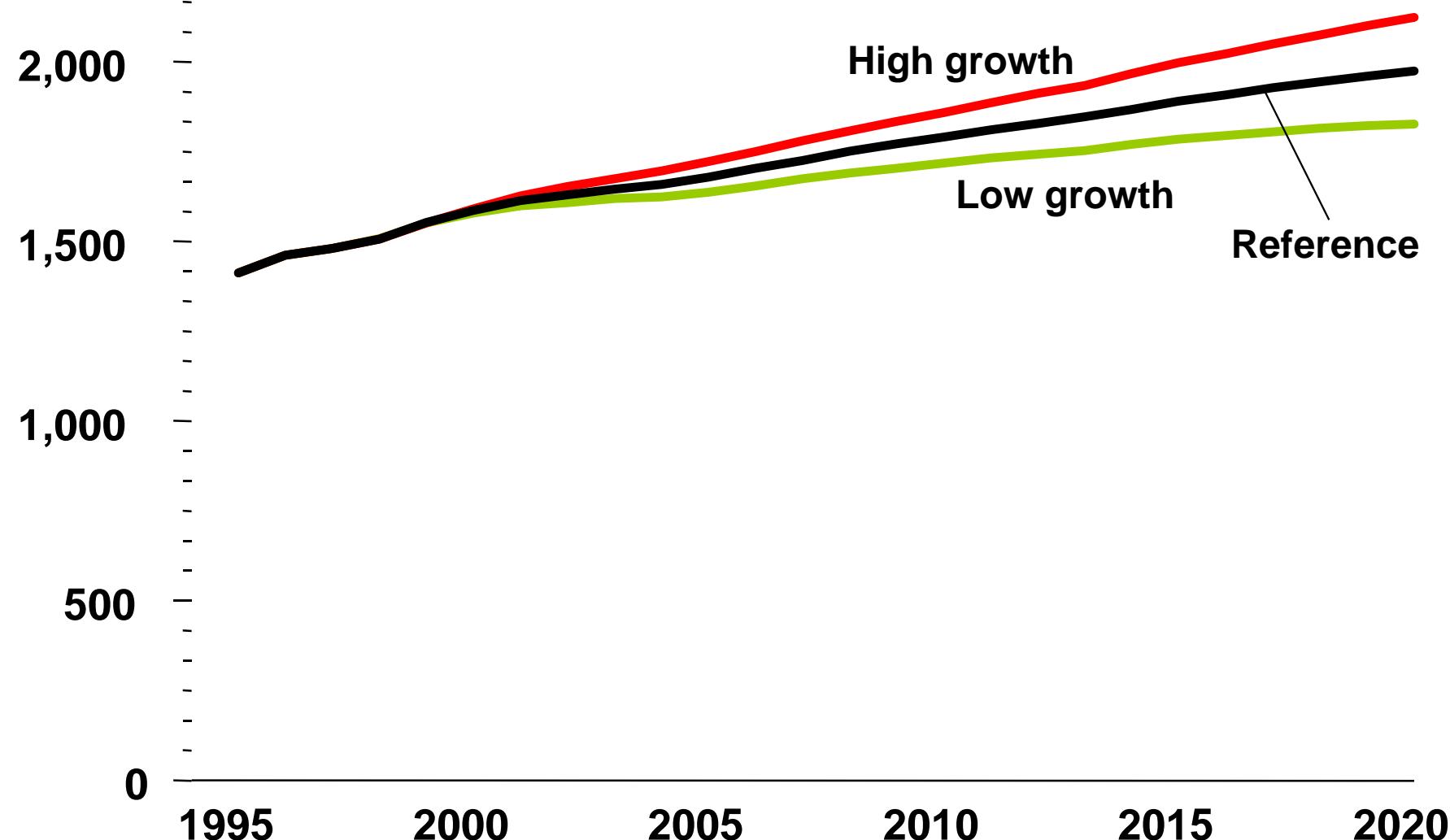
Carbon Emissions by Fuel, 1990-2020 (million metric tons)



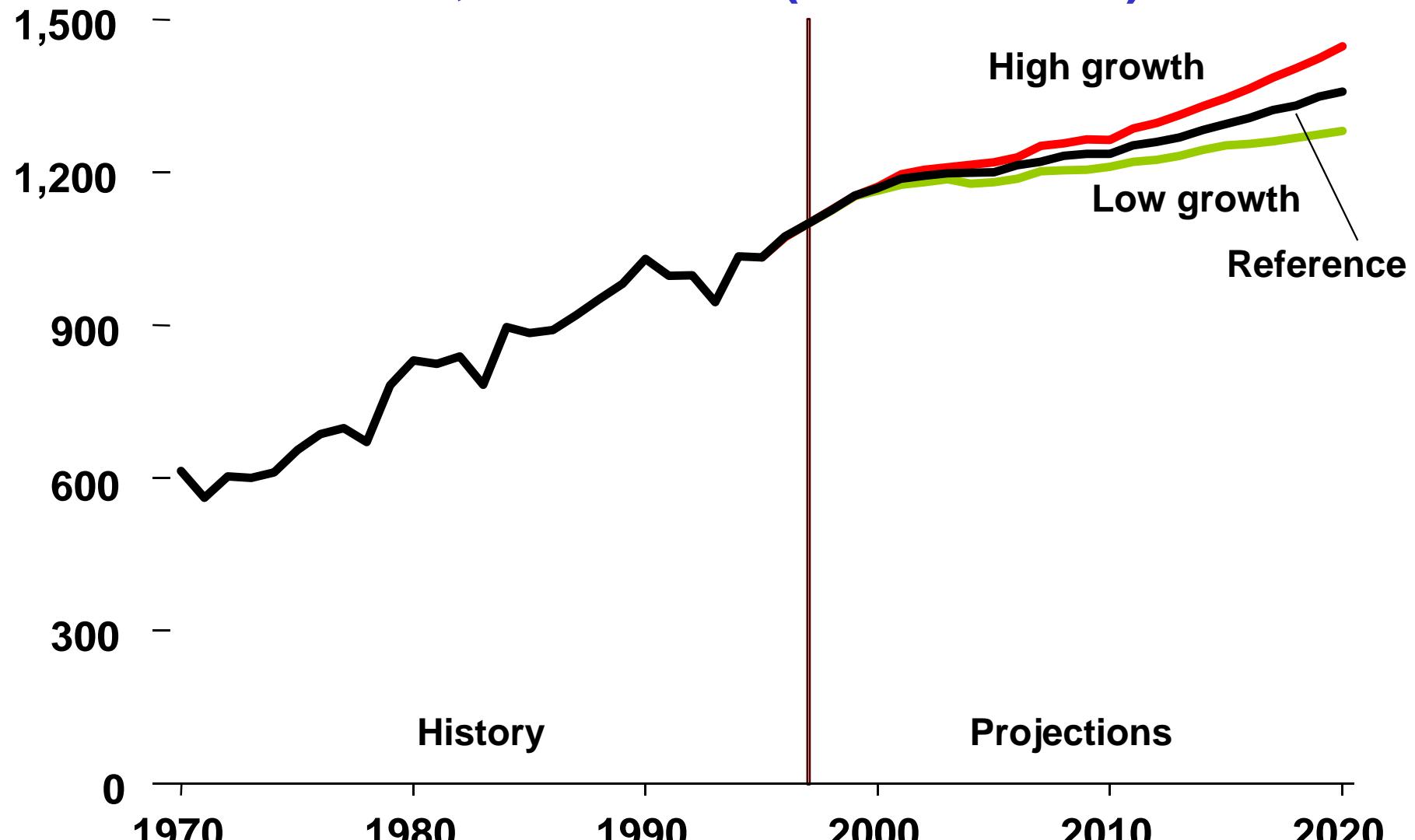
Carbon Emissions from Electricity Generation by Fuel, 1990-2020 (million metric tons)



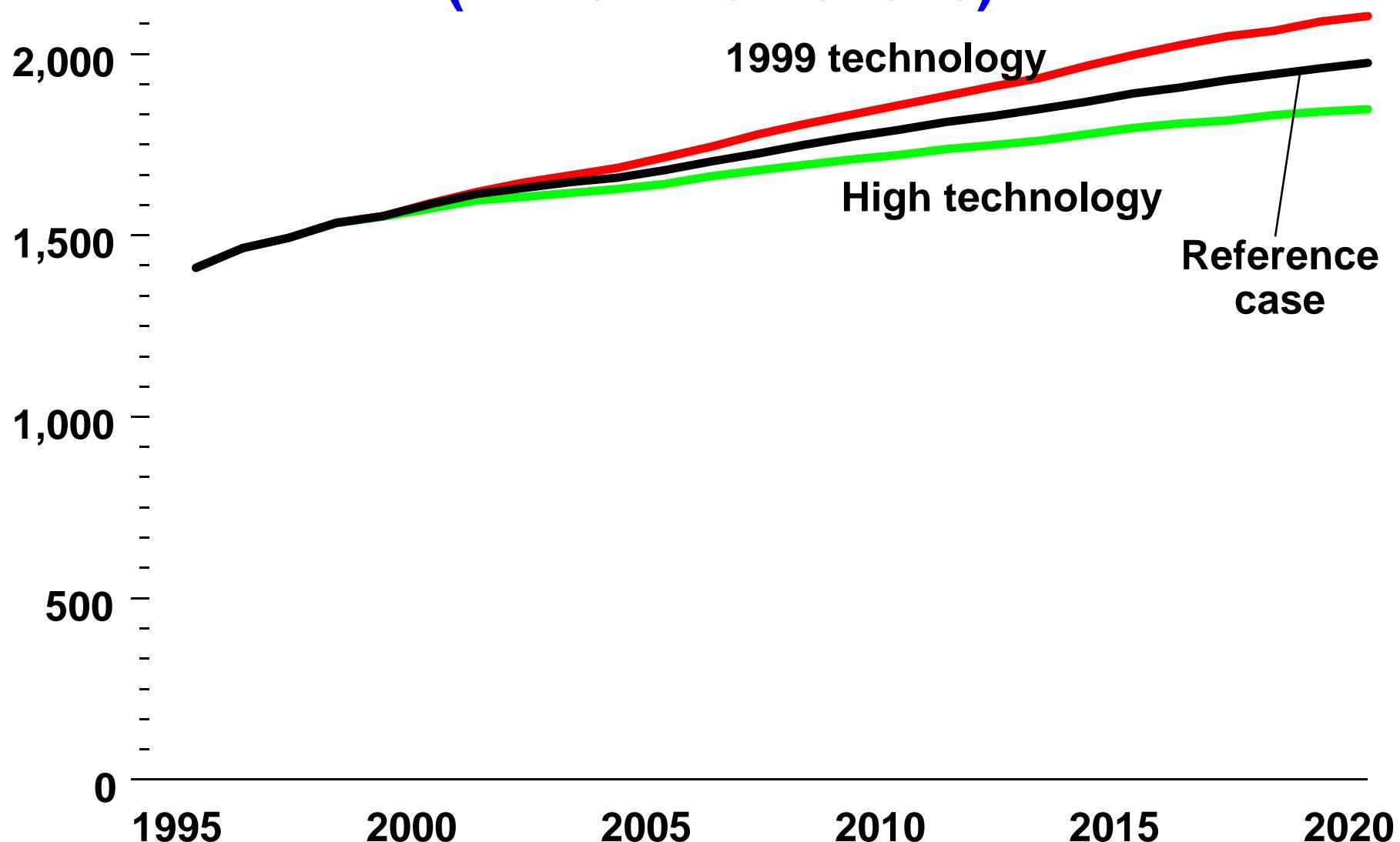
Carbon Emissions in Three Macroeconomic Growth Cases, 1990-2020 (million metric tons)



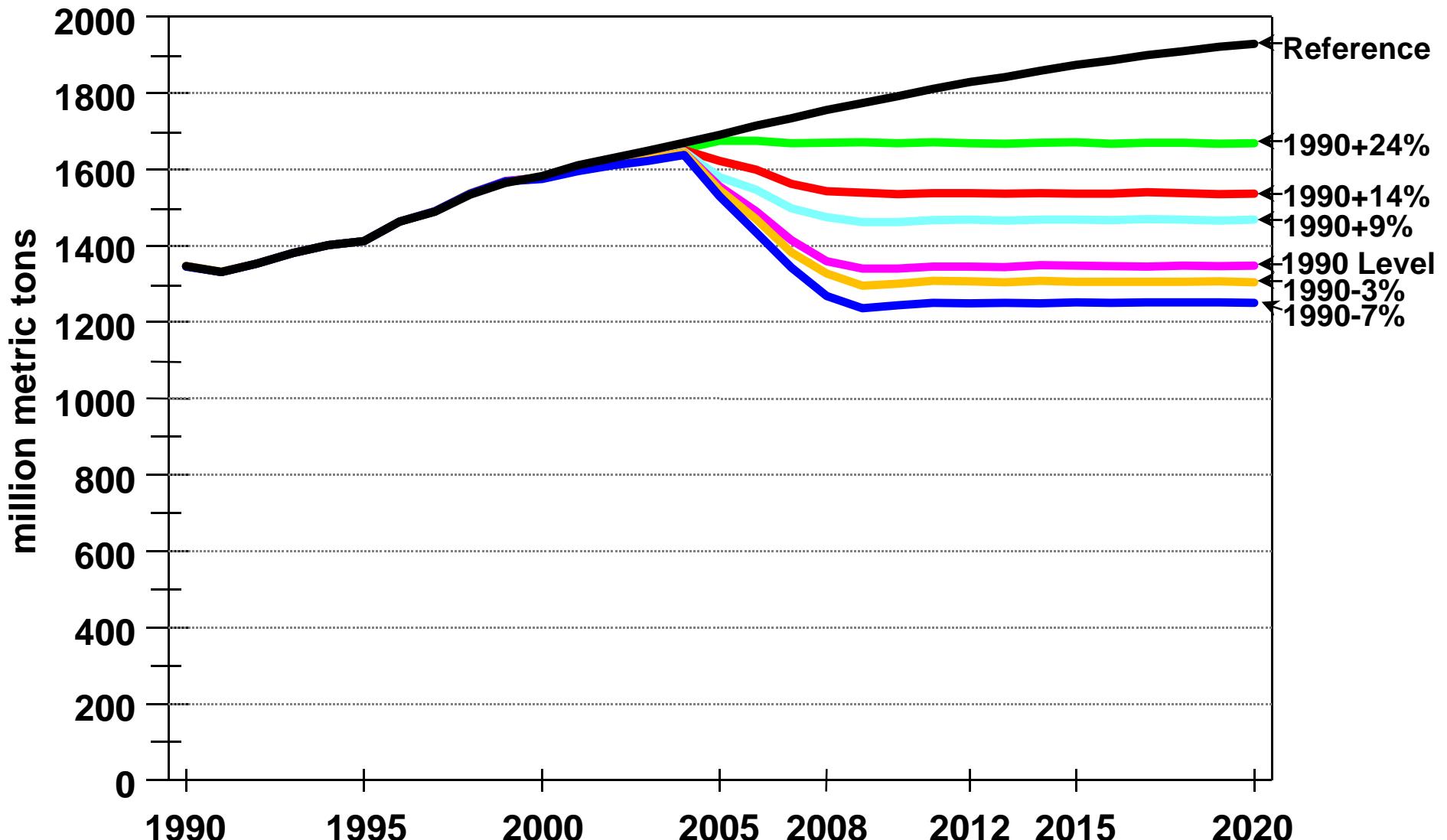
Coal Production in Three Macroeconomic Growth Cases, 1970-2020 (million tons)



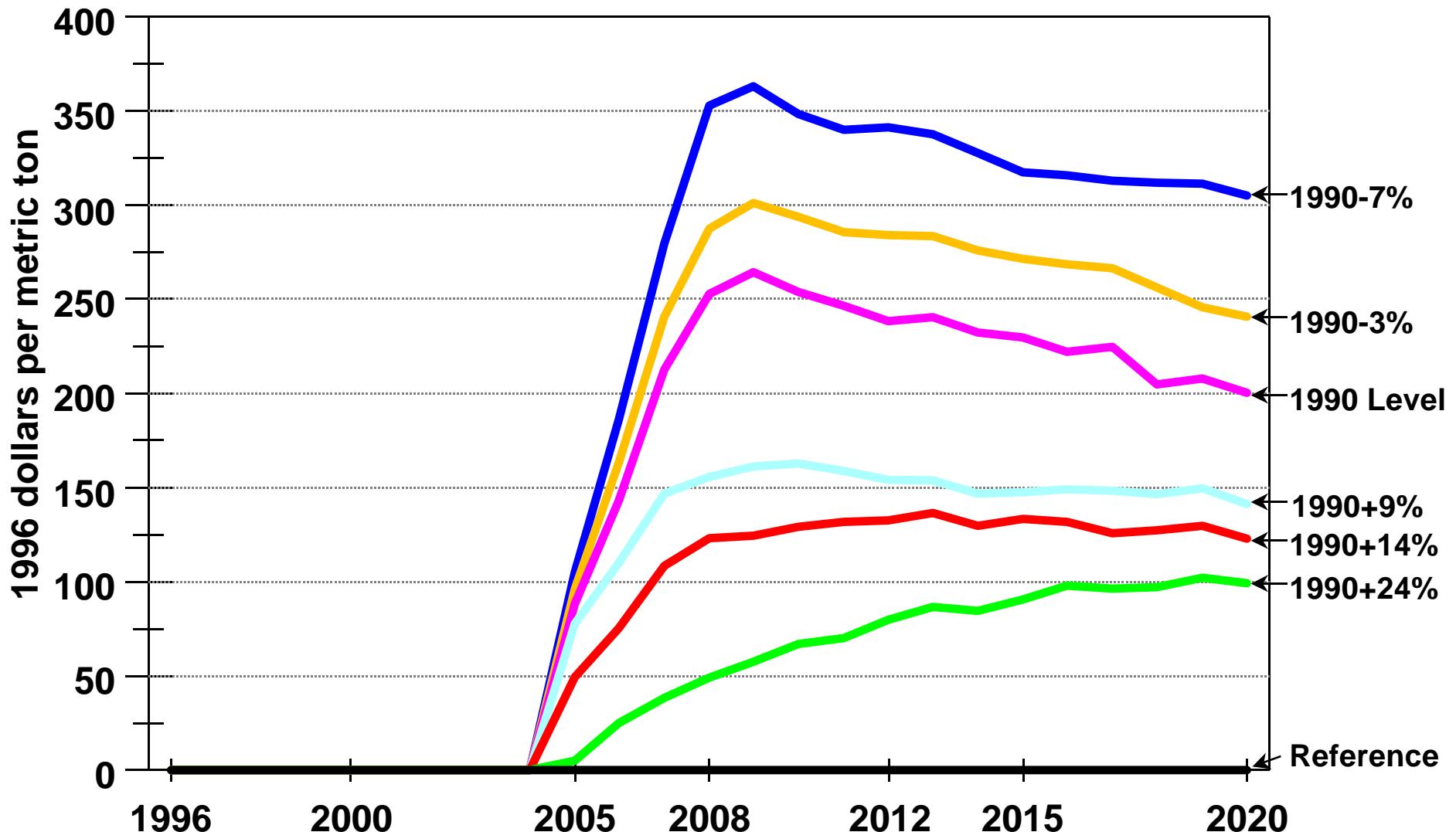
U.S. Carbon Emissions in Three Cases, 1995-2020 (million metric tons)



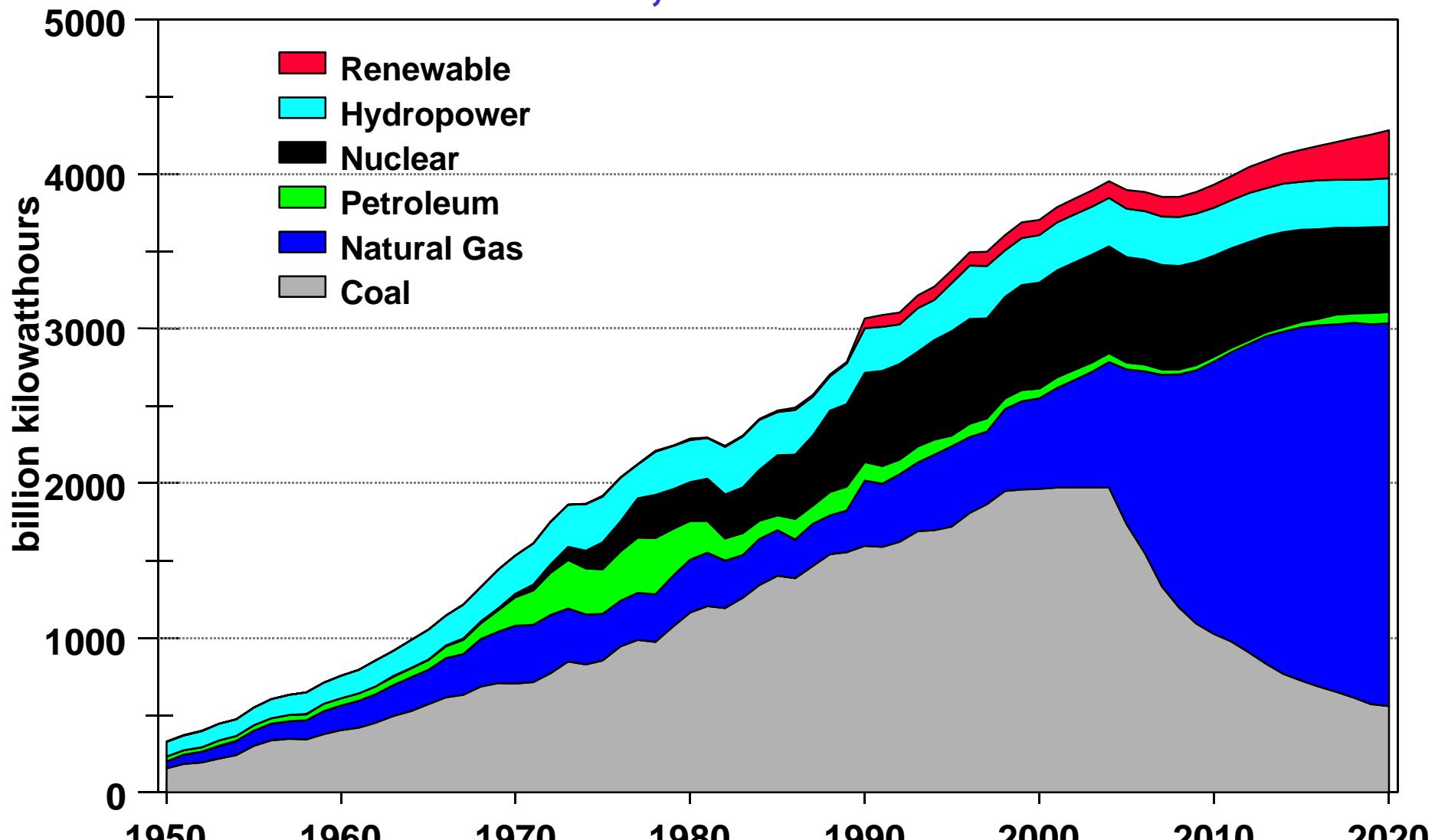
Carbon Emissions in the Reference and Six Target Cases, 1990-2020



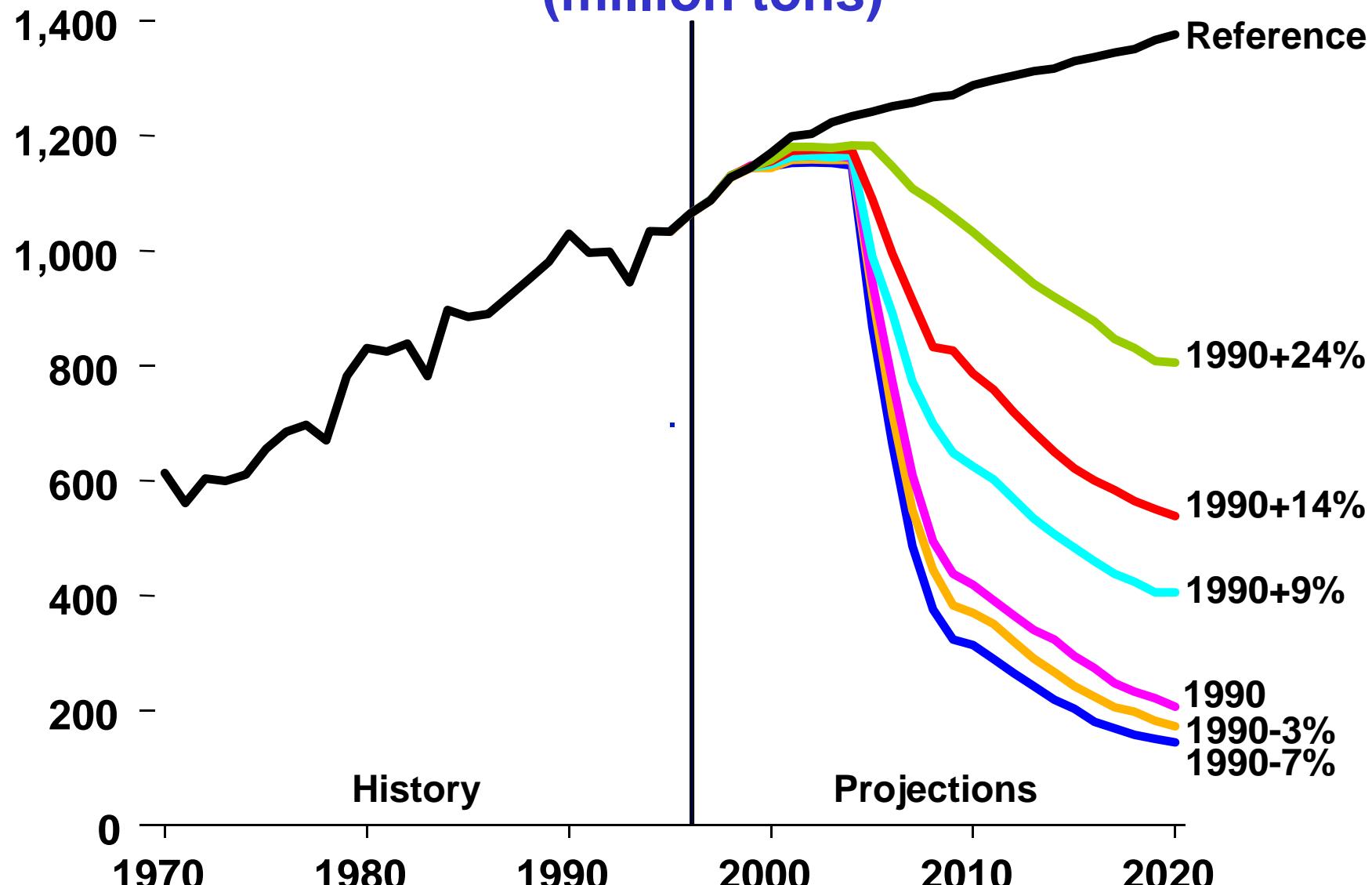
Carbon Prices in the Six Target Cases, 1996-2020



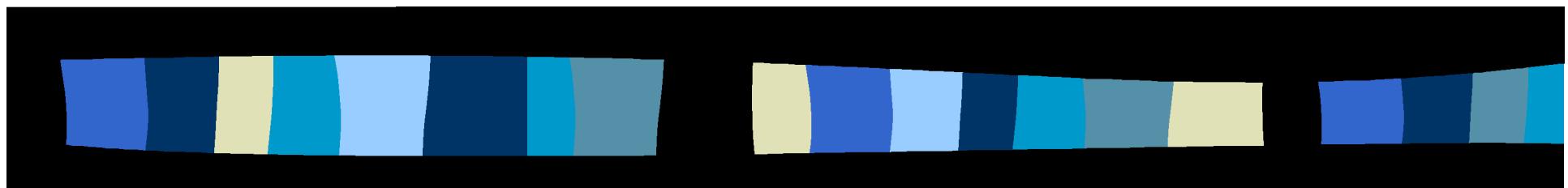
Electricity Generation by Fuel in the 9%-above-1990 Case, 1950-2020



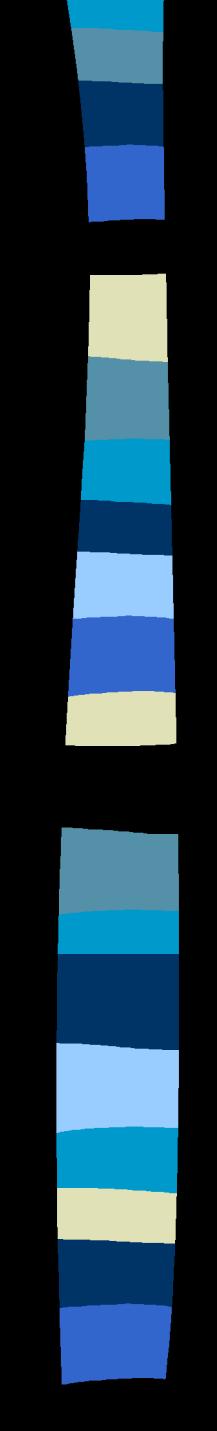
U.S. Coal Production, 1970-2020 (million tons)



Surface Coal Mining in West Virginia



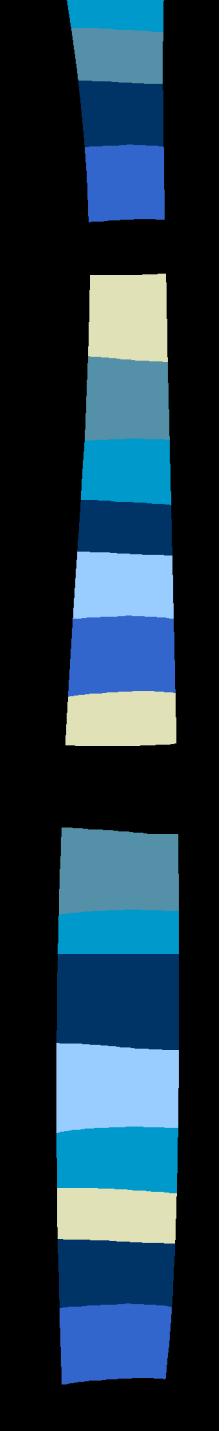
Some Expectations for the Future



Surface Mining Methods

■ Mountaintop Removal

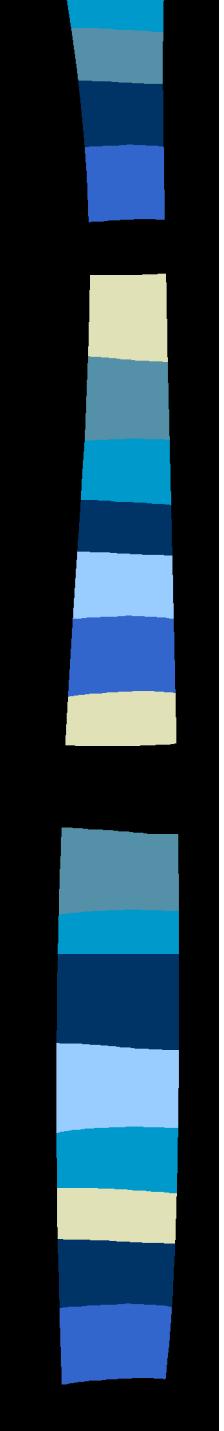
- Expect Existing Operations Mining to Depletion
 - Most Within ~10 Year Time Frame
- Reduction in New MTR Operations / Permits
 - Next 5 Years and Beyond
- Most Suitable Full Scale MTR Reserve Blocks
 - Either Currently Being Mined or Are “On the Board”



Surface Mining Methods

■ Multi-Method Surface Mining

- Expect Hybrid Operations to be More Prevalent
- Combination of Mining Methods on Single Sites
 - MTR & Area Mining
 - Point Removal
 - Contour Mining & Highwall Mining
 - Blast Casting & Dozer Production
- Methods Tailored Specific to the Reserve
 - Combined for Volume Efficiency
- Increase in Remining & Previously Marginal Sites



Surface Mining Equipment

■ Large Scale Mining Equipment

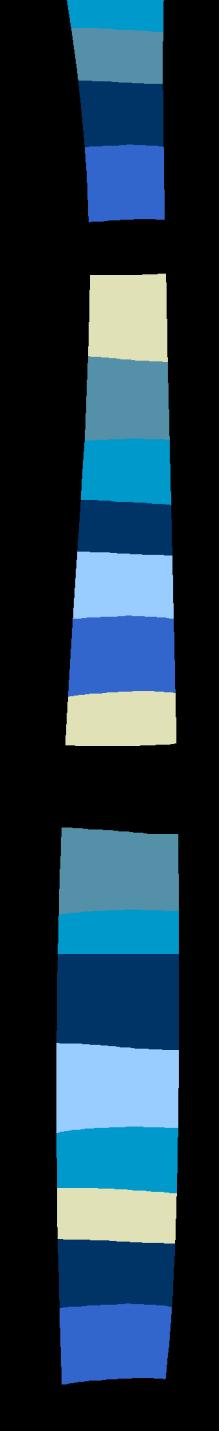
- Expect Limited Number of New Machines
 - Draglines & Shovel

■ Mobile Equipment

- Similarly Sized to Existing Equipment
 - Expect Technology, Productivity, & Efficiency Gains
 - Fuel Efficiency, Digital Technology, GPS, etc

■ Secondary & Highwall Mining Equipment

- Improvements in Productivity and Reliability
- Depth of Penetration Likely Limited by Reserves



Reclamation Techniques

■ **Regrading**

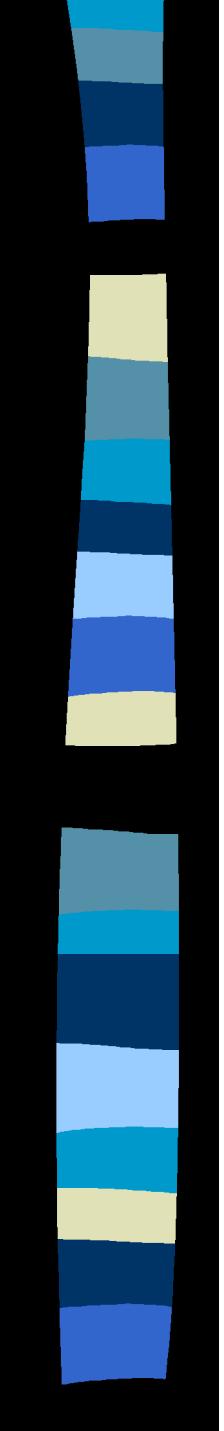
- Elimination of Over Compaction
 - Will Lead to Substantially Improved Reforestation

■ **Revegetation**

- Better Understanding of Interaction of Species
 - Improved Survival Rates & Less Re-Seeding

■ **Acid Mine Drainage**

- Expect Slow But Continual Technology Gains
 - Prevention Will Continue to be Best Approach



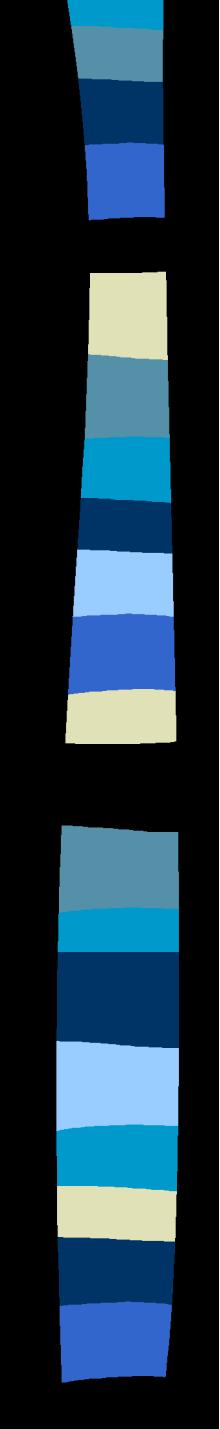
Environmental Impacts

■ Water Quality Improvement

- Existing Sites
 - More Consistent Flows & Lower Temperatures
 - Passage of Time
 - Rebound of Biological Populations
- Remined Sites
 - Opportunity to Eliminate Problem Areas
 - Incremental to Substantial Improvement Possible

■ Revegetation

- Expect More Commercial Woodland Projects



Coal Industry Impacts

■ Mining Companies

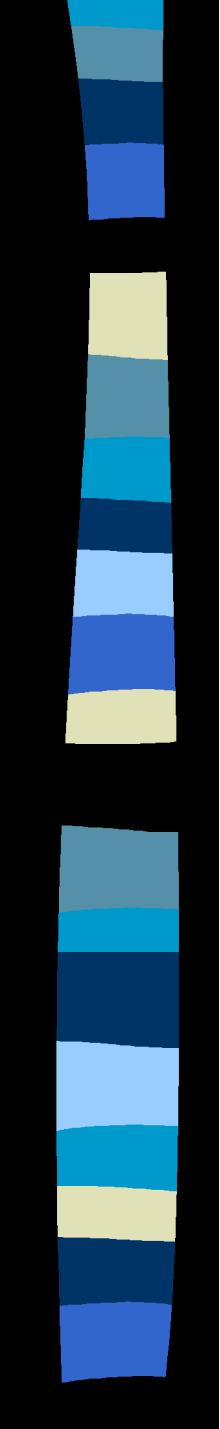
- Continued Consolidation Of Large Operators
- Small Operators Prosperous in Niche Markets

■ Productivity

- Modest Gains in Tons / Man Hour
 - Fueled by Technology and Competition

■ Overall Production

- Flat to Modest Increases Over Next 10 Years
- Overall Declines Beginning Thereafter



Impacts to Society

■ **Economic & Employment**

- Surface Mining Will Provide Substantial Economic Activity Over the Next 10 to 15 Years
 - Expect Some Declines in Direct Employment
 - Increased Secondary Employment Opportunities

■ **Post Mining Land Utilization**

- Many Entrepreneurial Opportunities Will Exist
- Location of Site and Infrastructure Will Play Biggest Role

■ **Unreclaimed & Problematic Sites**

- Can be Substantially Reduced with Cooperative Efforts

MOUNTAINTOP RECLAMATION: AOC AND EXCESS SPOIL DETERMINATIONS

To: Michael Miano, Director

From: AOC/Excess Spoil Guidance Team (WVDEP-David Dancy, Jim Pierce, Joe Ross, Ken Stollings, Ed Wojtowicz; OSM-Michael Superfesky, Michael Castle)

Subject: AOC/Excess Spoil Guidance

Date: March 18, 1999

Executive Summary

This guidance document, through the implementing regulations of the West Virginia Surface Coal Mining and Reclamation Act (WVSCMRA), provides an objective and systematic process for achieving approximate original contour (AOC) on steep-slope surface mine operations while providing a means for determining excess spoil quantities. Using this process maximizes the amount of mine spoil returned to the mined area while minimizing the amount of mine spoil placed in excess spoil disposal sites, i.e., valley fills. This, in turn, minimizes impacts to aquatic and terrestrial habitats through ensuring compliance with environmental performance standards imposed by WVSCMRA.

The definition of approximate original contour, as found in the Surface Mining and Coal Reclamation Act of 1977 (SMCRA) and WVSCMRA, requires that the final surface configuration, after backfilling and grading, closely resemble the general surface configuration of the land prior to mining while maintaining the necessary flexibility to accommodate site-specific conditions. A detailed analysis of the terms in the definition of AOC, along with additional reclamation requirements in the environmental performance standards of WVSCMRA and the promulgated rules serve to constrain what post-mining configuration is feasible. That is, a surface coal mining operation must meet not only AOC standards, but satisfy numerous other requirements including stability, access, and environmental provisions such as drainage, erosion and sediment control that influence the determination of AOC. Other factors that affect configuration are the diversity of the terrain, climate, biological, chemical and other physical conditions in the area and their impacts on fish, wildlife, and related environmental values.

The key variables found in the AOC definition, influencing AOC determination are: *configuration, backfilling and grading, disturbed area (mined area in SMCRA), terracing or access roads, closely resembles, and drainage patterns*. These variables, for analysis purposes, can be logically grouped into three focus areas: (A) configuration, (B) stability, and (C) drainage.

These focus areas are addressed through a formula-like model that portrays these variables in an objective yet flexible process for determining what post-mining surface configuration meets the

AOC definition. Applying this process during mine planning will determine the amount of total spoil material that must be retained in the mined-out area. The resultant post mining configuration should closely resemble the premining topography, thus satisfying not only the access, drainage control, sediment, and stability performance standards of WVSCMRA, but achieving approximate original contour as well. These same performance standards, applied in a similar formula-like model, determine the quantity of excess spoil that must be placed in excess spoil disposal site(s).

Using the AOC model in conjunction with the excess spoil model not only ensures compliance with the environmental performance standards of WVSCMRA, but provides an objective and feasible means for determining what constitutes compliance with the approximate original contour definition.

I. Applicable Provisions of State Law

Surface Mining Control and Reclamation Act of 1977 (SMCRA)

30 USC 1291 Section 701(2)

West Virginia Surface Coal Mining and Reclamation Act (WVSCMRA)

22-3-3(e)
22-3-13(d)(3)
22-3-13(b)(4)
22-3-13(b)(10)(B), (C), (F), (G)

West Virginia Surface Mining Reclamation Regulations (WVSMRR)

38 CSR 2-2.47
38 CSR 2-2.63
38 CSR 2-5.2, 5.3, 5.4
38 CSR 2-8, 8.a
38 CSR 2-14.5
38 CSR 2-14.8.a
38 CSR 2-14.14
38 CSR 2-14.15.a

II Objectives

This guidance document has been developed to accomplish the following objectives:

- Provide an objective process for achieving AOC while ensuring stability of backfill

material and minimization of sedimentation to streams.

- Provide an objective process for minimizing the quantity of excess spoil that can be placed in excess spoil disposal sites such as valley fills.
- Minimize watershed impacts by ensuring compliance with environmental performance standards imposed by WVSCMRA.
- Minimize impacts to aquatic and terrestrial habitats.
- Provide an objective process for use in permit reviews as well as field inspections during mining and reclamation phases.
- Maintain the flexibility necessary for addressing site-specific mining and reclamation conditions that require discretion by the regulatory authority as intended by WVSCMRA and Congress.

The West Virginia Division of Environmental Protection's (WVDEP) Office of Mining and Reclamation (OMR) recognizes the need for guidance on how the various performance standards of the West Virginia Surface Mining Control and Reclamation Act (WVSCMRA) and implementing regulations, West Virginia Surface Mining Reclamation Regulations (WVSMRR), Title 38, Series 2, influence the final land configuration following coal mining and reclamation. The following guidance document delineates the amount of excavated broken rock (also called mine spoil or overburden) that WVSCMRA considers "backfill," i.e., spoil placed in the mine area to restore the approximate original contour. Further, this document determines the amount of overburden or "excess" spoil that may be placed in excess spoil disposal sites outside the mining area or "pit." In so doing, this document provides guidance, as needed for WVSCMRA program administration in steep slope terrain, for determining whether the WVSCMRA provision of "approximate original contour," or AOC, has been attained.

Chapter 22, Article 3-13(b)(3) of WVSCMRA, as well as State and Federal regulations, requires all mining operations to return the mined areas to AOC, unless an appropriate variance is granted by the appropriate regulatory authority. Chapter 22, Article 3-3(e) of WVSCMRA defines AOC to mean,

"that surface configuration achieved by the backfilling and grading of the disturbed areas so that the reclaimed area, including any terracing or access roads, closely resembles the general surface configuration of the land prior to mining and blends into and complements the drainage pattern of the surrounding terrain, with all highwalls and spoil piles eliminated: Provided, That water impoundments may be permitted pursuant to subdivision (8), subsection (b), section thirteen of this article: Provided, however, That minor deviations may be permitted in order to minimize erosion and sedimentation,

retain moisture to assist revegetation, or to direct surface runoff.”

Section 701(2) of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) uses the term *mined area* instead of *disturbed area*. SMCRA requires that the mined area be reclaimed so that the area closely resembles the general surface mining configuration of the land prior to mining. Section 14.15 of WVSMRR requires, “Spoil returned to the mined-out area shall be backfilled and graded to the approximate original contour with all highwalls eliminated.” Section 2.89 of WVSMRR defines “pit” to mean “that part of the surface mining operation from which the mineral is being actively removed or where the mineral has been removed and the area has not been backfilled.” Section 2.47 of the WVSMRR regulations defines excess spoil as “overburden material disposed of in a location other than the pit.”

III. Elements of AOC Definition

In order to determine whether approximate original contour has been attained, processes must be developed to objectively assess what surface configuration *closely resembles the general surface configuration of the land prior to mining*, while maintaining the flexibility required to accommodate the *diversity in terrain, climate, biologic, chemical and other physical conditions in areas subject to mining operations*, as intended by Congress in Public Law 95-87 (SMCRA). To accomplish this, it is necessary to determine, and address, the variables that influence the postmining surface configuration. A detailed analysis of the terms in the definition of AOC, and additional reclamation requirements in the performance standards of WVSCMRA and the promulgated rules serve to constrain what post-mining configuration is feasible. That is, a surface coal mining operation must meet not only the AOC standards, but satisfy numerous other requirements, including stability, access, and environmental provisions such as drainage, erosion, and sediment control that influence the determination of AOC. Focusing on the collective requirements of WVSCMRA leads to an objective process for obtaining AOC.

The key variables found in the AOC definition, influencing AOC determination are: *configuration, backfilling and grading, disturbed area (mined area in SMCRA), terracing or access roads, closely resembles, and drainage patterns*. These variables logically group into the following three focus areas: (A) configuration, (B) stability, and (C) drainage.

A. Configuration: Configuration relates to the shape of regraded or reclaimed area after the reclamation phase. This shape should *closely resemble* the general pre-mining shape or surface configuration. However, final configuration, including elevation, is restricted or affected by the requirement to comply with performance standards found in WVSCMRA, such as ensuring stability, controlling drainage, and preventing stream sedimentation.

B. Stability: The second focus area, stability, concentrates on ensuring that the reclaimed configuration is stable. Section 22-3-13(b)(4) of WVSCMRA requires the

mining operation, at a minimum, to “Stabilize and protect all surface areas, including spoil piles, affected by the surface mining operation to effectively control erosion and attendant air and water pollution.” The WVSMRR also requires that spoil returned to the mined-out area to be backfilled and graded to achieve AOC (see 38 CSR-2-14.15.a.). The backfilling process places the spoil material in the mined-out area, while the grading process shapes and helps compact the material in a manner that ensures that the material is stable.

State regulations, (see 38 CSR-2-14.8.a. and 14.15.a) require the backfilled material to be placed in a manner that achieves a postmining slope necessary to achieve a minimum long-term static safety factor of 1.3, prevent slides, and minimize erosion. This is often obtained by using a combination of slopes and terraces (benches) as needed. Generally acceptable prudent engineering configurations are slopes of 2 horizontal to 1 vertical and terraces not to exceed 20 feet in width. The 2:1 slope is measured between the terraces. Compliance with these stability requirements, such as adding terraces and designed slopes, renders it virtually impossible to replicate the configuration of the land prior to mining. However, if backfilling and grading utilizes 2:1 slopes with terraces, the mine site will be reclaimed to a shape that closely resembles the pre-mining configuration.

C. Drainage: The third focus area, drainage, as referred to in the AOC definition, requires the postmining surface configuration to complement the drainage pattern of the surrounding terrain. WVSCMRA, see Section 22-3-13(b)(10)(B), (C), (F), and (G). WVSCMRA also requires the proposed operation “minimize the disturbances to the prevailing hydrologic balance at the mine-site and in associated offsite areas and to the quality and quantity of water in surface and groundwater systems both during and after surface mining operations and during reclamation...” Among these requirements are the prevention of stream sedimentation, construction of certified sediment structures prior to disturbance, restoration of recharge capacity of the mined area to approximate pre-mining conditions, and any other actions that the regulatory authority may require.

The State regulations, (see 38 CSR 2-2.63), define hydrologic balance to mean:

“the relationship between the quality and quantity of water inflow to, water outflow from a hydrologic unit including water stored in the unit. It encompasses the dynamic relationships among precipitation, runoff, evaporation, and changes in ground and surface water levels and storage capacity.”

Specific requirements for the protection of the hydrologic balance are found in 38 CSR 2-14.5; 38 CSR 2-5.2, 5.3 and 5.4. These performance measures require the minimization of disturbance to the hydrologic balance within the permit and adjacent areas as well as preventing material damage outside the permit area. The regulations provide appropriate measures for complying with these requirements through the use of designed diversions

channels and appurtenant drainage conveyance structures, designed sediment control structures, and measures, such as minimizing erosion, disturbing the smallest practical area at any one time, stabilizing the backfill, and retaining sediment within the disturbed area. As with stability, compliance with these drainage control requirements makes it virtually impossible to replicate the configuration of the land prior to mining.

Other performance standards that affect the reclamation configuration of the mine site must also be taken into account. If access to the reclaimed area is necessary, the placement of a road will obviously factor into the possible post-mining landform. The more flat areas cut into backfill slopes or placed on the mined bench at the toe of backfill, the more difficult it becomes to create a reclamation “template” that parallels the land configuration prior to mining. It is an absolute necessity to provide some combinations of these flat areas in a reclaimed mine backfill for access, as well as drainage and erosion control (sediment ditches, terraces, diversion channels), to conform with the environmental performance standards.

Another consideration in designing the post-mining configuration is minimizing the adverse impacts on fish, wildlife, and related environmental values (*see* 38 CSR 2-8). While seemingly general, when put into context with the requirements of the Fish and Wildlife Coordination Act and Clean Water Act, the provisions combine to limit mine site spoil disposal disturbances to stream channels and terrestrial habitats. This results in the requirement that excess spoil disposal should be confined to the smallest practicable site. Minimizing spoil disposal fill sizes means maximizing the amount of spoil backfill on the mining bench. Maximizing backfilling on the mine bench does not circumvent the need for stable backfill slopes, adequate drainage control, access roads (where necessary), and erosion/sediment control. However, it is feasible to configure a reclaimed area to satisfy configuration, stability, drainage control and also closely resemble the land surface that existed before mining. The planning process utilized in developing a surface coal mining permit application, while complex, can and must simultaneously satisfy all of these competing performance standards.

IV AOC and Excess Spoil Determination

This guidance document applies to steep-slope surface mining operations (*see* 38 CSR 2-14.8.a), including area mines and contour mines, that remove all or a large portion of the coal seam or seams running through the upper fractions of a mountain and propose to return the site to AOC. As described in the previous sections, many variables, such as stability requirements, drainage requirements, and sediment control requirements, affect or determine what the post-mining surface configuration, or shape, of the land will be at a steep slope surface coal mining operation proposing to return the site to AOC. Incorporating compliance with these performance standards into the proposed permit application requires the applicant to carefully plan the mining and reclamation phases of the proposed surface coal mining operation. This process requires, among other requirements, plans showing: post-mining contour maps, cross-sections, and profiles; spoil volume calculations; drainage structure designs; sediment control structure designs; access road

designs (if justified); spoil placement sequences; and excess spoil determinations and calculations. When these findings are integrated, the resulting surface configuration of the land should satisfy the Congressional intent, as presented in SMCRA, the Legislative intent as presented in WVSCMRA, and related regulations, of returning the land to AOC.

A. AOC Model: Portraying these performance standards as variables in a model or formula provides an objective, yet flexible, process for determining what post-mining surface configuration meets the AOC definition, while complying with the other performance standards in WVSCMRA. The following terms were developed and defined for use in the formula:

- OC** Pre-mining configuration, or volume of backfill material required to replicate the original contours of the undisturbed area proposed to be mined.
- SR** Backfill volume displaced due to compliance with stability requirements.
- DR** Backfill volume displaced due to compliance with drainage control requirements.
- SCR** Backfill volume displaced due to compliance with sediment control requirements.
- AR** Backfill volume displaced due to compliance with access/maintenance requirements.
- AOC** Volume of backfilled spoil required to satisfy the Congressional intent of SMCRA for approximate original contour.

This document uses the above acronyms for illustrative purposes only and are not intended to represent standard engineering terminology. Instead, they illustrate the AOC model process, rather than quantifying each term in the formula. While the terms can be quantified individually, this is not required by the AOC model process. Use of the model results in a reclamation configuration that can be quantified into a cumulative volume, accounting for the overall effect of the individual reclamation components which are performance standards in WVSCMRA. Volume calculations, however, are an integral requirement in order to satisfy the model.

The term “backfill volume displaced” refers not to specific volumes, but to the concept that, if not for complying with these performance standards, additional spoil or backfill material volumes could theoretically be placed in the location where these structures or slopes are proposed. (See Figure 1). In practice, however, placing additional spoil in

these location will violate other performance standards.

Details of Backfill Volume Displaced When Complying with Performance Standards

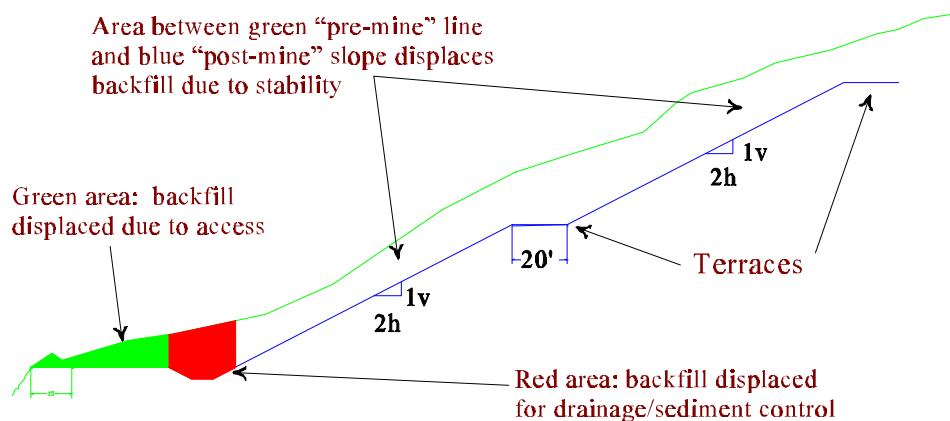


Figure 1

Based on the terms and illustrations used above, the following formula determines the amount of backfill which must be returned to the mined area to satisfy AOC.

$$\text{OC} - \text{SR} - \text{DR} - \text{SCR} - \text{AR} = \text{AOC}$$

Several of the terms must be further quantified to be used consistently in the AOC model:

Total Spoil Material (TSM) - Total spoil material is all of the overburden that must be handled as a result of the proposed mining operation. **TSM** will either be placed in the mined area or in excess spoil disposal sites (valley fill or pre-existing benches). This value is determined by combining the overburden (**OB**) volume over the uppermost coal seam to be excavated with the interburden (**IB**) volumes between the remaining lower coal seams. These values are typically expressed as bank cubic yards (bcy).

TSM volumes are determined by using standard engineering practice, such as average-end area, stage-volume calculations, or 3-dimensional (3-D) grid subtraction methods. The regulatory authority must have adequate information submitted by the applicant to **TSM** properly evaluate **TSM** calculations. If the applicant utilizes an average-end area method, cross-sections must be supplied for a base line or lines, at an interval no less than every 500 feet—or more frequently, if the shape of the pre-mined area is highly variable between

the 500-foot intervals. If the applicant utilizes a stage-storage method, planimetered areas should also be determined on a contour interval (CI) that is representative and reflects any significant changes in slope (20' CI or less recommended). If a 3-D model is used, the pre-mining contour map and, if possible, a 3-D model graphic should be provided. The grid node spacings used in generating volumetrics should be identified. If digital data is utilized by the applicant, it should be in a format and on a media acceptable to the regulatory authority.

TSM is determined by calculating the in-situ overburden and interburden volume, multiplied by a “bulking” factor (**BF**). Bulking factors are calculated by a two-step process: 1) “swell” volume is determined from the amount of expected expansion of in-situ material through the incorporation of air-filled void spaces; 2) “shrink” volume can be calculated from the amount the swelled material compacts during placement (reducing the void spaces and, consequently, the volume). Thus, the bulking factor is the swell factor minus the shrink factor, which varies based on the overburden lithology (e.g., sandstone swells more and shrinks less than shales). **TSM** is reported in cubic yards (cy). Permit applications should contain a justification of the weighted bulking factor utilized-based not only on the weighting of individual swell factors calculated for each major rock type to be excavated that will be placed in the backfill, but on the shrinkage or compaction factor due to spoil placement methods as well. In equation form:

$$(\mathbf{OB} + \mathbf{IB}) \times \mathbf{BF} = \mathbf{TSM}$$

Spoil Placement Areas - There are only two areas that **TSM** can be placed: 1) disturbed area (mined area in SMCRA) or backfill (**BFA**); and, 2) excess spoil disposal areas (**ESD**), i.e. valley fills.

BFA the backfill area, referred to as the mine area, is generally thought of as the area between, if viewed from a cross-section, the outcrop boundaries of the lowest coal seam being mined. (See Figure 2)

ESD excess spoil disposal sites are areas **outside of the mined area** used for placement of excess spoil. (See Figure 2)

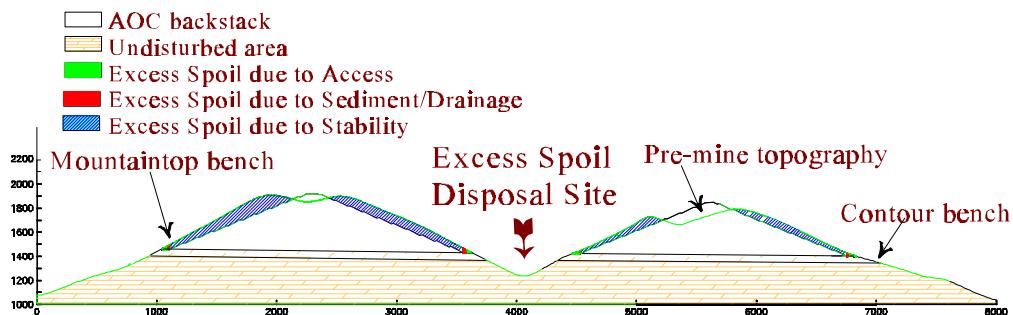


Figure 2

Original Contour (OC) - The original configuration of the mine area is determined from topographic maps of the proposed permit area. This configuration is developed through the use of appropriate cross-sections, slope measurements, and standard engineering procedures. Sufficiently detailed topographic maps, adequate numbers of cross-sections, or labeled 3-D model grids/graphics should be submitted that illustrate the representative pre-mine topography and slopes. Digital data should be submitted with the application in a format and on a media acceptable to the regulatory authority.

Stability Requirements (SR) - The concept of stability, in this model, focuses on the stability of the slopes of the spoil material placed in the backfill areas or excess spoil disposal sites. The spoil material must be placed in such a manner as to prevent slides or sudden failures of the slopes. State regulations require that slopes be designed to prevent slides and achieve a minimum, long-term static safety factor of 1.3. This safety factor should be the result of a worst-case stability analysis. There are standard engineering analytical procedures, that use unique shear strength and pore water pressure factors of the spoil material, for performing slope stability analyses. Therefore, it is the spoil strength characteristics and the water level anticipated within the backfill that determine the slope to which material can be placed and satisfy the safety factor requirement of the Federal and state counterpart regulations.

A generally acceptable practice, unless it results in a safety factor of less than 1.3, includes grading the backfill slopes (between the terraces) on a 2 horizontal to a 1 vertical ratio (2H:1V, or a 50 feet rise in 100 foot of slope length) and placing terraces where appropriate or required to control erosion or surface water runoff diversion (See Figure 3). It may be theoretically possible to place spoil on slopes steeper than 2:1, but other performance requirements may not recommend exceeding 2:1 slopes. For example, the Mine Safety and Health Administration recommends that slopes not be greater (steeper)

than 2:1, because that is the maximum safe slope for operation of tracked-equipment.

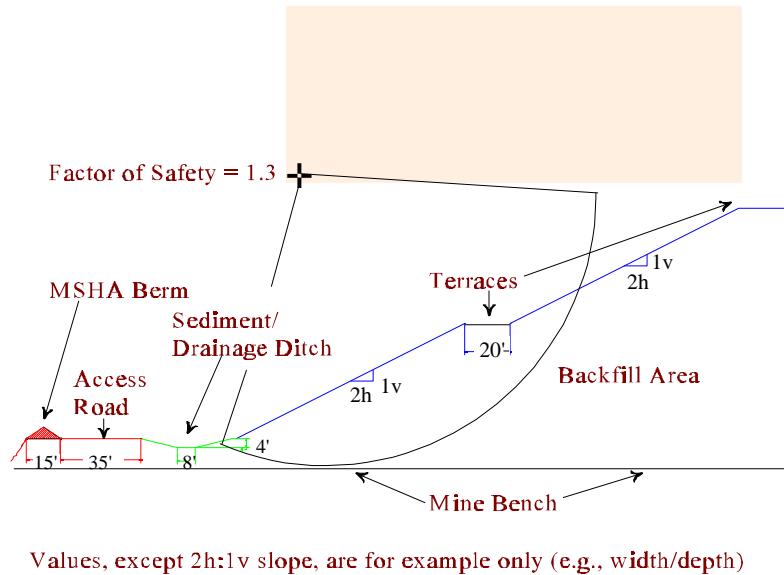


Figure 3

Slopes shallower or less than 2:1, with appropriate terraces, would result in more excess spoil material and would not closely resemble pre-mining configuration. Thus, the basis for these slopes would have to be documented based on engineering practices and approved by the regulatory authority. For example, if overburden and interburden were predominantly weak shales that cannot attain a 1.3 factor of safety at 2:1 slopes, more gentle slopes could be justified. The 2:1 backfill slope, and associated terraces or drainage conveyances will determine the ultimate backfill height for the mined area. This final elevation may be lower than the pre-mining elevation, approximate the pre-mining elevation, or exceed the pre-mining elevation.

However, as can be seen in Figure 4, this reclamation technique results in a configuration or shape that closely resembles the premining configuration, when defining the “approximate original contour.”

Drainage Control Requirements (DR) - Drainage structures are used to divert or convey surface runoff away from the disturbed area, after complying with effluent standards. These structures must be properly designed to adequately pass the designed flow. These structures are designed using standard engineering practices and theory. The purpose of these structures is to minimize the adverse impacts to the hydrologic balance (e.g., erosion, sedimentation, infiltration and contact with acid/toxic materials, etc.) within the permit area and adjacent areas, as well as prevent material damage outside the permit area

while ensuring the safety of the public. The size and location of these structures vary throughout the permit area depending on factors, such as travel time, time of concentration, degree of slope, design peak runoff curve, and depth, length, and width of drainage structures. The size and location of these structures necessarily reduce backfill spoil volume because of the flat area required to properly construct effective structures and meet drainage requirements.

Sediment Control Requirements (SCR) - Sediment control structures, like drainage control structures, are used to minimize the adverse impacts to the hydrologic balance within the permit area and adjacent areas, as well as prevent material damage to areas outside the permit area while ensuring the safety of the public. Their primary purpose is to prevent, to the extent possible, additional contributions of sediment to stream flow or to runoff outside the permit area. Oftentimes, drainage control structures and sediment control structures are combined into a single dual-purpose structure, i.e., the sediment control structure discharges from the disturbed area. These structures must be properly designed to accommodate the required sedimentation storage capacity and are designed using standard engineering practices and theory. As with drainage structures, the size and location of these structures dictate the amount of flat area that will, consequently, displace backfill spoil storage. When reviewing the size and placement of these structures for adequacy in meeting effluent and drainage control requirements, the regulatory authority will also assess the design plans to assure the structures are no larger/wider than needed for proper design.

Access/Maintenance Roads (AR) - these structures are often necessary to gain access to sediment control structures for cleaning and maintenance. They may also serve to provide principal access to the mining operation and reclamation areas. The size and location of these roads or benches will vary throughout the minesite and should be based on documented need. This distinction is important, because the larger the road, the more backfill material displaced which will increase the size of the excess spoil disposal sites. The regulatory authority permit review should evaluate the necessity for roads in the final reclamation configuration and approve only those widths suited for the road purpose and equipment size.

The top of the backfill should be no wider/flatter than is necessary for safely negotiating the largest reclamation equipment utilized for the mine site (see Figure 4). Areas larger than necessary to work this equipment would need to be documented and approved by the regulatory authority. The final configuration of the top of the backfill should be graded in a manner to facilitate drainage and prevent saturation.

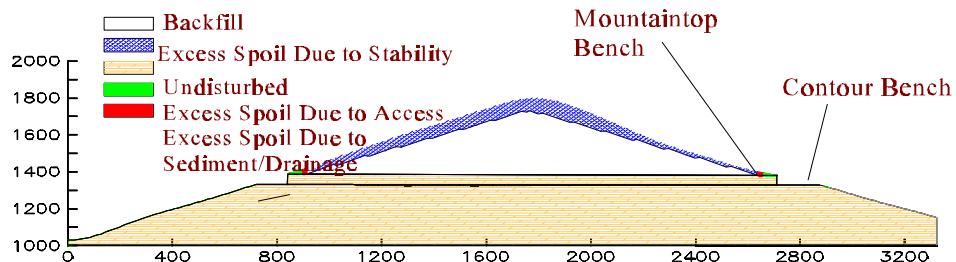


Figure 4a-results in lower elevation than pre-mining

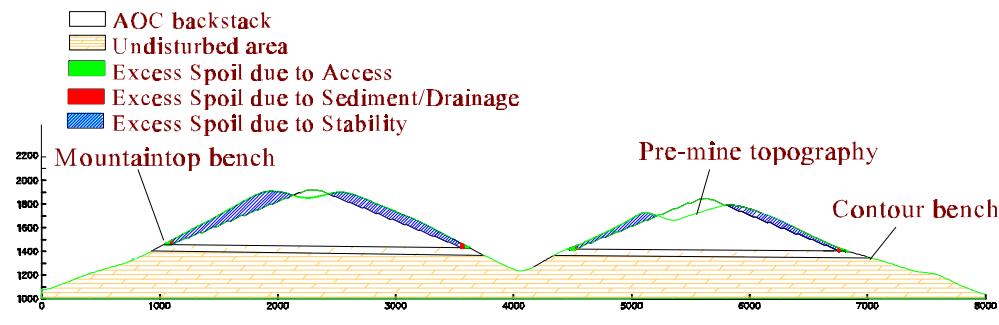


Figure 4b- results in approximately pre-mining elevation

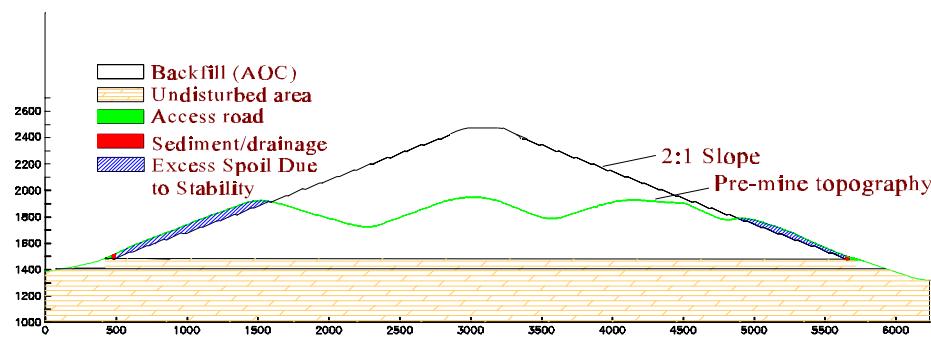


Figure 4c-results in higher elevation than pre-mining

Figure 4. Restoring contours and meeting performance standards

B. AOC Process Determination

Applying these performance requirements in the mine planning process will determine the amount of total spoil material which must be retained in the mined-out area. The backfill material that will be placed within the mined-out area can be backfilled in a flexible configuration, in accordance with a practical mine sequencing and haulback operation. Consequently, the resultant post-mining configuration should closely resemble the pre-mining topography, thus satisfying not only the access, drainage, sediment, and stability performance standards of WVSCMRA, but AOC in addition (See Figure 4).

Summarizing the formula or process:

$$\text{Formula: } \mathbf{OC - SR - DR - SCR - AR = AOC}$$

Step 1: Determine original or pre-mining configuration (Original Contour (**OC**))

Step 2: Subtract from Original Contour:

Volume displaced due to Stability Requirements (**SR**) (based on documented plans)

Volume displaced due to Drainage Requirements (**DR**) (based on documented plans)

Volume displaced due to Sediment Control Requirements (**SCR**) (based on documented plans)

Volume displaced due to Access Requirements (**AR**) (based on documented plans)

Step 3: Evaluate results. The remaining volume is what has been termed backfill (**BKF**) or spoil material placed in mined-out area. The configuration of this backfill material will be (point where 2:1 outslopes begin) dependent on the placement of roads, sediment, and drainage control structures (see Figures 1, 3 and 4)

Step 4: This is an iterative process that is linked to the placement of excess spoil in excess spoil disposal sites.

C. Excess Spoil Determination Model: The parameters used in the formula developed for determining the quantity of backfill material also are used to develop a model or

formula for determining the quantity of excess spoil. As with the backfill quantity formula, converting these variables into a model or formula provides an objective, yet flexible, process for determining what is truly excess spoil—while complying with the performance standards in WVSCMRA.

Applicable terms and concepts used in the development of the model:

TSM Total spoil material to be handled or available. This material will be classified as either backfill material (**BKF**) or excess spoil material (**ES**)

OC Pre-mining configuration, or volume of backfill material required to replicate the original contours of the undisturbed area proposed to be mined.

SR Backfill volume displaced due to compliance with stability requirements.

DR Backfill volume displaced due to compliance with drainage control requirements.

SCR Backfill volume displaced due to compliance with sediment control requirements.

AR Backfill volume displaced due to compliance with access/maintenance requirements.

AOC Volume of backfilled spoil required to satisfy the intent of WVSCMRA for approximate original contour.

BKF Volume of backfill or spoil material placed in the mined area

ES Volume of excess spoil remaining after satisfying **AOC** by backfilling and grading to meet **SR**, **DR**, **SCR**, **AR**.

The term “backfill volume displaced” refers not to specific volumes, but to the concept that, if not for complying with these performance standards, additional spoil or backfill material volumes could theoretically be placed in the location where these structures or slopes are proposed (See Figure 1). Spoil material unable to be placed in backfill area (in order to comply with all other performance standards), by default, must be excess spoil (**ES**), and placed in an approved excess spoil disposal site(s). The process for quantifying these terms is in Section IV A, above.

The **ES** quantity, as determined by the following formula, is obtained by complying with the

stability (slopes) standards as well as incorporating the other performance standards such as drainage controls, sediment control, and access/maintenance requirements.

The excess spoil relationships.

$$\mathbf{ES = TSM - BKF}$$

$$\text{Since } \mathbf{BKF = OC - (SR + DR + SCR + AR),}$$

Therefore:

$$\mathbf{ES = TSM - (OC - (SR + DR + SCR + AR))}$$

The regulatory authority should carefully evaluate the spoil balance information provided in the permit application to assure that excess spoil volumes are not inflated merely for achieving cost savings from material handling costs. Inflated excess spoil volumes would most likely occur because of wider or more numerous flat areas than required for drainage, sediment, or erosion control; access roads; or top of backfill areas. Use of backfill slopes less than 2:1 would also increase the excess spoil disposal. Permits that propose to conduct steep-slope surface mining operations, but change plans due to unanticipated field conditions (e.g., mining reduced to contour strip from area mining), should submit permit revisions containing revised volumetric calculations and excess spoil designs.

Solving this formula establishes the quantity of excess spoil material (**ES**) that must be placed in an excess spoil disposal site(s) (See Figure 2). Generally this **ES** volume, and/or mining logistics, requires more than one site. Typically, in steep-slope regions of Appalachia, excess spoil is placed in adjacent valleys. In areas where extensive “pre-law” mining (prior to passage of SMCRA, or August 3, 1977) has occurred, pre-existing benches are commonplace. Sometimes, operations utilize adjacent pre-existing benches (without coal removal occurring) as part of the permitted area for excess spoil disposal—if in close proximity to the operation. More often, pre-existing benches are part of the mined area, and provide for storage of additional backfill material—ultimately reducing the volume of excess spoil. Performance standards for excess spoil disposal areas are found in 38 CSR 2-14.14.

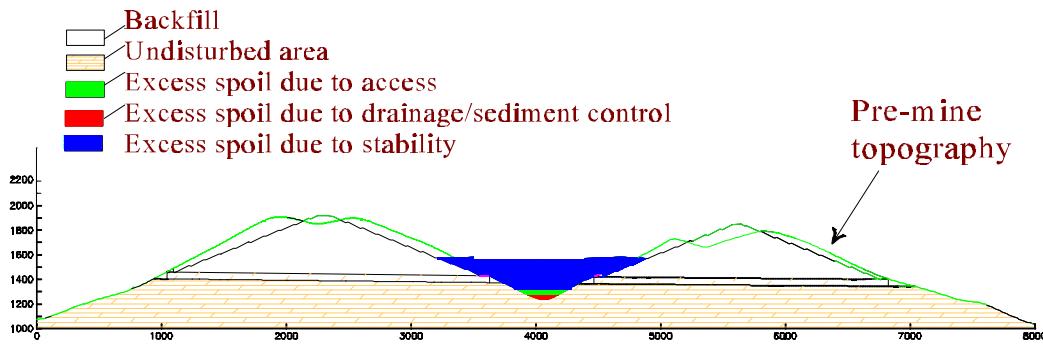
The most common site selected to place excess spoil is in the adjacent valleys. Site selection is typically made by calculating a stage-storage-volume curve for each valley adjacent to the mining operation. This stage-storage relationship changes, dependent on the point in the valley from which the downstream limits of fill is established. The permit application should contain the alternative stage-storage-volume data illustrating the various valley capacities for excess spoil storage dependent on toe location and crest elevation.

If pre-existing benches are to be used as excess spoil disposal sites, the capacity of each pre-existing bench area must be calculated. Typically these calculations utilize the average-end area method based on cross-sections representing the site configuration. After determining the capacity of these sites, the total value determined for excess spoil will be reduced by this value. The remaining quantity of excess spoil will then be placed in an adjacent valley(s), as described above.

Other factors, besides the quantity of material, that go into this **ES** site selection may include: 1) if a valley, the steepness of the valley profile (so as not to exceed 20 percent for durable rock fills or other value designated by regulatory authority relative to design changes for additional stability); 2) location in relation to mining phase; and, 3) other statutory requirements, such as the size of watershed that can be disturbed without additional permitting requirements.

Regardless of which factor(s) determine the location of the toe of the fill, the process is an iterative procedure that requires the available backfill and excess spoil material to balance, consistent with the formula developed above. After this material balance is achieved, the excess spoil disposal areas are designed to accommodate this quantity of excess spoil. If the excess spoil disposal site is a valley fill, this design will determine the height or elevation of the crest (top) of the excess spoil disposal site or fill. Once this design is complete, and top of fill elevation is determined, the next step would be to repeat or perform another iteration using the AOC model or process (See Figure 5).

If the excess spoil disposal sites are pre-existing bench areas, the sites are designed to accommodate the calculated quantity of excess spoil, while complying with the performance standards imposed by the regulatory authority's regulations.



Height of fill area determined through material balance process

Figure 5

D. Combining AOC Model with Excess Spoil Determination Model: The excess spoil model in Section IV B establishes the quantity of material that must be placed in an excess spoil disposal site(s). Performing a material balance, comparing the excess spoil volumes with the valley storage possibilities established the height or elevation of the fills. At least a second iteration of the AOC model must be performed to establish the final reclamation configuration. Before performing a new iteration of the AOC model (as in Section IV A), another term or concept must be introduced. The new concept determines the interface between the backfill area and the excess spoil disposal area. (See Figure 2). This demarcation can be used consistently in any steep slope mining situation, and is determined using the following process:

Locate the outcrop of the lowest seam being mined, whether contour cut only or removal of the entire seam. (See Figure 6)

Project a vertical line upward beyond the crest of the fill and backfill elevations (See Figure 2).

The area where coal removal occurs, to one side of this line, is backfill area (BFA); and, the area on the other side of the line, including the valley bottom, is excess spoil disposal area (see Figure 2).

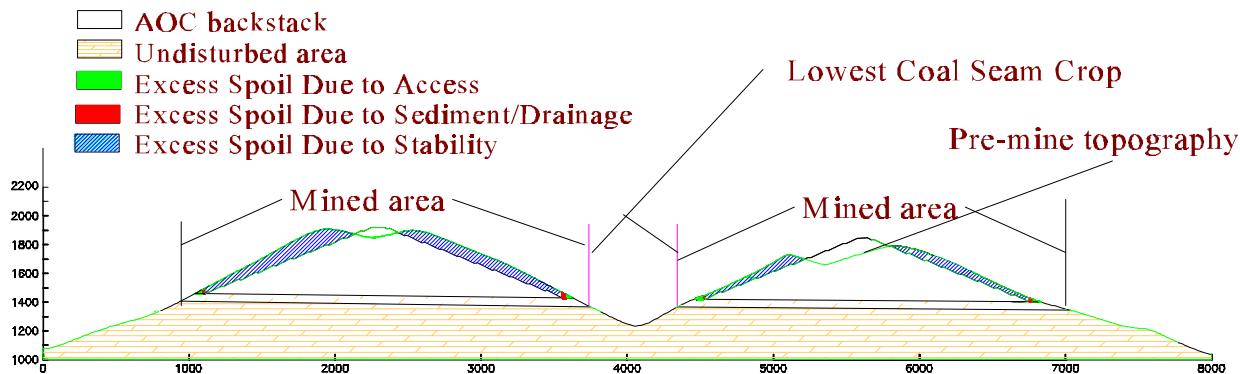


Figure 6. Lowest coal seam outcrop and mined area

Establishing this boundary between excess spoil areas and backfill areas is not arbitrary. It is the same procedure used by some regulatory authorities in determining where permanent diversion ditches must be located. Also, this boundary establishes where permanent sediment control structures may be placed without being considered a violation of the prohibition of locating a permanent impoundment on an excess spoil disposal site.

This point becomes a reference line to perform the second or additional iterations of the AOC model used in Section IV A. That is, the road access, stability, drainage, sediment control analysis is applied to establish where backfilling at a 2:1 slope begins. The additional material placed on the mined area as a result of the iteration process creates the need to perform another material balance exercise, as described above in Section IV B. This readjustment of the material balance may result in a reduction of excess spoil volume. In either case, the elevation of the fills would not be lowered, but instead the material balance would result in a reduction of length of the fills or possibly the elimination of some proposed fills (See Figures 7 and 8).

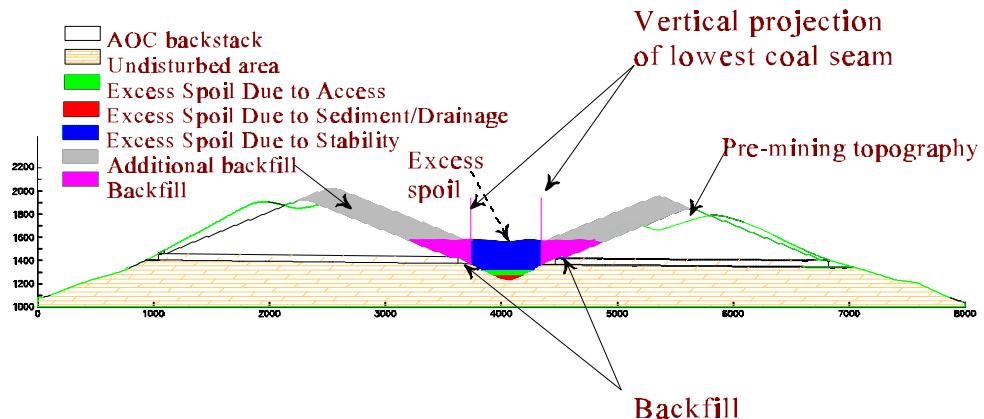


Figure 7

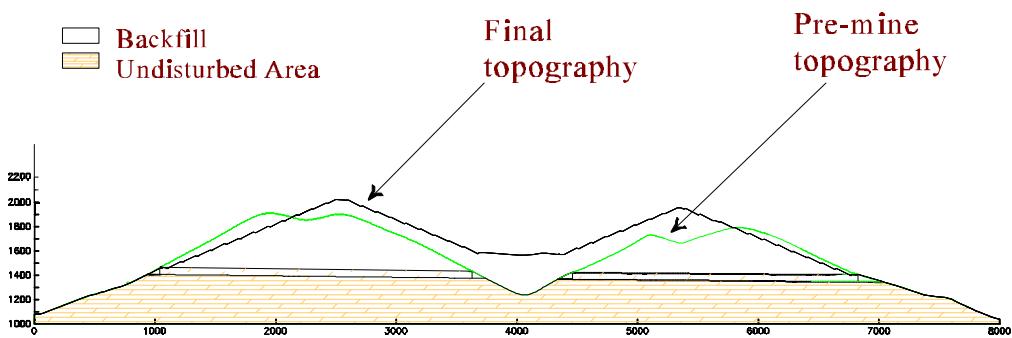


Figure 8

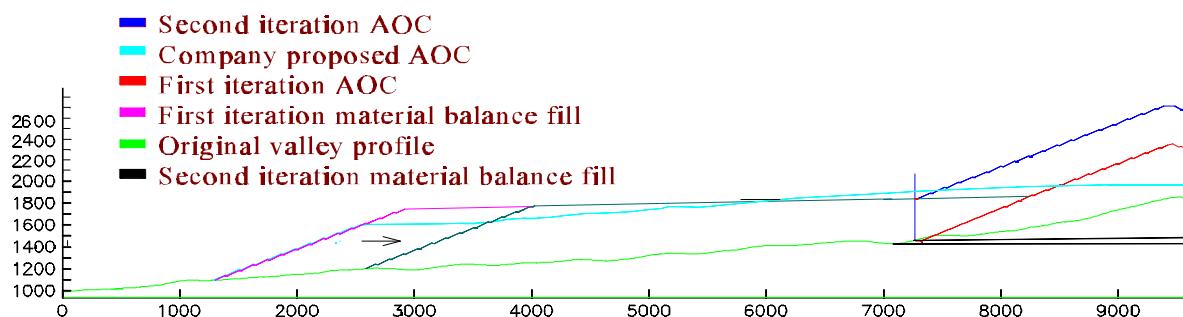


Figure 9. How the AOC process affects fill length

Reevaluation of fill designs using this second iteration becomes an important component of the permit design. Reduction in fill lengths could result in the toe of the fill being placed upon too steep of a slope—requiring additional material excavation for a keyway cut, or additional material placement for a stabilizing toe buttress.

However, this process may still result in large flat areas at the fill crest that could be used to store additional backfill. This provides the further option of storing additional excess spoil in the crest area—reducing excess spoil fill length. This option would further minimize terrestrial and aquatic impacts in the excess spoil disposal area because the toe of the fill would move upstream (See Figure 9).

E. Contour Mining Operations: Contour mining excavates only part of the mountainside, leaving undisturbed areas above and below the excavation (see Figure 10). The mining phase of a contour mine creates a cliff-like highwall and shelf-like bench on the hillside that must be restored to approximate original contour, with the highwall completely eliminated, in the reclamation phase. The AOC/excess spoil determination models, described in IV A-C, are used to achieve AOC and determine excess spoil volumes for this type of surface mining operation as well.

For example, a contour mine typically takes one (1) contour “cut” (see Figure 10) and progresses around the coal outcrop, leaving a highwall and bench after the coal is removed.

Reclaiming the site, utilizing the AOC process, would require documentation showing drainage structure designs, access road requirements, and properly designed sediment structures. The application would also require documentation demonstrating the stability of the outslope of the material placed in the backfill area. Regulations require that slopes be designed to prevent slides and achieve a minimum long-term static safety factor of 1.3. A generally acceptable practice, unless it results in a static safety factor of less than 1.3, includes grading the backfill slopes (between terraces where required) on a 2 horizontal to a 1 vertical ratio (2H:1V) (See Section IV A for details). If compliance with the other performance standards, i.e., drainage, access, and sediment control, result in backfill outslopes being steeper than 2:1, the application should contain adequate documentation that the backfill configuration meets a 1.3 static safety factor (see Figure 10). Documentation described in Section IV A would be required if slopes flatter than 2:1 are proposed.

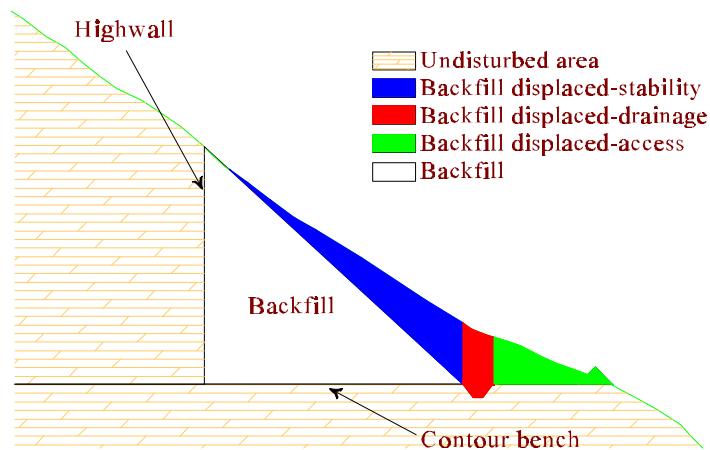


Figure 10

Oftentimes, contour mining operations encounter long, narrow ridges or points that require more than one cut to recover the coal seam(s). Although the mining phase utilizes both the contour and area mining methods when this occurs, the AOC/excess spoil determination models are used in the same way for determining AOC and excess spoil volumes. The same principles and performance standards apply—drainage, sediment control, and access requirements must be designed and documented. Also, compliance with the stability requirements for the outslopes of the backfill must be achieved and documented.

However, in order to comply with these requirements and achieve AOC, the reclamation phase of these sites must integrate two perspectives when utilizing the AOC model: 1) elimination of the highwall (perpendicular to the ridge line); and, 2) returning all spoil material that is not excess spoil to the mined area(s) (the area between the highwall and the

end of the ridge line). Combining the two perspectives results in a postmining configuration that closely resembles the general configuration of the ridge or point prior to mining, while still complying with the performance standards discussed earlier in Section IV A- D.

To obtain a hard copy of following articles written by Horst J. Schor, contact:

H. J. Schor Consulting
626 North Pioneer Drive
Anaheim, CA 92805

Phone: 714-778-3767
Fax: 714-778-7656

[Article 1 - Grading on the Curve](#)

[Article 2 - Landform Grading: Building on the Curve](#)

[Article 3 - Landform Grading Comparative Definitions of Grading Design](#)

[Article 4 - Landform Grading and Slope Evolution](#)

BUSINESS

ORANGE COUNTY
Los Angeles Times

Landform grading sculpts the hillside of Talega project into new shapes in technique created by Horst Schor.

Grading on the Curve

Developer Goes for Natural Look in Sculpting Hills for Talega Project

By JOHN O'DELL
TIMES STAFF WRITER

Fred Moeller has been operating bulldozers for almost 40 years now, piling dirt, cutting trenches and grading slopes all over Southern California. But for all that experience, Moeller has never been on a job quite like this one.

Usually, when preparing hillsides and valleys for a housing project, Moeller and other heavy-equipment operators are asked to prepare a staircase arrangement of flat-faced slopes with building pads on top.

At Arvida Co.'s Talega development in the hills just inland of Orange County's southernmost city, the rules have changed.

Moeller and fellow operators are being asked to think like sculptors as they follow a complex natural grading plan that can help create slopes, valleys, gullies, hillocks and ridges for the homes and commercial buildings that will one day dot the 3,500-acre master-planned community.

In some places they are merely altering existing slopes to accommodate building pads. In others they are creating hills where none ever existed.

The grading process was invented in the late 1970s by Horst Schor, now Arvida's vice president for development. At the time, Schor worked for the Anaheim Hills Co. as it was developing its hillside community on the southern slopes of Santa Ana Canyon.



KEN RIVELY / Los Angeles Times

But no one else ever picked up on the idea, Schor said, despite the industry publicity the technique received at the time when the American Planning Assoc. bestowed an award of merit on Anaheim Hills Co. for its innovative natural grading plan.

One reason other developers didn't adopt what Schor calls landform grading is that it costs a little more—adding about 1% to a project's grading costs—and requires a little effort to train the grading crews.

"But Arvida feels the time is really ripe for this," he said. Environmental concerns and complaints about development that destroys natural landscape and ridgesides can delay projects for months, even years.

Schor said Arvida's natural grading plan shaved at least 12 months off the time it took to get approval from San Clemente officials for the Talega development—which is located partly within the city and partly in unincorporated county territory. The time saved can more than make up for the extra grading costs.

There are three key elements of landform grading, he said Thursday during a demonstration of the process:

- Building hills and slopes with natural contours;
- Putting the drainage system into the flow of the land so it follows the valley bottoms like a natural creek system instead of cutting straight down the face of slopes with concrete channels, as is done in a typical stair-step grading plan; and

Please see TALEGA, D7



FRIDAY

JULY 12, 1991

CC*

BUSINESS

ORANGE COUNTY
Los Angeles Times

Grading on the Curve

Developer Goes for Natural Look in Sculpting Hills for Talega Project

[continued]

Continued from D6

■ Designing a natural landscape plan that mimics nature by placing the trees and shrubs in the valleys and on flat spots, where the heaviest runoff collects, and covers the protruding areas with less-thirsty ground covers.

For Morlier, who spent Thursday morning contouring a small hill with a 25-ton Caterpillar bulldozer, the process isn't much more difficult than building a traditional staircase.

"It's a lot more challenging, because you're not just going in straight lines."

Russ Churchill, who works with Morlier and the other equipment operators as a grade checker—overseeing their work from the ground to make sure they are following the grading plan—said there is a lot more for him to concentrate on in a landform grading project.

"It's challenging," said Churchill, "but it is very satisfying to see the end result. I didn't really see the whole thing we're working on here until the other day when I was leaving the site about 6 in the evening and happened to look back up the road and saw it all highlighted with the setting sun and the shadows. It was really awesome."

GLENN KONING / Los Angeles Times
Traditional grading of sites for homes is shown in picture of Tuscany Hills development in Lake Elsinore area.

Landform Grading: Building Nature's Slopes

By HORST SCHOR
Senior Vice President, Anaheim Hills, Inc.

The advantages and necessities of hillside living are becoming more widely evident as flatlands—the traditional building sites—are consumed by housing, industry and agribusiness.

However, hillside building can require massive grading that may become the focal point of local resistance, thus impeding planning approval. The innovative "landform" grading method was born of negative impressions gained in viewing the conventional, linear slopes commonly manufactured throughout the building industry.

Hills agreed to finance the experimentation and to use the results in the community.

There seemed to be no reason we couldn't grade the slopes to resemble natural slopes. The question then arose: what do natural slopes look like? Curiously, there was no published information about slope shapes as a total unit. We were on our own.

Project research involved study of slopes in such diverse areas as Death Valley, Brazil, Alaska, Hawaii and Anaheim Hills in an attempt to separate dis-

gineers, grading contractors and public officials had always worked in straight lines. Now we were saying, "the more irregular, the better."

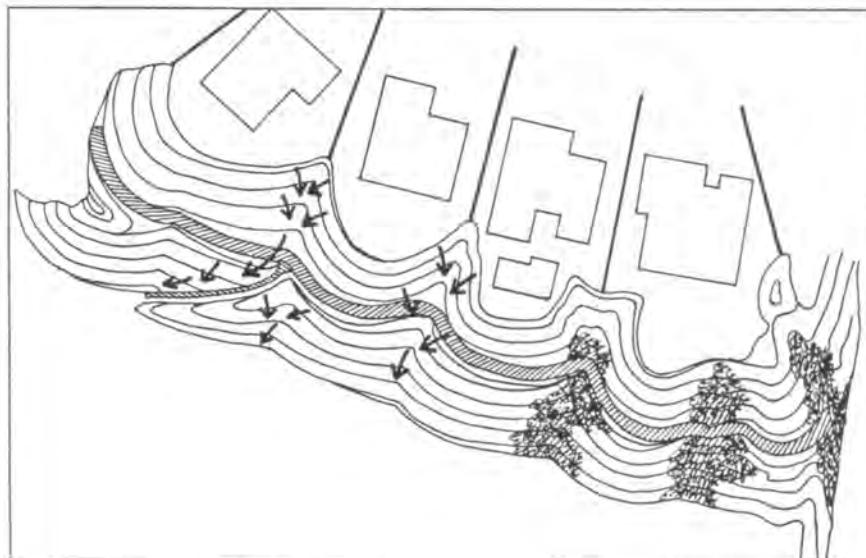
Communication of the new ideas was difficult at times. Initially we made clay models in which we combined the basic slope shapes and took them out to the civil engineers and grading contractors. They, in turn, conveyed the ideas to their equipment operators in the field. However, the grading was not shaping up as we expected. We finally had to go into the field and call a bulldozer operator off his machine, show him the drawings and photos and explain the ideas. He then said, "Sure, I can do that. Why didn't you say that in the first place?" With each grading project, we improved and streamlined the operations.

We've now been doing the grading in Anaheim Hills for seven years. Contractors experienced in landform grading prefer it because the finished product doesn't need to meet precise slope-angle measurements, and it affords the operator more leeway in his bulldozing.

There is less finishing cost to the contractor, although there are more engineering, design and field control costs in landform grading. The cut and fill slopes are very complex to design. It is an art to assemble the various shapes on the slopes so they won't look unnatural. They have to blend together and work structurally. Landform grading gets its look not from one component shape or one gully but from a series of them. The landform shapes become a sequence of undulations, peaks and gullies.

We have to deal with three planning commissions in Anaheim Hills: the cities of Anaheim and Orange and the County of Orange. The planners are delighted with the landform grading idea. At first they were doubtful, but once we'd graded several slopes, we invited them out for a look. They walked over the slopes, viewed them from different angles and saw the value of what we were doing.

The civil engineers were more skeptical. They felt that the shapes we were creating would cause severe erosion. We proved them wrong. Early on, we graded an experimental slope 70 feet high without the artificial drainage interception aids required by the building codes. Rather, we let the curves and elbow shapes of the landforms absorb the im-



TOPOGRAPHICAL REPRESENTATION of a section of landform-graded slope, showing radial water flow, foliage placement in swales and redistribution of land on lots to conform with landform configurations. Hatched area is concrete terrace drain required by building codes.

Anaheim Hills is situated in 4,300 acres of beautiful, undulating hillsides in northeastern Orange County, California. We, like every other developer, were taking natural terrain and transforming it into rigid, mathematical shapes for building. It was a practice based on the idea: "We've always done it that way." Since there was no specific reason, other than expediency, why it was being done, the time had come to examine ways of changing the accepted thinking about mass grading. The search for an alternative was an attempt to improve the aesthetics of graded hillsides. Anaheim

tinct features from among the natural slopes and to determine if there was any relationship between climate, soil type and vegetation and slope configuration. Yet it was two years before distinct, repeating patterns emerged from the jumble of forms. Simply stated, cones, pyramids, "elbows," ridges and various combinations of these elements produce natural slope shapes.

The challenge was now to apply these basic shapes to the grading process. Could they be designed and graded? We would have to retrain everyone concerned with the project. Designers, en-

pact of the running water, as happens in nature.

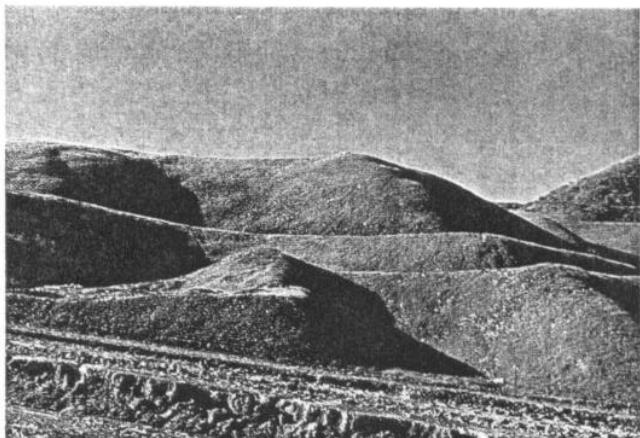
The rains from 1977 to this year have been heavy. From September through March 1977-78, it rained more than 31 inches. The same period in 1978-79 gave us more than 21 inches, and 1979-80 during the similar months put more than 22 inches of water on the slope. The slope is still in perfect condition. Nature doesn't follow building codes, but its designs still work.

Ironically, we found that conventional, angular grading tends to encourage erosion. Water generally will sheet flow on a flat surface and will tend to carve swales in the weakest sections of the slope. To compensate, building regulations require terrace drains every 25 feet to break the momentum of the water. Yet there is an entire set of building regulations predicated upon the efficiency of conventional, linear slopes.

On the other hand, the drainage pattern of a landform-graded slope is radial in nature and swales are already provided for the runoff. If the land is formed naturally, as in our process, the water follows the channels, which break its speed by virtue of their energy-dissipating shapes. Further, most foliage occurs in the channels or swales, and its presence breaks the speed of the running water. Our landscaping also follows this natural pattern. We also experimented with such ideas as planting Acacia Rosemary, a lush, low growth, to cushion the impact of rainfall.

Mother Nature is full of surprises. She knows how to control erosion without using the clumsy terrace drains we use in man-made slopes. We've minimized the visual impact of the required concrete drains by running them diagonally and curvilinearly across the slopes, which makes them considerably less visible. We also line them with river rock, so when they are visible they complement the landform slope aesthetics.

FRESHLY GRADED landform slopes show ridges, swales and pyramid shapes.



AERIAL PHOTO of landform-graded region in Anaheim Hills. Note irregular patterns formed by landform-graded slopes along perimeter of lot pads.

Initially, we and the builders were concerned about the buildable land that would be lost to the landform grading process on each lot. We solved that by reshaping backyards to conform with the grading configurations. The center sections of the lots, which are used most extensively, bulge outward with the ridgelines of the grading. The corners of the yard are taken up by the swales and these edges are characteristically used less often. In effect, we redistributed the lot pad square footage to our advantage.

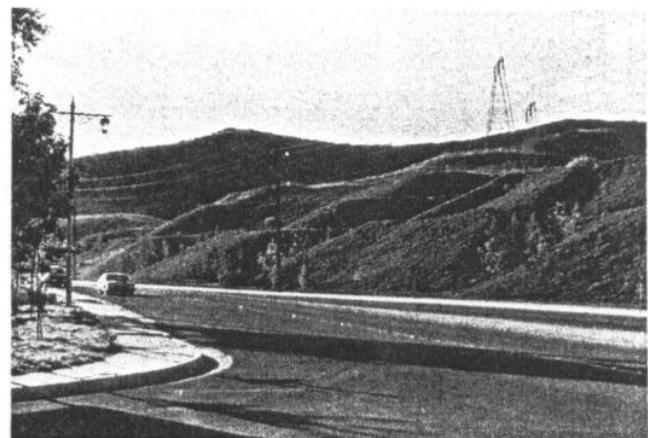
We are pleased with the results of our experiments. When covered with mature vegetation, our landform graded slopes appear very much like natural slopes. The grading has allowed us to move away from straight lines and abrupt angles in our community planning. The

homes are positioned more irregularly, which discourages the monotonous look of row housing. And, importantly, we come very close to restoring the slopes to their natural conditions.

We believe that sooner or later developers will be required to use this type of landform grading. This method of grading is part of the future of land development in this country and eventually in all other countries because most urban and suburban flatland has been built upon in one way or another. Landform grading involves more effort to achieve, design, implement, construct and engineer. However, the cost in time and labor is well worth the results of aesthetics, structural integrity and the value to developers of public acceptance and municipal planning approval.



MATURE LANDFORM slopes with vegetation and foliage in swales.



Volume 9 • Number 11

November 1993

LANDSCAPE ARCHITECT

AND SPECIFIER NEWS



HILLSIDE DEVELOPMENT

See the
LASN
Marketplace
on pages 26 - 41

Landform Grading: Comparative Definitions of Grading Designs

by Horst J. Schor



The advantages and necessities of hillside living have become more widely evident as flatlands, the traditional building sites, are being consumed rapidly by urban development.

Hillside building, while appealing to the consumer, can require massive grading that may become the focal point of local resistance, thus impeding government approval.

However, grading is a necessity to accommodate street and building areas for development, meeting building codes, and safe engineering practices. Grading is also frequently required to correct unstable soils and

geologic conditions inherent in many natural hillsides.

The innovative "Landform Grading and Revegetation" concept was conceived to solve negative impressions gained in viewing the typical re-manufactured hillsides using conventional planning, engineering and construction methods. Conventional grading drastically alters a landscape, remanufacturing natural forms and shapes and plant distribution patterns to replace them with artificial, sterile and uniform shapes and patterns.

The concept, as developed and described here, consists of three components:

- Grading
- Drainage Structures
- Revegetation/Landscaping

Grading

In recent years attempts have been made by some to design and construct "LANDFORM grading," while in reality, these efforts can only, at best, be described as contouring or rounding of slopes. Therefore it is necessary to establish proper definitions and characteristics for the three types of grading available: Conventional, Contour and Landform Grading.

Comparative Definitions of Grading Designs

Conventional Grading

- Conventional graded slopes are characterized by essentially linear, planar slope surfaces with unvarying

gradients and angular slope intersections. The resultant pad configurations are rectangular.

- Slope drainage devices are usually constructed in a rectilinear configuration in exposed positions.

- Landscaping is applied in random or geometric patterns.

Contour Grading

- Contour-graded slopes are basically similar to conventionally graded slopes except that: the slopes are curvilinear rather than linear, the gradients are unvarying and profiles are planar. transition zones and slope intersections have generally some rounding applied. Resultant pad configurations



The natural hillside above illustrates that vegetation clusters in the swales of the mountain. The goal of landform revegetation is to replicate these natural patterns.



Continued from page 23

while convex portions are planted mainly with ground covers.

Revegetation/Landscape

Historically, landscaping on manufactured slopes has been applied in uniform patterns, with trees typically spaced 15 feet on center and shrubs 3 feet on center to achieve what has been known in the industry dubiously as "Uniform Coverage."

It is this uniformity that can add to the artificial, man-made look, already created by the

uniformity in grading. In the "Landform Grading and Revegetation" approach, landscaping is applied in patterns that occur in nature.

The approach should be thought of as "Revegetation". Trees and shrubs require more moisture, so it makes sense to cluster them in the swales and valleys where moisture concentrates and evaporation is minimized. Shrubs are heavily concentrated along the drainage flow of each swale and thinned to each side to minimize any erosion.

As opposed to the rigid forms of conventional grading (below left), landform grading (below right) provides shadows, depth and a more natural looking hillside.



Conclusion

Hillside development can be done in an aesthetically pleasing manner. Landform grading and landform revegetation are just two concepts that accomplish this goal. With sensitivity, creativity and the will to improve, we can shape our hillsides by imitating mother nature to recreate a more "natural" habitat for all.

Horst Schor is the principal of H.J. Schor Consulting, Creative Concepts in Land Development, in Anaheim, California. **LASN**



The aerial photo to the left shows a 4,200 acre planned community in which the design revolves around the landform grading and revegetation concept.

The hill above illustrates how landform grading replicates the irregular shapes of natural slopes. The landscaping will be a "revegetation" process emulating the patterns of natural growth.

In high visibility areas, concrete drainage devices are lined with natural river rock to create a stream bed effect (right) in the finished landscape.

are mildly curvilinear.

- Slope drainage devices are usually constructed in a geometric configuration and in an exposed position the slope face.

- Landscaping is applied in random or geometric patterns.

Landform Grading

- Landform Grading replicates the irregular shapes of natural slopes, resulting in aesthetically pleasing elevations and profiles. Landform-graded slopes are characterized by continuous series of concave and convex forms interspersed with mounds that blend into the profiles. Non-linearity and varying

slope gradients are significant transition zones between man-made and natural slopes. Resultant pad configuration are irregular.

- Slope down-drain devices either follow "natural" lines of the slopes or are tucked away in special swale and berm combinations to conceal the drains from view. Exposed segments in high visibility areas are treated with natural rock (see right photo).

- Landscaping becomes a "revegetation" process and is applied in patterns that occur in nature. Trees and shrubs are concentrated largely in concave areas,

Continued on page 25

Make the LASN Marketplace Buyer's Guide on page 41 your first choice for all your product inquiries.

November 1993 / 23

Hillside Development



LANDFORM GRADING AND SLOPE EVOLUTION

By Horst J. Schor¹ and Donald H. Gray,² Member, ASCE

ABSTRACT: Transportation corridors and residential developments in steep terrain both require that some grading be carried out to accommodate roadways and building sites. The manner in which this grading is planned and executed and the nature of the resulting topography or landforms that are created affect not only the visual or aesthetic impact of the development but also the long-term stability of the slopes and effectiveness of landscaping and revegetation efforts. Conventionally graded slopes can be characterized by essentially planar slope surfaces with constant gradients. Most slopes in nature, however, consist of complex landforms covered by vegetation that grows in patterns that are adjusted to hillside hydrogeology. Analysis of slope-evolution models reveals that a planar slope in many cases is not an equilibrium configuration. Landform-graded slopes on the other hand mimic stable natural slopes and are characterized by a variety of shapes, including convex and concave forms. Downslope drains either follow natural drop lines in the slope or are hidden from view in swale-and-berm combinations. Landscaping plants are placed in patterns that occur in nature as opposed to random or artificial configurations. The relatively small increase in the costs of engineering and design for landform grading are more than offset by improved visual and aesthetic impact, quicker regulatory approval, decreased hillside maintenance and sediment removal costs, and increased marketability and public acceptance.

INTRODUCTION

All slopes are subject to erosion and mass wasting. Various measures can be invoked to slow, if not completely prevent, this degradation. Biotechnical slope-protection methods, for example, have attracted increasing attention as a cost-effective and visually attractive means of stabilizing slopes. This approach has been used to stabilize and revegetate cut-and-fill slopes along highways as well as slopes in residential hillside developments. Kropf (1989) described the use of contour wattling in combination with subdrains to repair and stabilize a debris flow above a housing development in Pacifica, California. Gray and Sotir (1992) described the use of brush layering to stabilize a high, unstable cut slope along a highway in northern Massachusetts. Brush layering and other soil bioengineering measures have likewise been employed (Sotir and Gray 1989) to repair a failing fill embankment along a highway in North Carolina.

Transportation corridors and residential developments in steep terrain both require that some excavation and regrading be carried out to accommodate roadways and building sites. The manner in which this grading is planned and executed and the nature of the resulting topography or landforms that are created affect not only the visual or aesthetic impact of the development but also the stability of the slopes and effectiveness of landscaping and revegetation efforts.

Succinct descriptions and comparative definitions of grading designs are as follows.

Conventional Grading

Conventionally graded slopes are characterized by essentially linear (in plan), planar slope surfaces with unvarying gradients and angular slope intersections. Resultant pad configurations are rectangular.

Slope drainage devices are usually constructed in a rectilinear configuration in exposed positions.

¹Prin., H.J. Schor Consulting, 626 N. Pioneer Dr., Anaheim, CA 92805. (714) 778-3767.

²Prof., Dept. of Civ. & Envir. Engrg., Univ. of Michigan, Ann Arbor, MI 48109.

Note. Discussion open until March 1, 1996. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on September 14, 1994. This paper is part of the *Journal of Geotechnical Engineering*, Vol. 121, No. 10, October, 1995. ©ASCE, ISSN 0733-9410/95/0010-0729/\$2.00 + \$25 per page. Paper No. 9236.

Landscaping is applied in random or geometric patterns to produce "uniform coverage."

Contour Grading

Contour-graded slopes are basically similar to conventionally graded slopes except that the slopes are curvilinear (in plan) rather than linear, the gradients are unvarying, and profiles are planar. Transition zones and slope intersections generally have some rounding applied. Resultant pad configurations are mildly curvilinear.

Slope drainage devices are usually constructed in a geometric configuration and in an exposed position on the slope face.

Landscaping is applied in random or geometric patterns to produce "uniform coverage."

Landform Grading

Landform grading replicates irregular shapes of natural, stable slopes. Landform-graded slopes are characterized by a continuous series of concave and convex forms interspersed with swales and berms that blend into the profiles, nonlinearity in plan view, varying slope gradients, and significant transition zones between man-made and natural slopes. Resultant pad configurations are irregular.

Slope drainage devices either follow "natural" slope drop lines or are tucked away in special swale-and-berm combinations to conceal the drains from view. Exposed segments in high visibility areas are treated with natural rock.

Landscaping becomes a "revegetation" process and is applied in patterns that occur in nature: trees and shrubs are concentrated largely in concave areas, whereas drier convex portions are planted mainly with ground covers.

GRADING APPROACHES

Conventional

Conventional grading practice often results in drastically altered slopes and the replacement of natural hillside forms with artificial, sterile, and uniform shapes and patterns. Conventionally graded slopes can be characterized by essentially planar slope surfaces with constant gradients and angular intersections as shown in Fig. 1. Slope-drainage devices are usually constructed in a rectilinear and exposed fashion.



FIG. 1. Conventional Grading with Planar Slopes and Rectilinear Drainage Ditch in Highly Visible and Exposed Location



FIG. 2. Conventionally Graded Hill Slope with Planar Face, Rectilinear Drainage Ditch, and uniformly Spaced Plantings

Grading specifications in southern California, for example, typically call for flat, planar 2:1 ($H:V$) slopes with a midslope bench and a drainage ditch, commonly placed straight down the slope, that collects and conveys water from brow and midslope bench or terrace drains, respectively. Landscaping and plants are applied in random or geometric patterns as shown in Fig. 2.

Contour Grading

Contour grading offers a slight improvement over the sterile and simple geometry achieved by conventional grading. Some scalloping or curvilinear appearance is introduced onto the slope when seen in plan view; however, the slope gradients or profiles remain planar and unvarying. Transition zones at the bottom and top of slopes may also have some rounding applied. Slope drainage devices are still constructed in the same geometric configuration and exposed position on the slope face as in conventional grading. Landscaping and plants are also applied in random or geometric patterns.

Landform Grading

"Landform grading" essentially attempts to mimic nature's hills. This approach has been largely developed and pioneered by Schor (1980, 1992, 1993), who has successfully applied landform grading to several large hillside developments and planned communities in southern California. It is important to note that very few hillsides are found in nature with linear, planar faces. Instead, natural slopes consist of complex land-

forms covered by vegetation that grows in patterns that are adjusted to hillside hydrogeology, as shown in Figs. 3 and 4. Accordingly, landform-graded slopes are characterized by a variety of shapes including convex and concave forms interspersed with ridges and elbows in the slope.

Downslope drain devices either follow natural drop lines in the slope or are tucked away and hidden from view in special concave swale and convex berm combinations as shown in Fig. 5. Landscaping plants are not placed in random or artificial patterns. Instead they are applied in patterns that



FIG. 3. Natural Hill Slopes with Multiple and Complex Shapes and Profiles



FIG. 4. Natural Hill Slopes Showing Vegetation Patterns



FIG. 5. Example of Landform Grading with Drainageway that is Placed in Special Swale-and-Berm Combination to Conceal it from View

occur in nature (see Fig. 6). Trees and shrubs are concentrated primarily in concave areas, while drainage tends to concentrate, while drier convex portions are planted primarily with herbaceous ground covers. A schematic depiction of conventional site planning versus landform site planning is shown in Fig. 7.

SLOPE-EVOLUTION CONSIDERATIONS

Landform-graded slopes present more than a varied and pleasing visual appearance. They also tend to be intrinsically more stable. The general lack of straight, planar slopes in nature says something. Slopes wear away or degrade over time by gravity-driven forces of erosion and mass wasting. The slopes proceed toward an equilibrium profile, which evidently does not include a linear and unvarying gradient.

Geomorphologists have been interested for some time in various slope-evolution models. The spatial and temporal variation of any point in a slope can be expressed by a number of two-dimensional mathematical models. These models predict the rate of change of elevation (dY/dT) of any point on a slope with elapsed time (T) and coordinate location (X, Y). Examples of these mathematical models are the following:

$$\text{Model } \#1 \frac{dY}{dT} = -A \quad (1)$$

$$\text{Model } \#2 \frac{dY}{dT} = -B (dY/dX) \quad (2)$$

$$\text{Model } \#3 \frac{dY}{dT} = -C \text{ (height above base)} \quad (3)$$

$$\text{Model } \#4 \frac{dY}{dT} = -D \text{ (distance from crest)}^{0.6} \quad (4)$$



FIG. 6. Example of Landform Grading and Revegetation with Concave and Convex Slope Forms and Nonlinear, Varying Slope Gradients

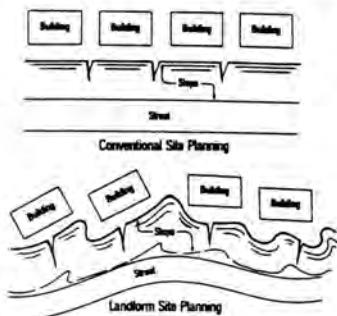


FIG. 7. Plan View of Conventional versus Landform Site Planning

$$\text{Model } \#5 \frac{dY}{dT} = -E (d^2Y/dX^2) \quad (5)$$

Graphical illustrations or simulations of these models are shown in Figs. 8–12. Each of these mathematical models has some physical basis. Model #2, for example, describes the "parallel retreat of slope" concept, which postulates that upon reaching its limiting slope angle (angle of repose) a slope retreats back at a constant inclination. A purely frictional, sandy slope whose stability is independent of slope height could conceivably fit this model. Model #4 fits observations from the Universal Soil Loss equation, which indicates that rainfall erosion losses from a slope (all other factors equal) are a function of the slope length. Model #5 is the so-called diffusion model, which postulates that in a transport-limited slope the passage of material down the slope from a point above is limited by the transfer rate at a point below. The slope profile adjusts itself over time to optimize this stepwise or sequential transfer of material down-slope by various erosion or mass-wasting processes. Note that in the diffusion model, an initially planar slope evolves over time into a concave-convex slope as shown in Fig. 12.

The diffusion model (#5) was tested as part of a doctoral dissertation on slope evolution models at the University of

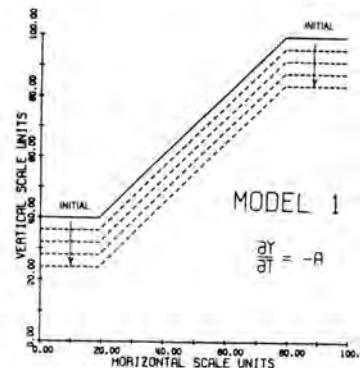


FIG. 8. Evolution of Hillside Slope when Rate of Lowering is Uniform over Entire Slope Profile (Model 1) [from Nash (1977)]

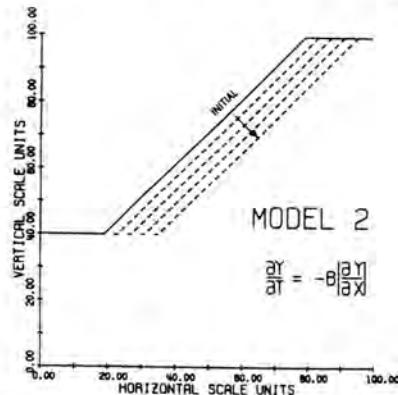


FIG. 9. Evolution of Hill Slope when Rate of Lowering at Point on Slope is Proportional to Profile Gradient at Point (Model 2) [from Nash (1977)]

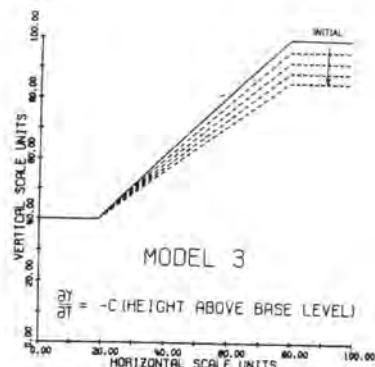


FIG. 10. Evolution of Hillside Slope when Rate of Lowering of a Point on Slope Profile is Proportional to Elevation of Point (Model 3) [from Nash (1977)]

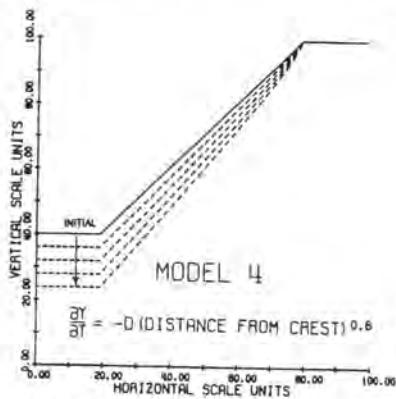


FIG. 11. Evolution of Hill Slope when Rate of Lowering at Point on Slope Profile is Proportional to Distance that Point Lies from Crest or Divide (Model 4) [from Nash (1977)]

Michigan (Nash 1977). The slope profiles of present-day, modern wave-cut bluffs along Lake Michigan and those of ancient, abandoned bluffs marking former glacial lake margins were used for this purpose. The study assumed that slope processes at work on the bluffs have remained relatively constant over geologic time. The ancient bluffs and their ages respectively, are the Nipissing bluffs (4,000 yr) and Algonquin bluffs (10,500 yr). Actual slope profiles for these three bluffs superposed at their midpoint are shown in Fig. 13. The correspondence or fit between the profiles predicted by the diffusion model and the actual profiles was examined for various diffusion constants. The configurations predicted by the diffusion model for an abandoned bluff after 4,000 years and 10,500 years using a diffusion coefficient of 0.012 m²/yr and an initial, planar profile similar to the profile of the modern bluff are shown in Fig. 14. According to the diffusion model, the slope profiles gradually change over time from a linear to a concave-convex configuration, as illustrated in Fig. 14.

The fit or correspondence between actual and predicted profiles is quite good as can be seen by comparing slope profiles in Figs. 13 and 14. More importantly, this modeling

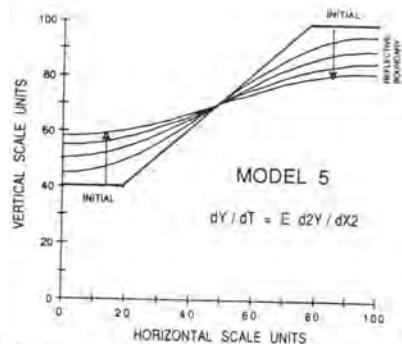


FIG. 12. Evolution of Hillside Slopes when Rate of Lowering of Point on Slope Profile is Proportional to Profile Curvature at that Point, Assuming Reflective Left and Right Boundaries (Model 5) [from Nash (1977)]

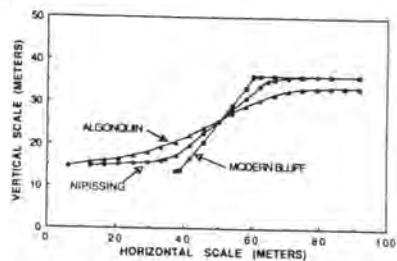


FIG. 13. Modern Bluff Profile, Nipissing Bluff Profile (4,000 yr), and Algonquin Bluff Profile (10,500 yr) Superposed at their Midpoint [from Nash (1977)]

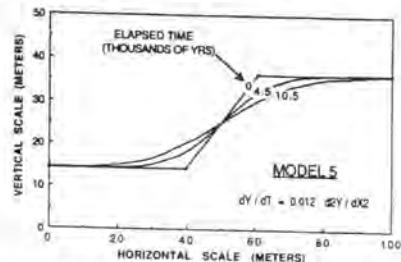


FIG. 14. Slope Profiles Predicted by Model 5 for Initial Planar Slope after 4,000 and 10,500 Years of Elapsed Time Using Diffusion Coefficient of 0.012 m²/yr and Initial Inclination Similar to Present Wave Cut Bluff [from Nash (1977)]

work indicates that in transport-limited slopes, at least, a planar slope with constant inclination, typical of conventional grading practice, is not a stable, long-term equilibrium slope.

REVEGETATION AND LANDSCAPING

If monotony and uniformity in grading are combined with a uniform or artificial pattern of revegetation, the overall effect is not only sterile and ugly but also ineffective. Successful and attractive revegetation must invoke the same concepts and approaches as landform grading. Vegetation pat-

terns that are found in nature should also be mimicked. Shrubs and other woody vegetation growing on natural slopes tend to cluster in valleys and swales where moisture is more abundant. Random patterns or uniform coverage should be avoided. Instead, the vegetation is placed where it makes sense, i.e., where it has a better chance of surviving and does a better job of holding soil. Trees and shrubs require more moisture, and they also do a better job of stabilizing a soil mantle against shallow mass wasting. Accordingly, it makes sense to cluster them in swales and valleys in a slope (see Fig. 15), where runoff tends to concentrate and evaporation is minimized. Shrubs should also be heavily concentrated along the drainage flow of each swale.

By purposely controlling the drainage patterns on a slope, runoff can be concentrated in concave areas where it is needed or where it can best be handled by woody slope vegetation (see Fig. 16). Conversely, runoff and seepage will be diverted away from convex areas. These areas should be planted with grasses or more drought-tolerance herbaceous vegetation. Irrigation needs are thus reduced by careful control of drainage pattern on a slope and selection of appropriate plantings for different areas.

IMPACT ON DEVELOPMENT COSTS

Design Engineering and Surveying Costs

Design and surveying can be measurably higher if it is initially performed by a team only experienced in conventional methods. Design engineering and construction staking

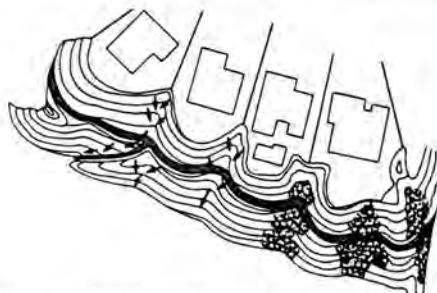


FIG. 15. Topographic Representation of Landform Configuration Showing Radial Flow of Water, Foliage Placement in Swales, and Lots that Conform with Landform Grading Configuration [after Schor (1992)]



FIG. 16. Landform-Graded Slope with Convex and Concave Slope Shapes, Varying Gradient, Curvilinear Drainage Ditch Concealed in Berm and Swale Configuration, and Clustered Plantings

and surveying costs are directly related to the experience, talent, and versatility of the design engineer and his full understanding of the concept. When first implemented with a totally inexperienced staff during pioneering stages, design cost was 15% higher and field cost 10% higher than conventionally designed and surveyed slopes. From that initial experience, design costs quickly decreased to a factor of 1–3%, and surveying to 1–5% over conventional methods and approaches.

A willingness and an open mind to depart from old concepts are essential elements for realizing the benefits of landform grading. In-depth training of the designer, draftsman, and project manager are indispensable, as well, before attempting the landform-grading method. Approving agencies must also be brought into the information dissemination process so that plan check, permitting and, later, inspection can proceed smoothly.

Construction/Grading Costs

Construction/grading costs are most directly related to the size and volume of earth movement than any other factor. In addition, there is a direct relationship to the competitive marketplace situation at a given time. Competition for larger projects, such as those for 1,000,000 cu yd or more, tends to eliminate adherence to landform-grading standards as a significant factor.

Grading costs in hillsides of largely sedimentary materials and not requiring blasting or extremely heavy ripping range from \$0.75 to \$1.25 per cubic yard with an average of \$1.00 per cubic yard. Variables affecting the unit cost include the quantity of material, the nature of the operating area, i.e., open or confined, the length and steepness of the haul from the cut areas to the fill areas, and the rippability by conventional dozer/scraper equipment.

At first glance it appears that landform-graded projects would be significantly more expensive to construct than conventional ones because of the more intricate details and natural shapes required. However, experience has shown that the differential is minor when compared to the total project cost. This is true because the largest percentage (on average 90%) of the earth volume moved, the mass "X" shown in Fig. 17, can be moved, placed, and compacted in a totally conventional manner. Only the outer slope layers, 20–50 ft thick (or approximately 10% of volume), require specialized shaping. Moreover, even this outer layer can still be placed and compacted with conventional equipment and methods. This outer component needs an additional grade checker for control and a dozer with an experienced operator for final shaping. Accordingly, when costs are reckoned on the basis of the actual additional operations involved they are a minor component, typically on the order of 1% of the total cost.

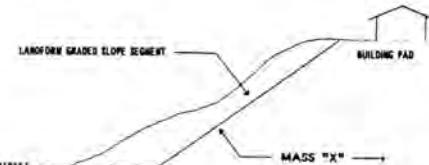


FIG. 17. Relative Amounts and Location of Earth Movement by Conventional as Opposed to Landform Grading

COST-IMPACT COMPARISONS ON VARIOUS SIZE PROJECTS

Large-Scale Projects

On a recently completed hillside project involving 20,000,000 cu yd of earth movement at a cost of some \$24,000,000, the total additional cost incurred including design, surveying, construction staking, and grading, was \$250,000, or about 1% of the total cost of the grading.

No loss of residential density was encountered, because land planning was done concurrently with the engineering. There was a loss of approximately 1% of commercial pad area due to concave valleys projecting into them. This was offset, however, by the credit given by the governing agency for these indentations toward landscape requirements and coverage calculations for the building pad areas. Furthermore, entitlement approvals were advanced by at least 1 year by being able to mitigate the previous strong community opposition to conventional hillside design and construction methods.

Small-Scale Projects

A 10-acre, 24 custom-lot subdivision requiring 300,000 cu yd of earth movement, initially designed by conventional methods, with little hope for approval, was reconfigured to landform-grading standards. The project applicants had previously proposed conventional grading and had for 2 1/2 years tried to secure permitting agency approvals in a community where grading practices had become a major and highly controversial issue. The governing agency insisted that the applicant apply landform-grading concepts before any further resubmittals. The project was redesigned by adhering to these concepts, and the new layout resulted in 21 lots, a loss of three lots. Design and staking costs also increased by approximately \$10,000. However, this revision reduced construction costs by reducing the amount of grading required by 20%. The loss of the lots and additional design costs were further offset by reduced street and storm-drain improvements, tree-removal costs, and an enhanced and aesthetically pleasing project with larger open spaces for each of the lots. This in turn, increased the marketability of the projects. In addition to these benefits, the project received unanimous community approval within 3 months.

APPLICABILITY OF LANDFORM GRADING TO OTHER PROJECTS

In addition to residential and commercial developments the landform-grading concept should lend itself readily to highway slopes. Public objections are often voiced against these highly visible and stark slopes. In addition they are sometimes prone to erosion problems and generation of excess runoff. These problems and objections could be greatly mitigated by the application of this concept, thereby improv-

ing public acceptance. This benefit would likely offset any associated additional right-of-way acquisition costs.

Other large earthmoving and shaping projects that result in man-made landforms could also benefit from landform grading. Such projects include sanitary landfills, tailings embankments and mining waste stockpiles, and downstream faces of earthfill dams.

CONCLUSIONS

Grading considerations are very important to the successful stabilization and revegetation of slopes. Conventionally graded slopes can be characterized by essentially planar slope surfaces with constant gradients. Most slopes in nature, however, consist of complex landforms covered by vegetation that grows in patterns that are adjusted to hillside hydrogeology. Analysis of slope evolution models reveals that a planar slope often is not an equilibrium configuration.

Landform-graded slopes, on the other hand, are characterized by a variety of shapes including convex and concave forms that mimic stable natural slopes. Downslope drain devices either follow natural drop lines in the slope or are tucked away and hidden from view in special concave swale and convex berm combinations. Similarly landscaping plants are not placed in random or artificial patterns, but rather in patterns that occur in nature. Trees and shrubs are clustered primarily in concave areas, where drainage tends to concentrate, while drier convex portions are planted primarily with herbaceous ground covers.

Design and engineering costs for landform grading increase approximately 1–3%, and surveying 1–5% over conventional methods. Construction and grading costs are most strongly affected by the volume of earth movement and the competitive market. Accordingly, a landform-grading specification on a large project is not a significant factor. The relatively small increase in the costs of engineering and design are more than offset by improved visual and aesthetic impact, quicker regulatory approval, decreased hillside-maintenance and sediment-removal costs, and increased marketability and public acceptance.

APPENDIX. REFERENCES

Gray, D. H., and Sotir, R. (1992). "Biotechnical stabilization of a highway cut." *J. Geotech. Engrg., ASCE*, 118(10), 1395–1409.

Kropp, A. (1989). "Biotechnical stabilization of a debris flow scar." *Proc., XX Annu. Conf., Int. Erosion Control Assoc. (IECA)*, Steamboat Springs, Colo., 413–429.

Nash, D. B. (1977). "The evolution of abandoned, wave-cut bluffs in Emmet County, Michigan." PhD dissertation, Univ. of Michigan, Ann Arbor.

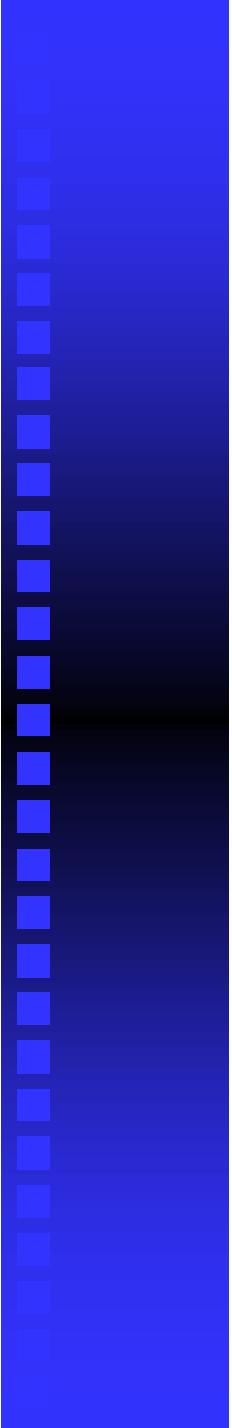
Schor, H. (1980). "Landform grading: building nature's slopes." *Pacific Coast Builder*, (Jun.), 80–83.

Schor, H. (1992). "Hills like nature makes them." *Urban Land*, (Mar.), 40–43.

Schor, H. (1993). "Landform grading: comparative definitions of grading designs." *Landscape Arch. & Specifier News*, (Nov.), 22–25.

Sotir, R., and Gray, D. H. (1989). "Fill slope repair using soil bioengineering systems." *Proc., XX Annu. Conf., Int. Erosion Control Assoc. (IECA)*, Steamboat Springs, Colo., 473–485.

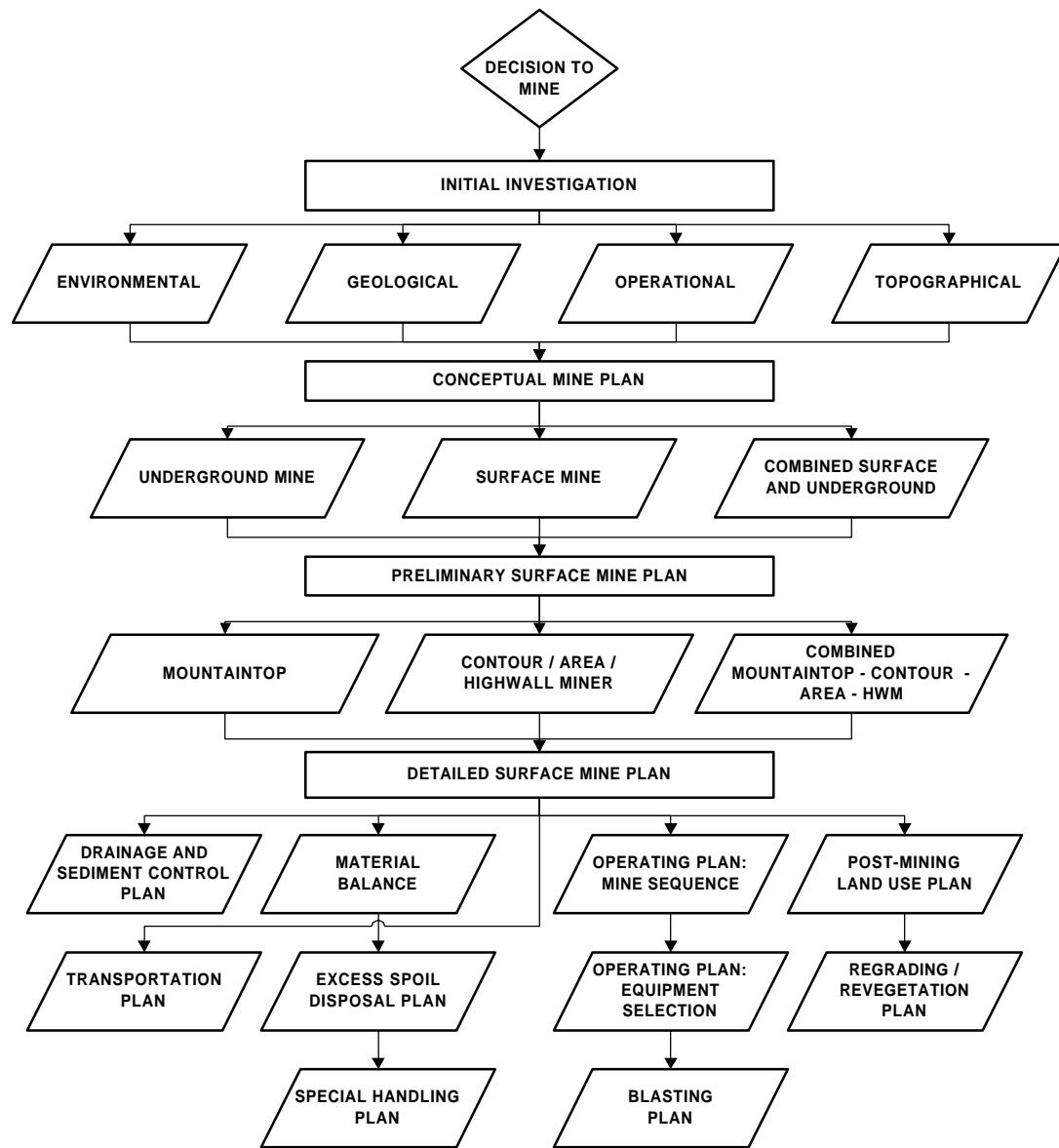
A West Virginia Mining Case Study



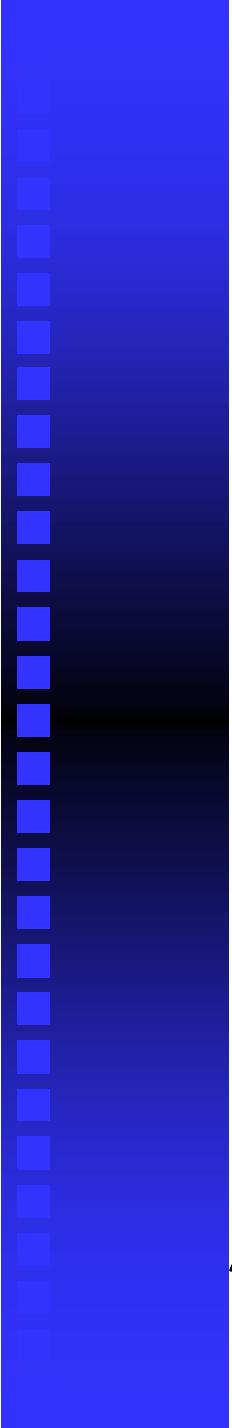
The Decision-Making Process Related to Coal Mining

Presented to EIS Symposium

June 24, 1999



Overall
Decision
Process



```
graph TD; A[DECISION TO MINE  
vs  
INVESTMENT ELSEWHERE] --> B{COAL MINING  
INVESTMENT}; B --> C[USA  
Outside  
West Virginia]; B --> D[West Virginia]; B --> E[Outside USA];
```

DECISION TO MINE
vs
INVESTMENT ELSEWHERE

COAL MINING
INVESTMENT

USA
Outside
West Virginia

West Virginia

Outside USA

Mining Options

**USA Outside
West Virginia**

Other Appalachia
Wyoming

Utah
Colorado

Other

West Virginia

Southern WV
(Low Sulfur)

Northern WV
(High Sulfur)

Outside USA

Colombia
Venezuela

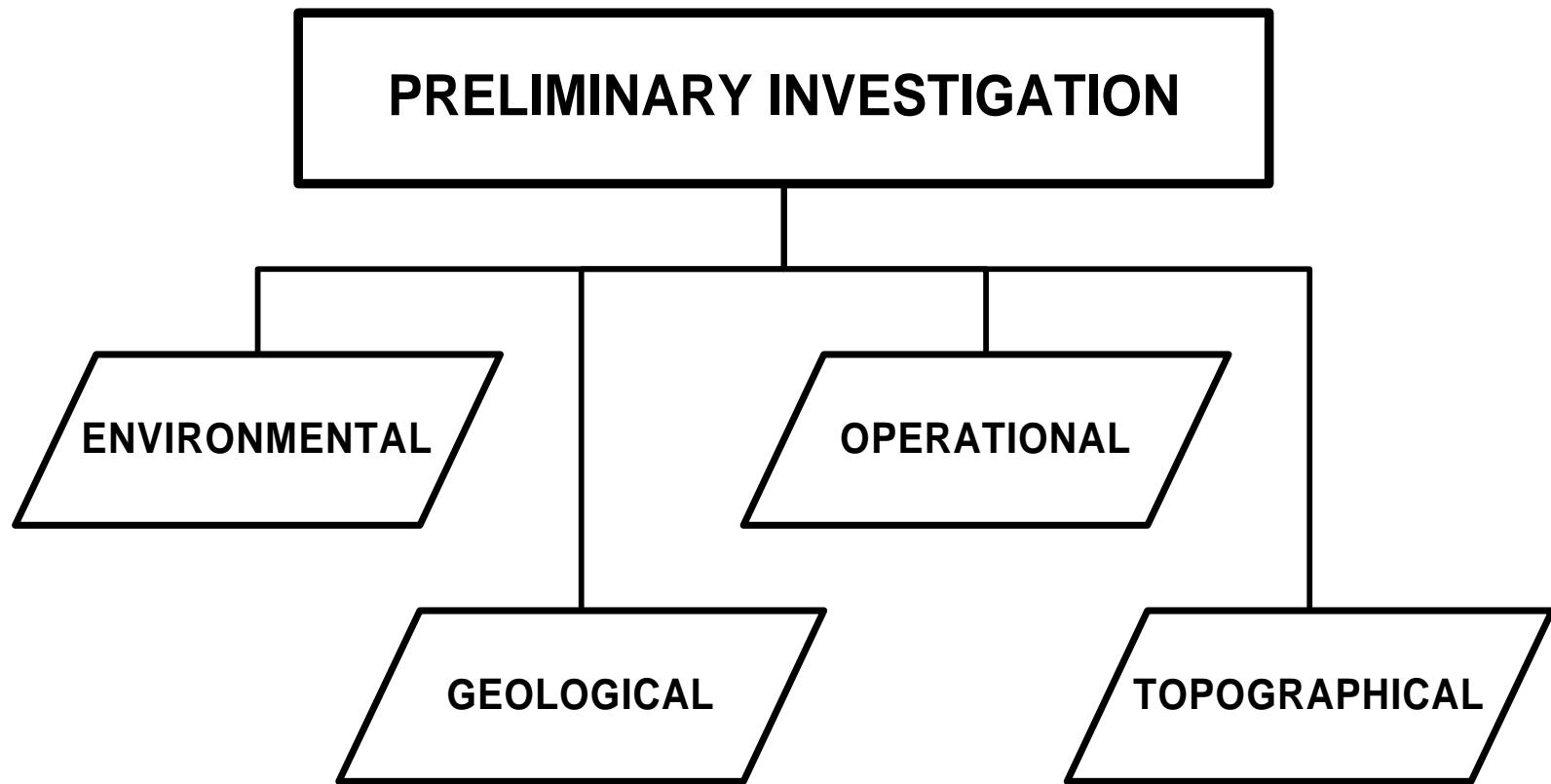
Australia
South Africa

Other

Preliminary Investigation

**Definition of Key Characteristics of
Multiple Reserves**

**Required for Valid Comparison of
Competing Opportunities**



ENVIRONMENTAL

- Unique Aquatic or Terrestrial Habitat
- Endangered Species
- Special Characteristics
- Water Quality
 - Existing Acid Mine Drainage (AMD)
 - TMDL (Upcoming)
- Proximity to Residents / Communities
- Archeological, Historic, Cultural Features

Environmental Factors

Hydrology

Surface Water

Six Months Data

Flow, pH, TSS, Iron, Mn, Alkalinity, Acidity, Aluminum, TDS, Spec. Conductance, Sulfates

Ground Water

0.7 mile groundwater user inventory

Aquifer Delineation and Usage

Depth, TSS, pH, Iron, Mn, Acidity, Alkalinity, Specific Conductance, Sulfates, TDS

Existing Treatment, If any

Environmental Factors

Collect Data to Evaluate

- Probable Hydrologic Consequences
- Hydrologic Regime Effects

Avoid AMD and Material Damage

Treatment Plan if AMD Occurs

Avoid TSS to Receiving Streams

Water Rights Protection

Hydrologic Balance in Project Area

GEOLOGICAL

- **Stratigraphy**
- **Coal Seam Thickness**
- **Coal Quality**
- **Overburden Types (Sandstone, Shale, Other)**
- **Overburden Quality**
 - Acid Base Accounting
 - Slake Durability
 - Strength

Geology

Regional Data

County Reports

Reports on Adjacent Property

Site Specific Data

Drilling Records

Geophysical (Electric) Logs

Resistivity, Density, and Water Level

Geologist Logs

Driller's Logs

Overburden Data

Acid-Base Accounting
RQD (Rock Quality Designation)
Percent Clays
Percent Sulfur
Forms of Sulfur
Alternative Topsoil Analysis
Slake Durability

Classification of Reserves

Proven

Area of Influence Less than 1320 feet

Probable

Area of Influence 1320 feet to 2560 feet

Inferred

Area of Influence Greater than 2560 feet

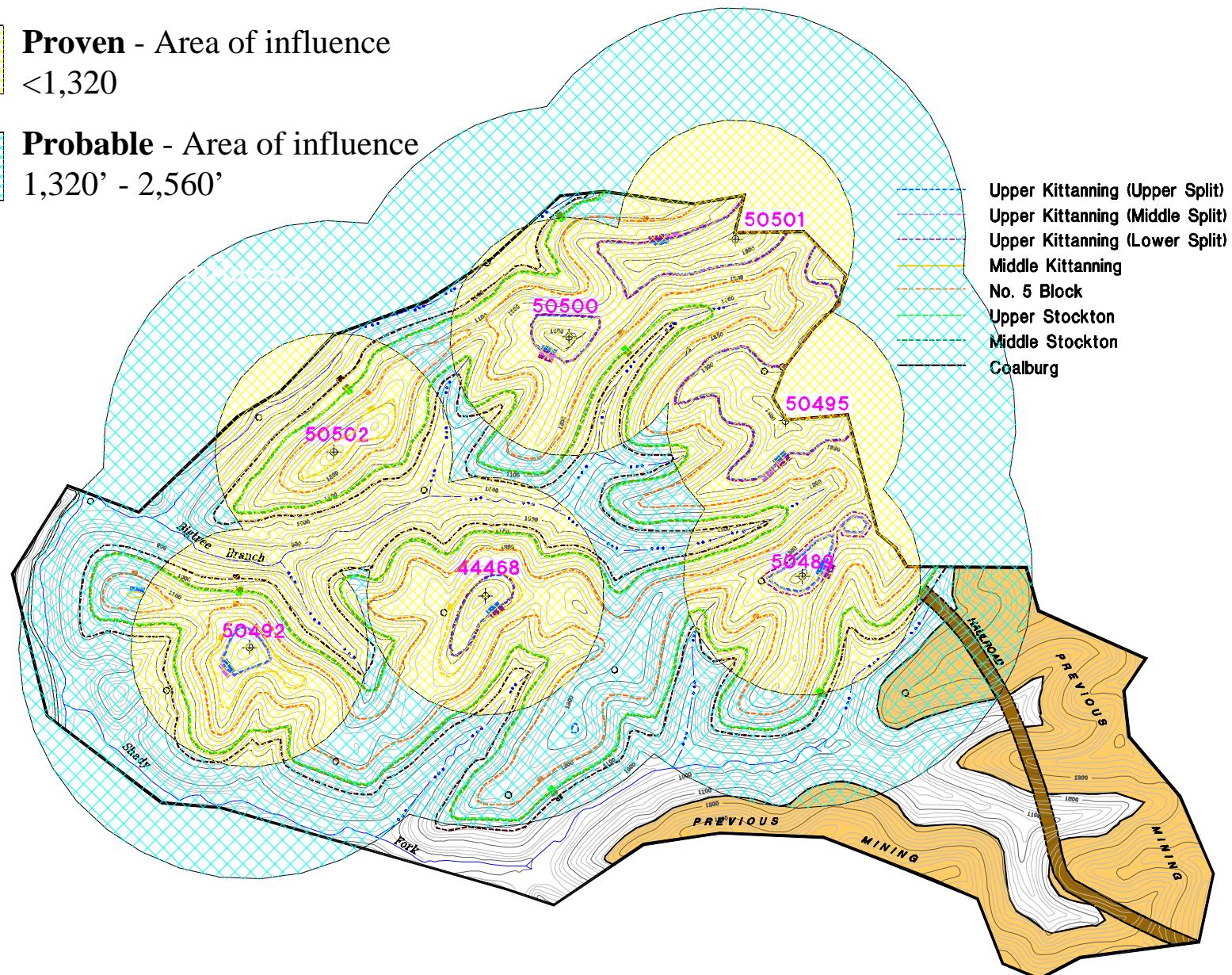
Reserve Classification



Proven - Area of influence
<1,320'



Probable - Area of influence
1,320' - 2,560'



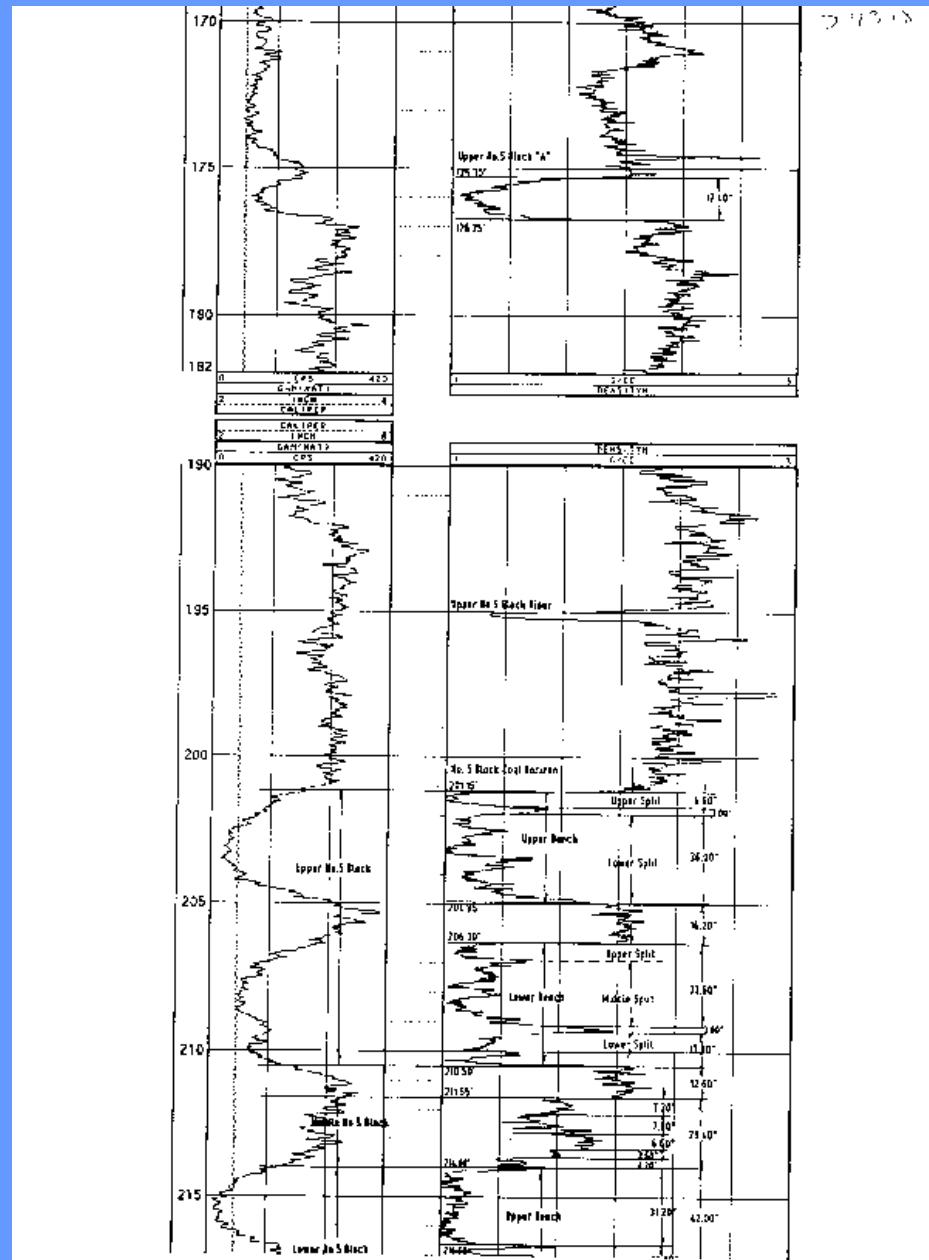


BORE HOLE LOG

BORE NUMBER * DT9706 *

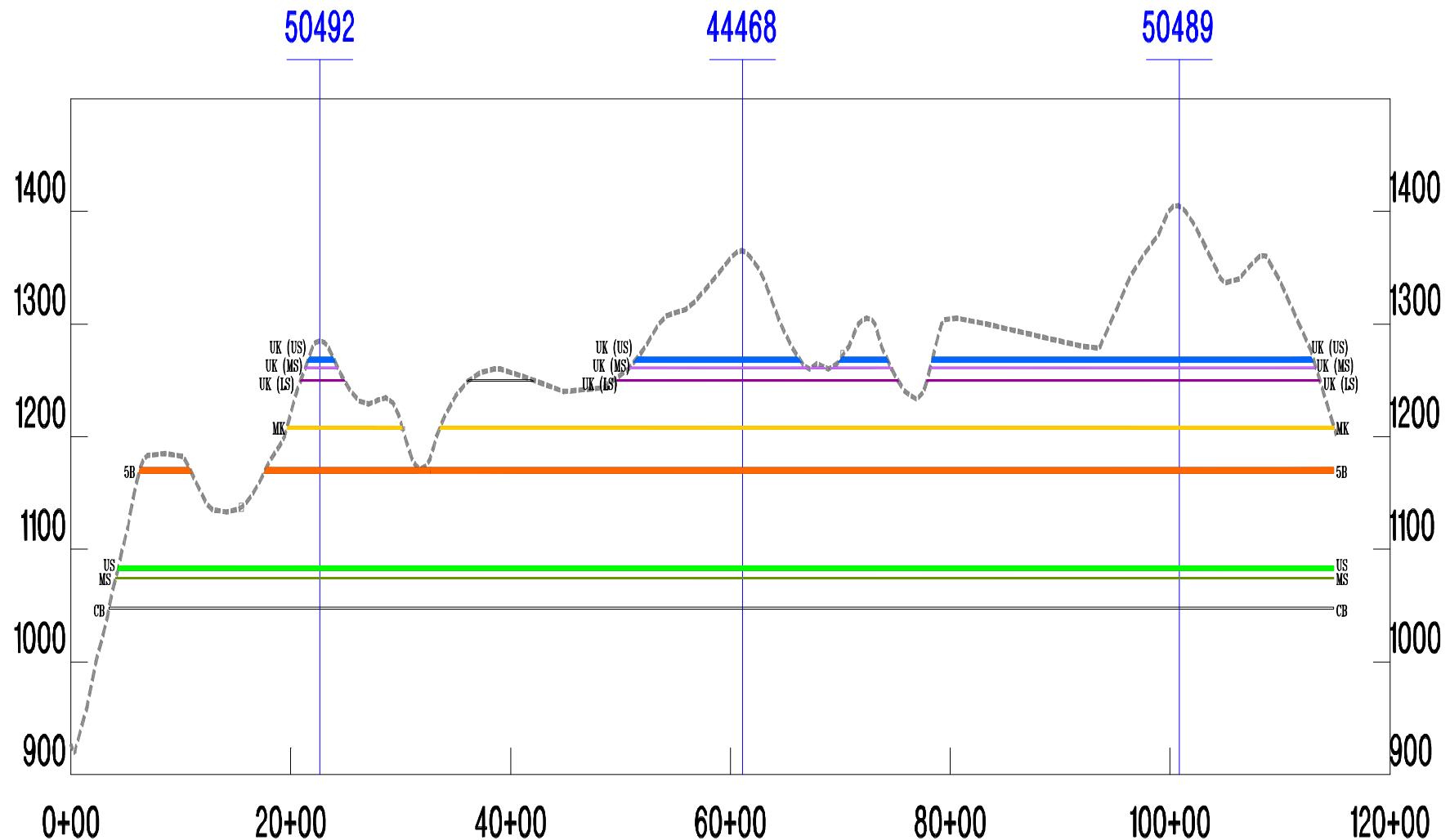
SEAM	WORK STR- SRM	ROOF	FLOOR	APPARENT	ANALYTICAL
CODE NO	SEC1 AT1- REA	DEPTH	DEPTH	THICKNESS	DESCRIPTION
	GRAN CLT	ft	ft	ft	
	LHM	0.000	20.000	20.000	CASENG.
	LHM	20.000	50.000	10.000	SANDSTONE, <CHLPPED>
	LHM	50.000	48.890	18.890	SANDSTONE, BROWN GREY, FINE GRAIN SIZE, MEDIUM GRAIN SIZE, MASSIVE, SHARP BASE, MEDIUM HARD.
	LHM	48.890	53.490	4.600	SHALE: SANDY, GREY, LAMINATED, DISTINCT BASE, MEDIUM HARD.
	LHM	53.490	70.500	17.010	SANDSTONE: SHALEY, LIGHT GREY, FINE GRAIN SIZE, SHARP BASE, HARD.
UST1	LRO	70.530	70.760	0.230	COAL, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	70.760	70.810	0.050	CARBONACEOUS SHALE: COALY, BLACK, SHARP BASE, MEDIUM HARD.
UST1	LRO	70.810	71.300	0.490	CLAYSTONE, LIGHT GREY, ROOT STRUCTURES, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	71.300	71.920	0.620	SHALE: SANDY, GREY, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	71.920	72.320	0.400	CARBONACEOUS SHALE, BLACK, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	72.320	72.430	0.110	SHALY COAL, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	72.430	73.800	1.370	FIRECLAY, GREY, DISTINCT BASE, MEDIUM SOFT.
UST1	LRO	73.600	75.830	0.230	COAL - DULL, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	73.830	74.000	0.170	CARBONACEOUS SHALE, BLACK, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	74.000	74.400	0.400	COAL, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	74.400	74.910	0.510	COAL - BONEY, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	74.910	75.200	0.290	COAL, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	75.200	75.610	0.410	COAL - BONEY, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	75.610	75.680	0.070	BONE, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	75.680	75.770	0.090	COAL, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	75.770	75.860	0.090	BONE, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	75.860	76.010	0.150	COAL - BONEY, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	76.010	76.190	0.180	BONE, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	76.190	76.420	0.230	COAL - BONEY, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	76.420	77.200	0.780	CARBONACEOUS SHALE, BLACK, DISTINCT BASE, MEDIUM HARD.
UST1	LRO	77.200	77.400	0.200	SHALY COAL: BONEY, SHARP BASE, MEDIUM HARD.
UST1	LRO	77.400	161.940	84.540	SANDSTONE: SHALEY, GREY, FINE GRAIN SIZE, MEDIUM GRAIN SIZE, CROSS BEDDED, MASSIVE, SHARP BASE, MEDIUM HARD.
	LRO	161.940	170.840	8.900	SHALE: SANDY, GREY, SIDEFRITIC, LAMINATED, SHARP BASE, MEDIUM HARD.
	LRO	170.840	171.690	0.850	CARBONACEOUS SHALE, BLACK, MASSIVE, SHARP BASE, MEDIUM HARD.
	LRO	171.690	172.590	0.900	SHALE, GREY, DISTINCT BASE, MEDIUM HARD.
	LRO	172.590	173.490	0.900	CARBONACEOUS SHALE, BLACK, MASSIVE, DISTINCT BASE, MEDIUM HARD.
	LRO	173.490	174.360	0.870	CLAYSTONE, GREY, DISTINCT BASE, MEDIUM HARD.
	LRO	174.360	174.430	0.070	CARBONACEOUS SHALE, BLACK, DISTINCT BASE, MEDIUM HARD.
UST	LRO	174.430	174.910	0.480	COAL - BONEY, DISTINCT BASE, MEDIUM HARD.
UST	LRO	174.910	175.160	0.250	SHALY COAL, DISTINCT BASE.
	LRO	175.160	176.310	1.150	FIRECLAY, GREY, FOSSILIFEROUS, DISTINCT BASE, MEDIUM HARD.
	LRO	176.310	196.300	17.990	SHALE: SANDY, GREY, SIDEFRITIC, FOSSILIFEROUS, LAMINATED, DISTINCT BASE, MEDIUM HARD.
	LRO	196.300	217.200	20.900	SANDSTONE: SHALEY, BROWN GREY, FINE GRAIN SIZE, MEDIUM GRAIN SIZE, MASSIVE, CROSS BEDDED, SHARP BASE, HARD.
UCB1	LRO	217.200	217.370	0.170	SHALY COAL, DISTINCT BASE, MEDIUM HARD.
UCB1	LRO	217.370	218.760	1.390	COAL - BONEY, DISTINCT BASE, MEDIUM HARD.

Geologist Log

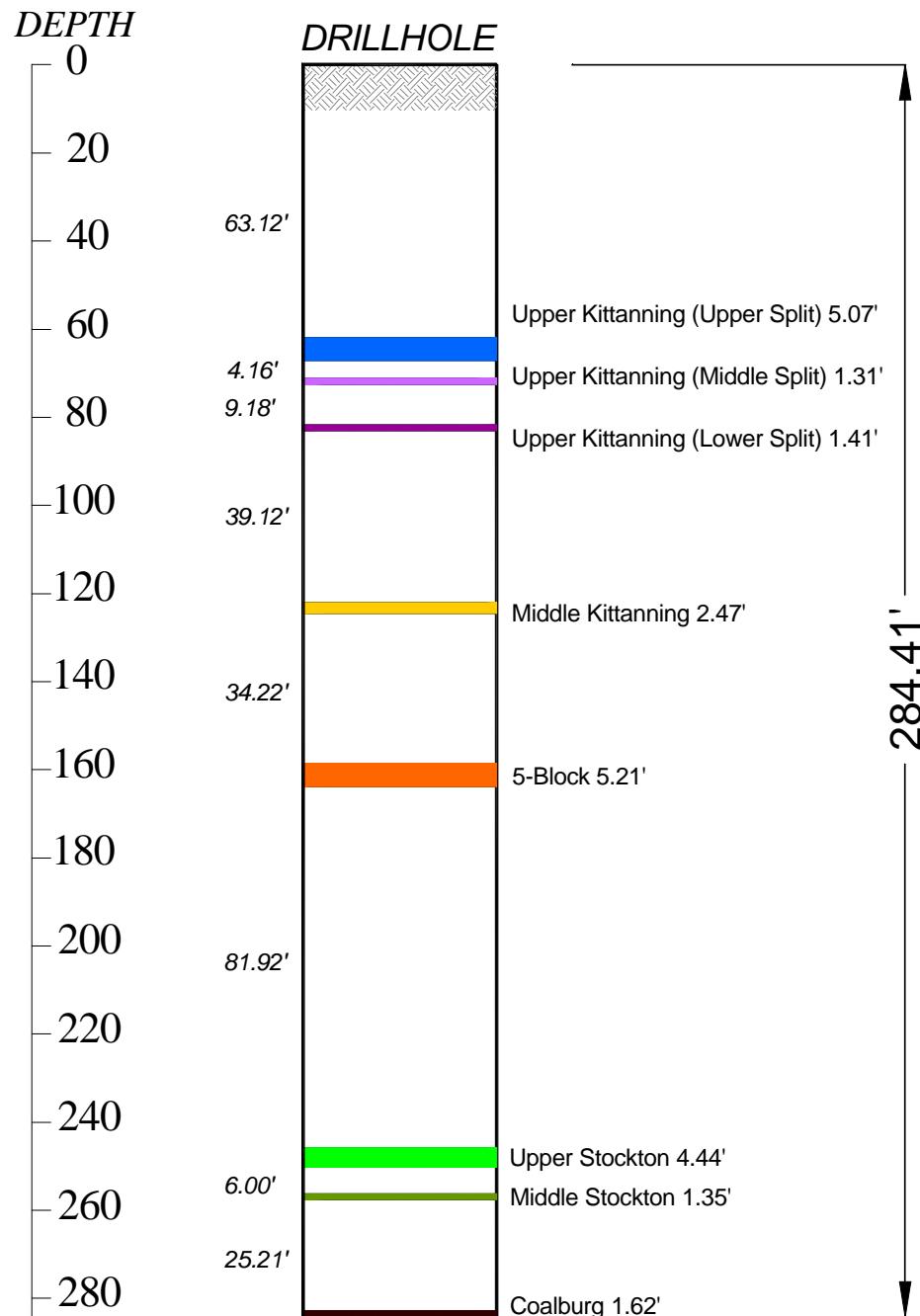


Geophysical (Electric) Log

Stratigraphic Cross-Section



Geologic Column



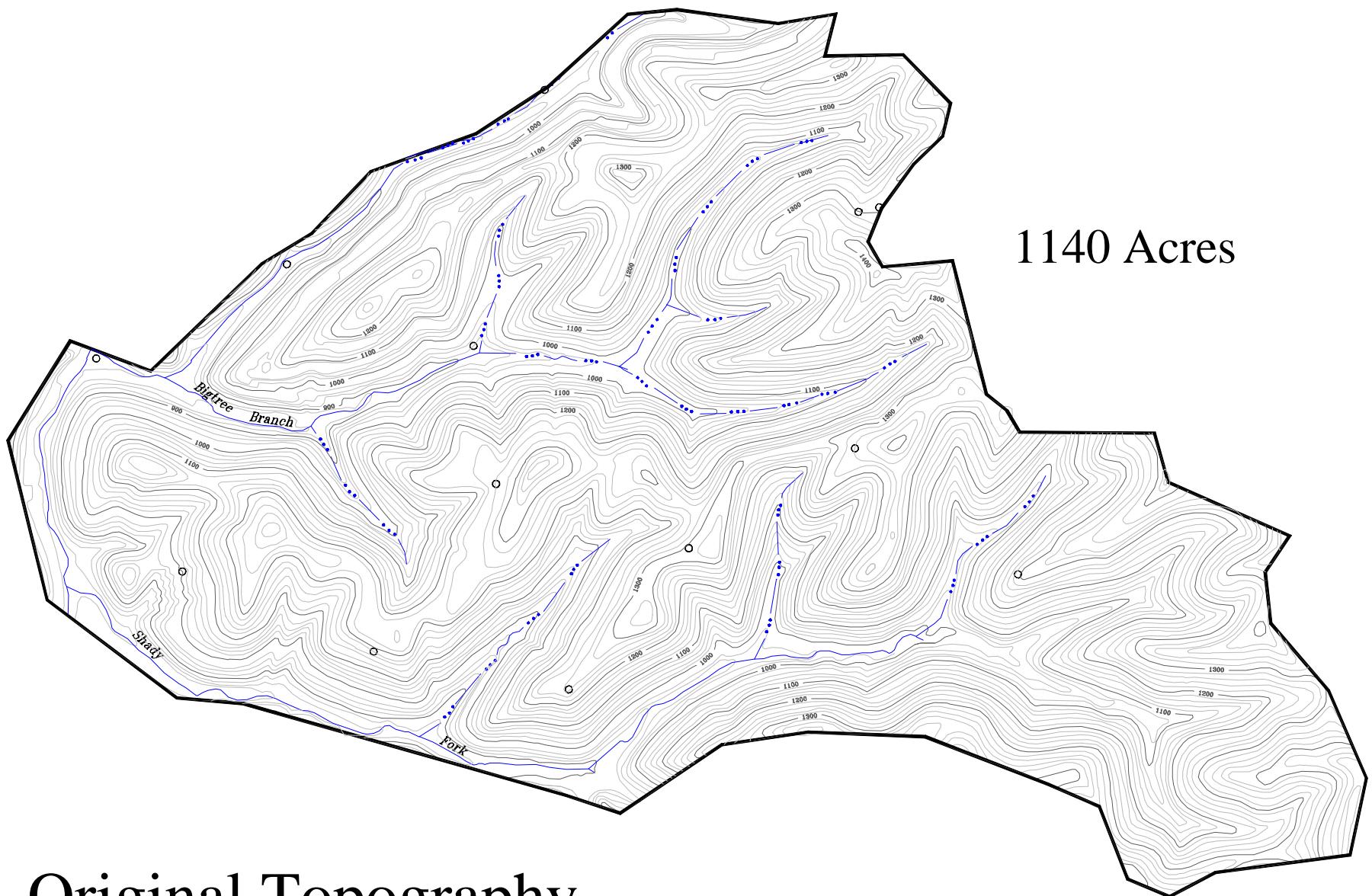


OPERATIONAL

- **Location**
- **Access**
- **Legal Considerations**
 - Mineral Ownership
 - Surface Ownership
 - Oil and Gas Rights
- **Infrastructure**
 - Coal Preparation Facilities
 - Transportation Facilities

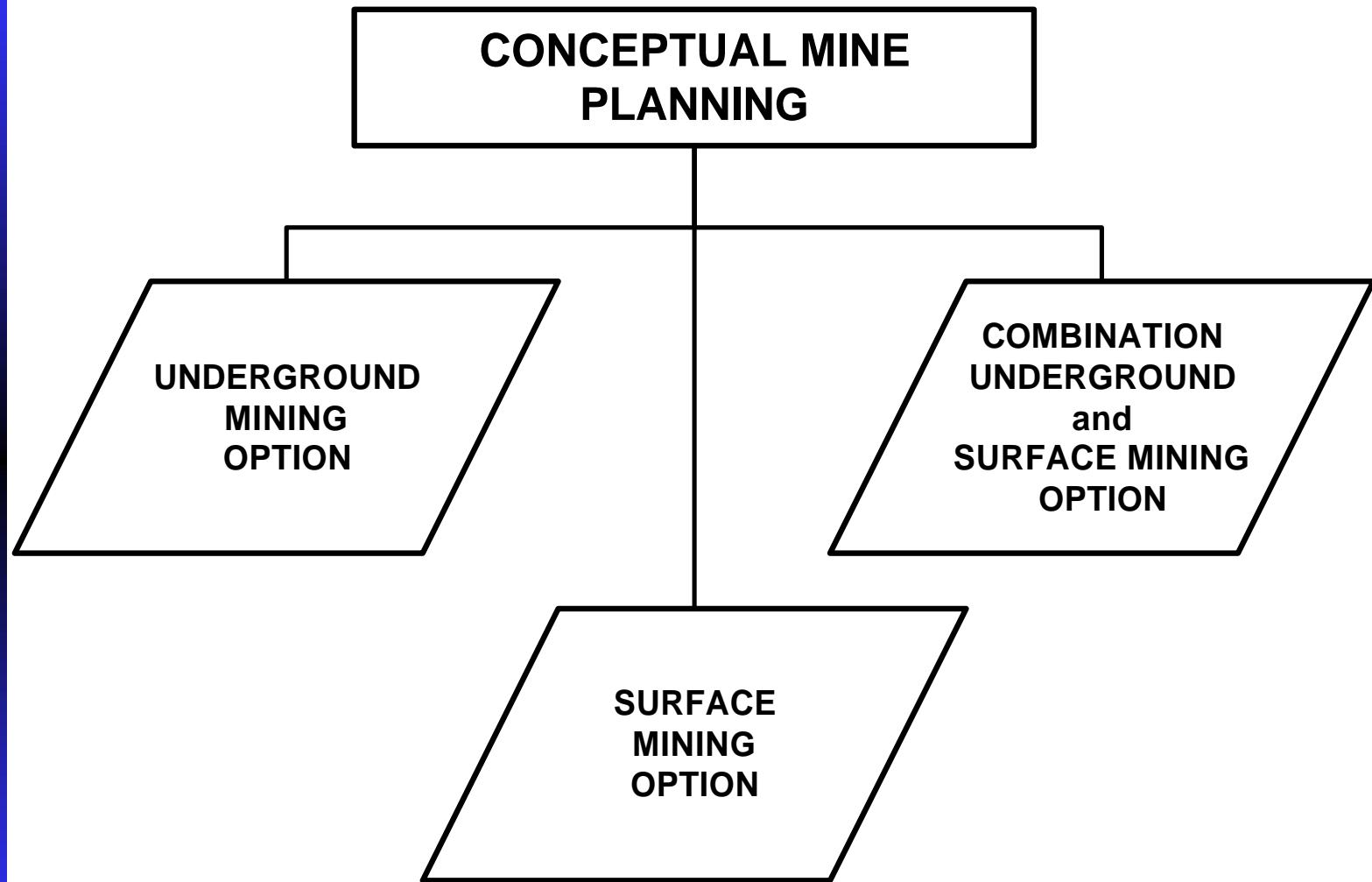
TOPOGRAPHICAL

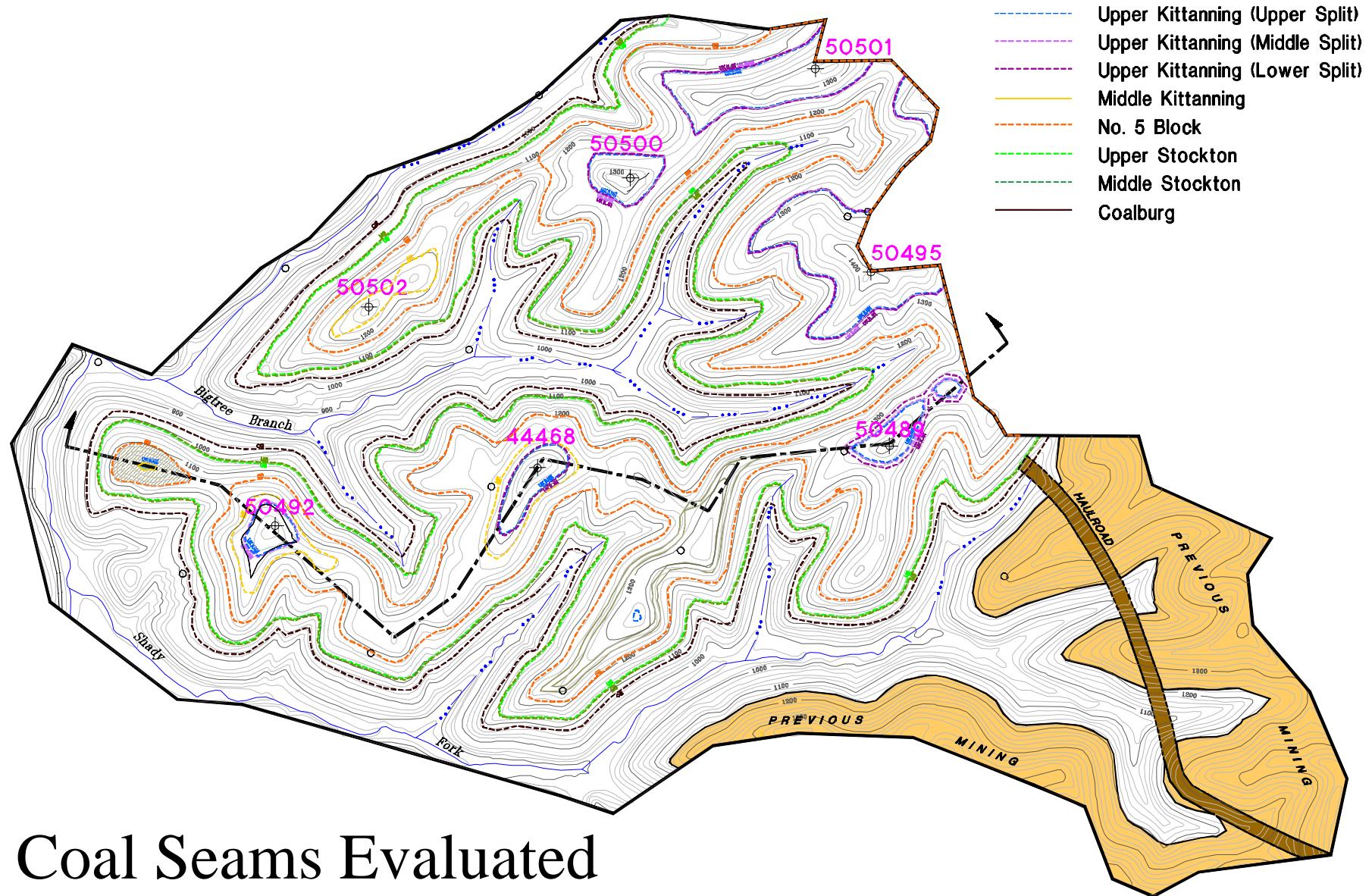
- **Drainage Patterns**
- **Natural Terrain**
 - Slopes
 - General Configuration
- **Relative Elevations**
 - Coal Seams to Surface
 - Seam to Seam
- **Potential Excess Spoil Sites**



Conceptual Mine Plan

**Identification and Evaluation
of
Alternatives**





Coal Seams Evaluated
Location of Stratigraphic Cross-Section

Reserve Criteria

Mining Method Analysis

Assumptions

Deep Mining

- A Minimum 30" Mining Height
- B Minimum 100 feet of Cover
- C Leave 100 foot outcrop barrier
- D Reserve size of at least 500,000 clean, recoverable tons
- E Mining Recovery of 60%
- F Must have at least 40 feet of interval to subjacent or superadjacent deep mining
- G Yield must be greater than 50%
- H Minimum 3" Out of Seam Dilution added during mining
- I Must leave 200 ft. barrier to old works
- J Must leave 100 ft. radius barrier around gas wells

Contour Mining

- A Must have at least 20 feet of cover
- B Seam must be at least 12" thick to be recovered
- C 85% pit recovery
- D Bench width must be at least 80 feet.
- E Split must be at least 6" to be loaded

Mountaintop Mining

- A Must have at least 20 feet of cover
- B Seam must be at least 12" thick or 6" if a split of another seam to be recovered
- C 85% pit recovery

Miscellaneous

- A Washed Quality based on 1.60 float gravity
- B Plant efficiency is 92%
- C Ash must be less than 16% (Dry Basis) to be direct shipped
- D BTU must be at least 12,800 (Dry Basis) to be direct shipped

UNDERGROUND MINING

- **Identify Minable Seams Based on Available Reserve and Projected Mining Conditions**
 - Seam Extent and Thickness
 - Roof and Floor Conditions
 - Expected Recovery
- **Identify Potential Mine Portal Sites**
- **Estimate Coal Extraction Rate**
- **Predict Coal Quality (Markets and Price)**
- **Define Other Constraints / Assumptions**

Underground Mining Percent Recovery

Underground

Room and Pillar
54-60%

Second Mining
70-80%

Longwall
85%

AMD Prediction: Underground or Auger Mining

AMD Potential Indicated? - No

 Develop Total Reserve Body

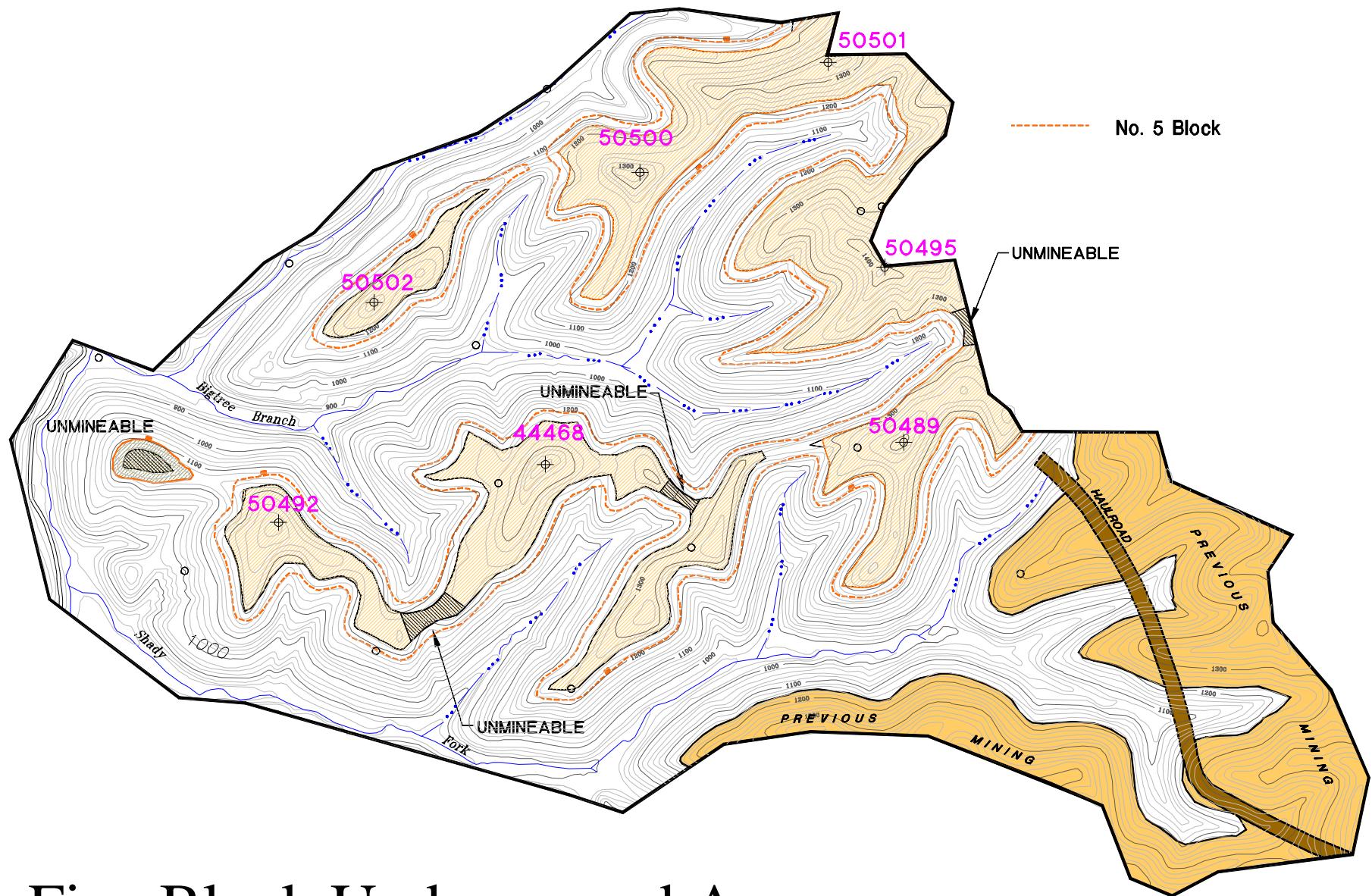
AMD Potential Indicated? - Yes

 Is Seam Accessible to Eliminate Potential AMD?

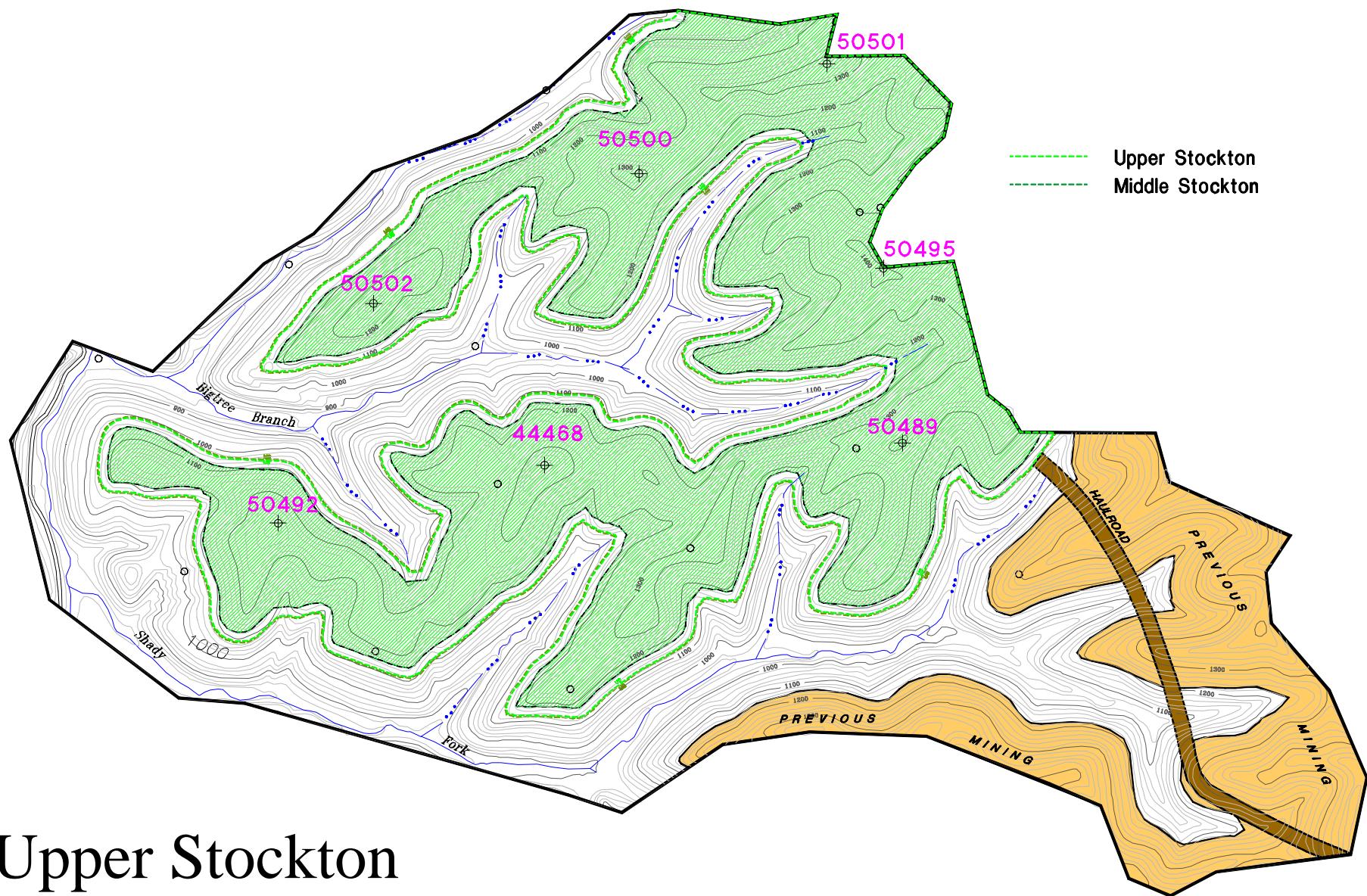
 Define Extent of Reserve Body Minable

Calculate Run of Mine Recoverable Reserves

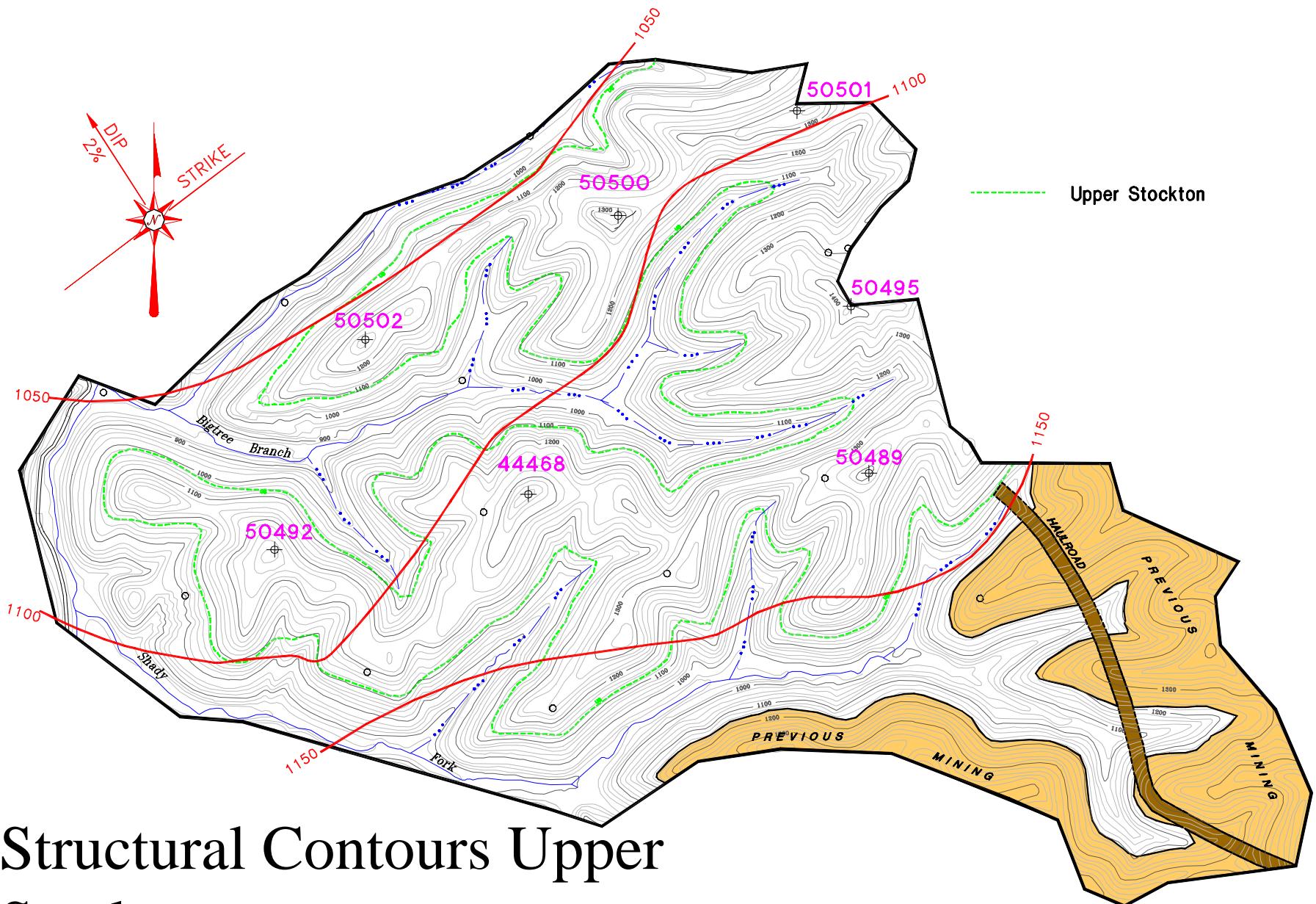
Calculate Clean Recoverable Tons



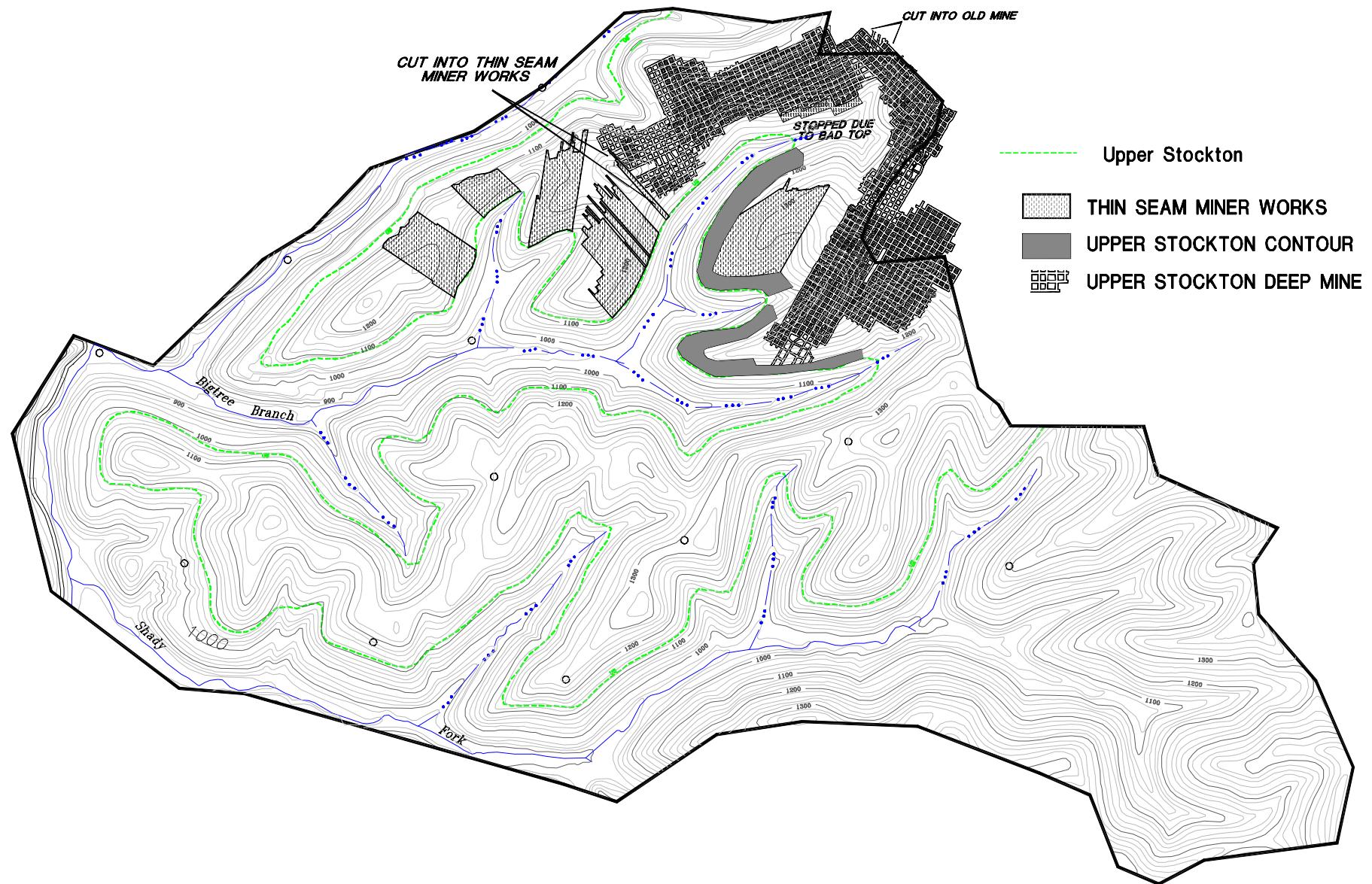
Five Block Underground Area



Upper Stockton
Underground Mine



Structural Contours Upper Stockton



Bigtree Underground Mine Works



13.R

60.C

7.R

No. b

SURFACE MINING

- **Identify Minable Seams Based on Thickness and Incremental Ratios**
- **Tentatively Assign Mining Method to Each Seam (Mountaintop, Contour, Area)**
- **Predict Coal Quality Per Seam or Seam Split (Markets and Price)**
- **Identify Strata Requiring Special Handling**
- **Identify Excess Spoil Disposal Sites**
- **Define Other Constraints / Assumptions**

Surface Mine Methods

Percent Recovery Within Pit

Surface

Mountaintop
85%

Contour
85%

Auger
30 %

Highwall Miner
35-45%

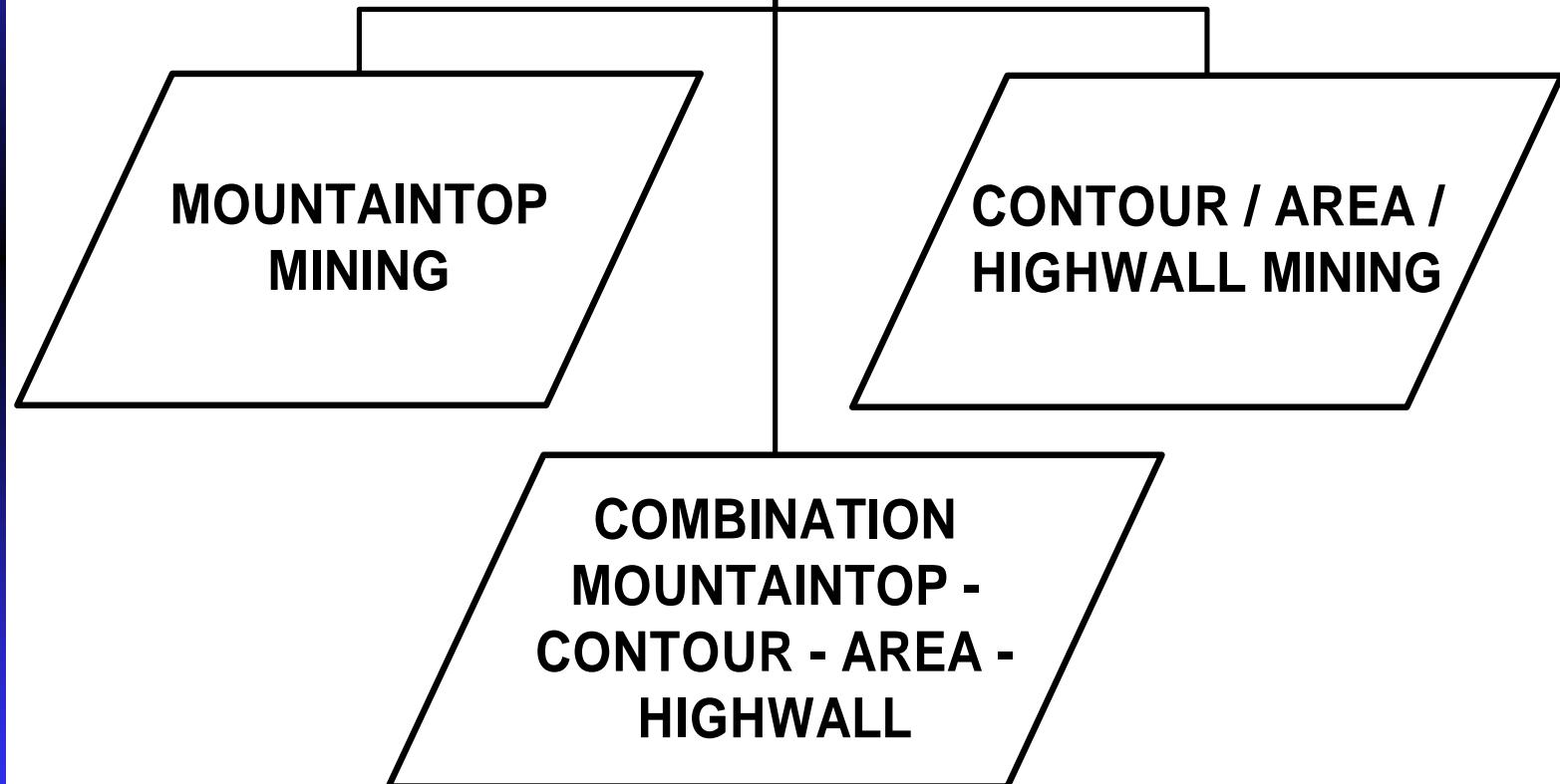
Combination Underground and Surface Mining

- **Identify Seams to be Surface Mined**
- **Identify Seams to be Deep Mined**
- **Locate Excess Spoil Disposal Sites**
- **Locate Underground Mine Facilities to Avoid Conflicts with Surface Mining**
- **Define Other Constraints / Assumptions**

Preliminary Surface Mine Plan

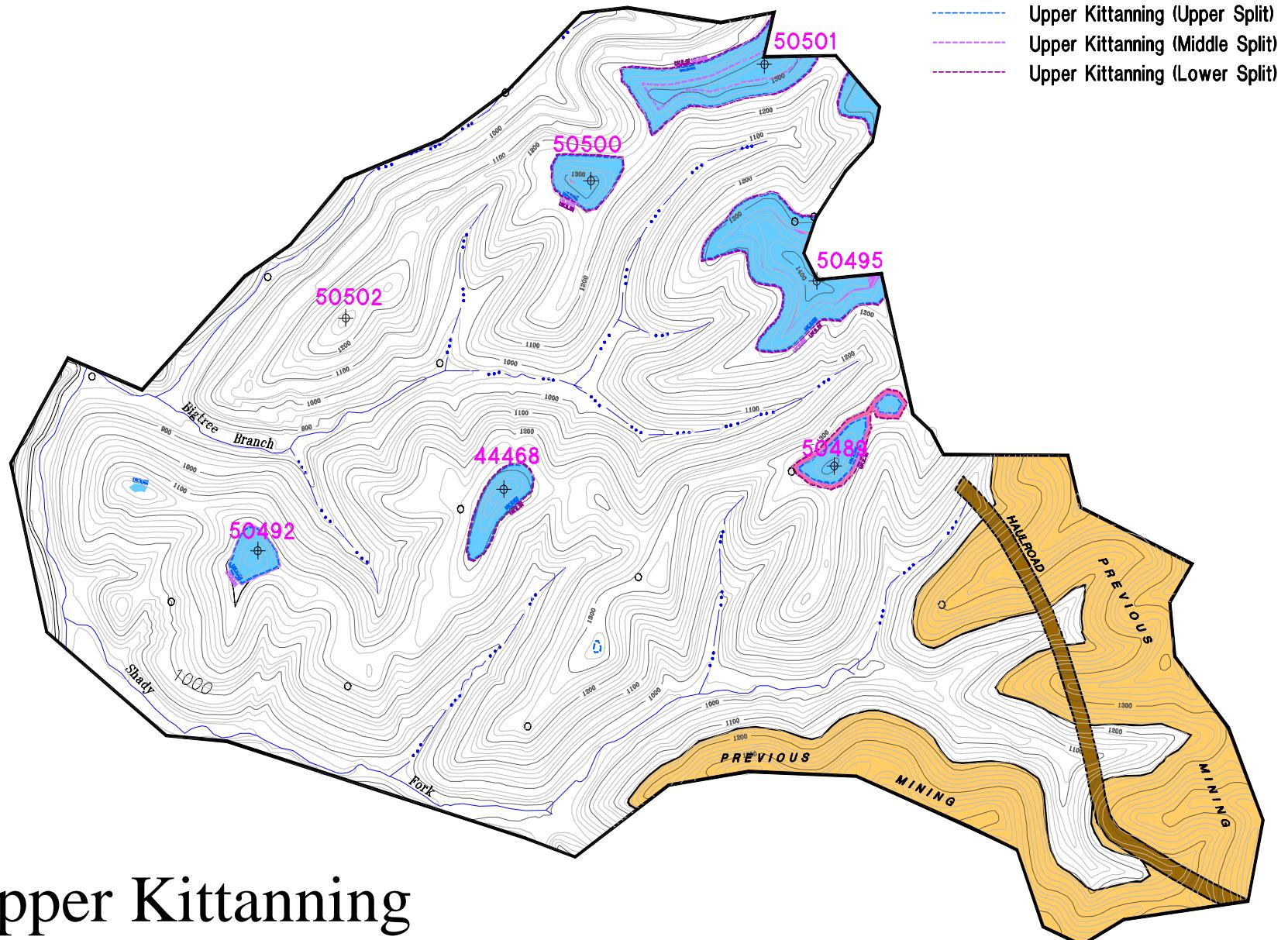
**NOTE: Presumes That Other
Alternatives Have Been Considered and
Discarded**

PRELIMINARY SURFACE MINE PLANNING

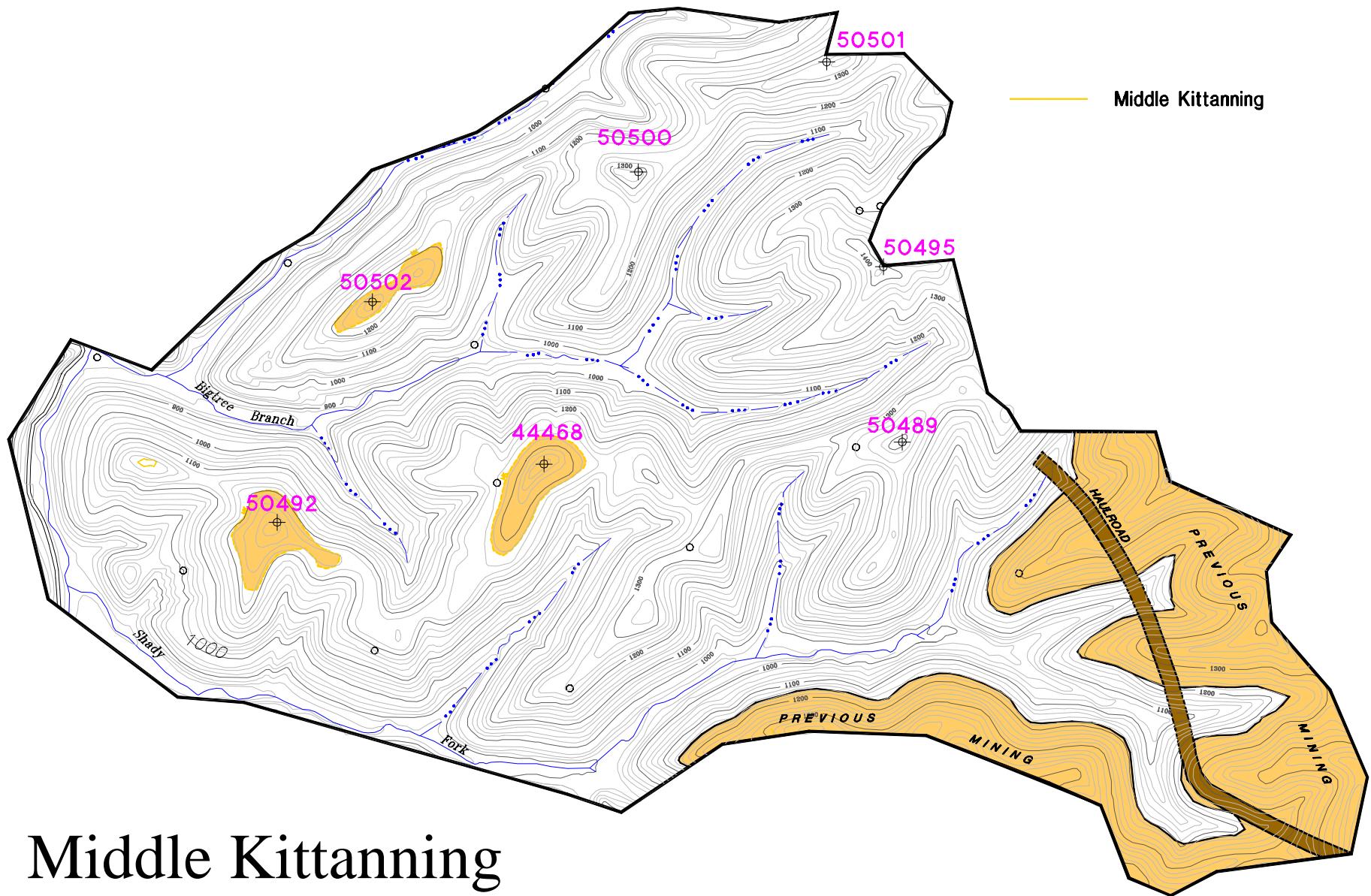


MOUNTAINTOP MINING

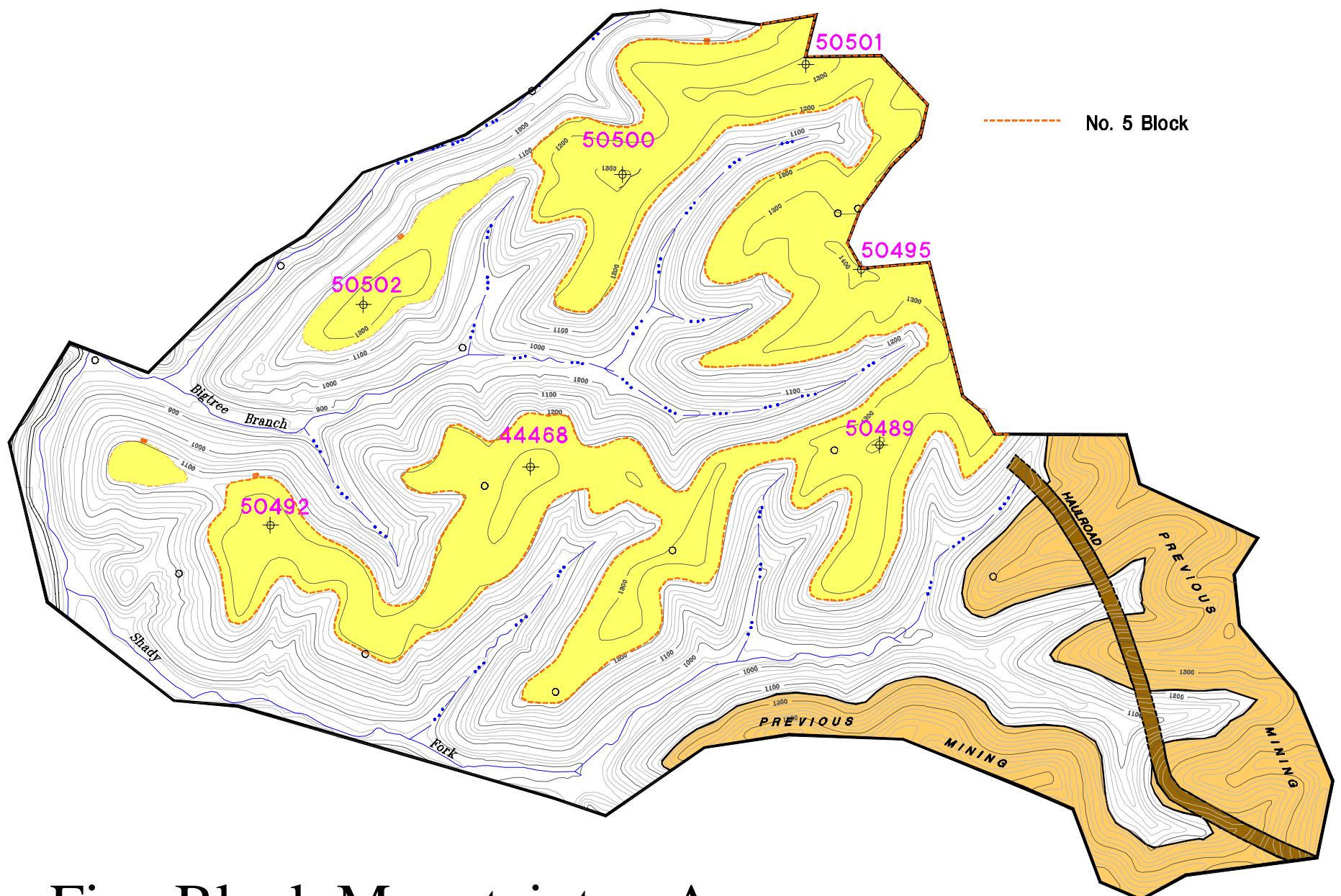
- **Define Economic Extent of Potential Mining**
- **Estimate Coal Recovery as Tonnage and Quality Per Specific Seam**
- **Construct Preliminary Layout**
 - **General Mine Sequence**
 - **Preliminary Regraded Configuration**
 - **Preliminary Spoil Balance**
 - **Preliminary Drainage Control Plan**
- **Define Specific Assumptions / Constraints**



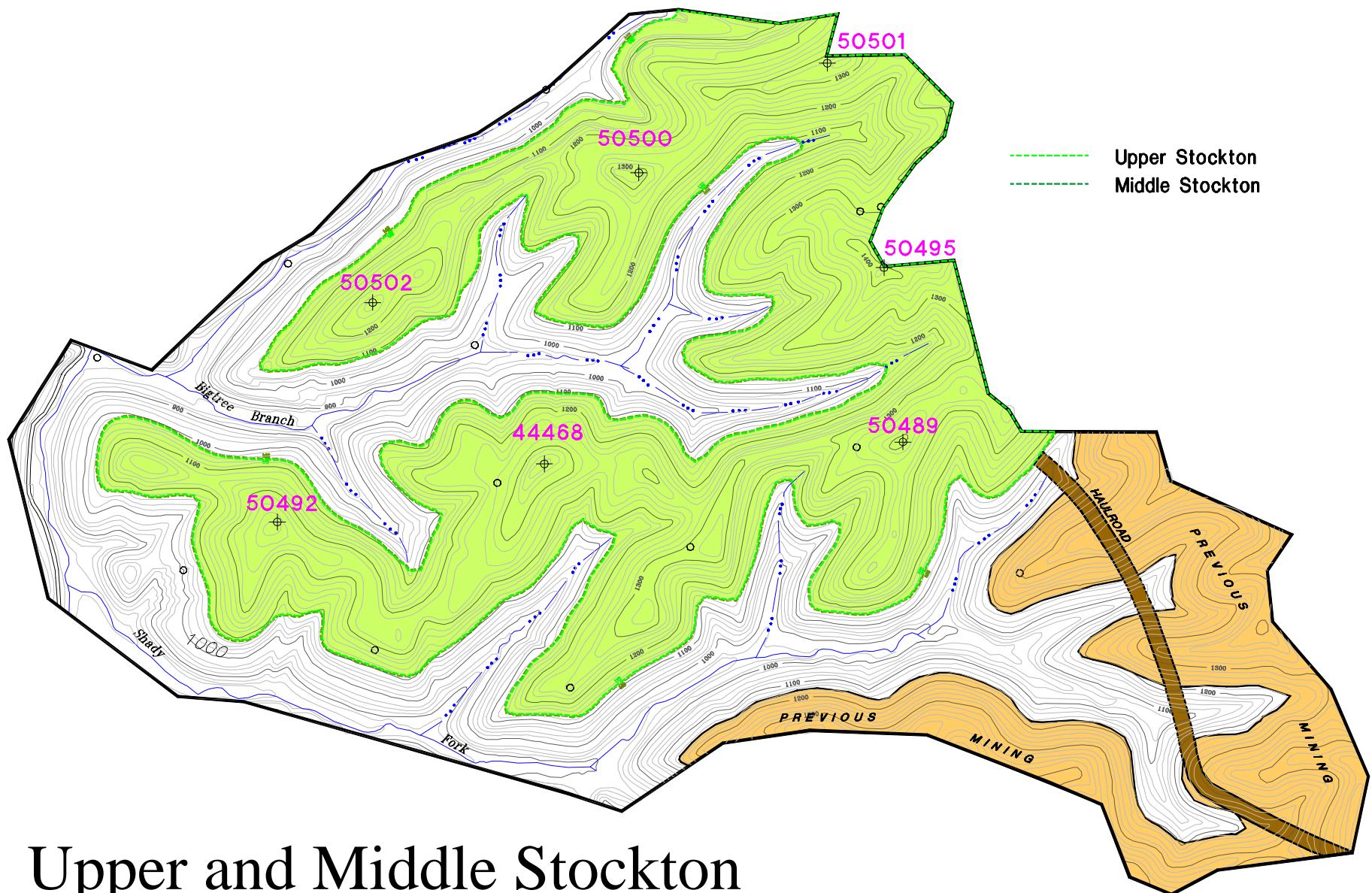
Upper Kittanning
Mountaintop Area



Middle Kittanning
Mountaintop Area



Five Block Mountaintop Area



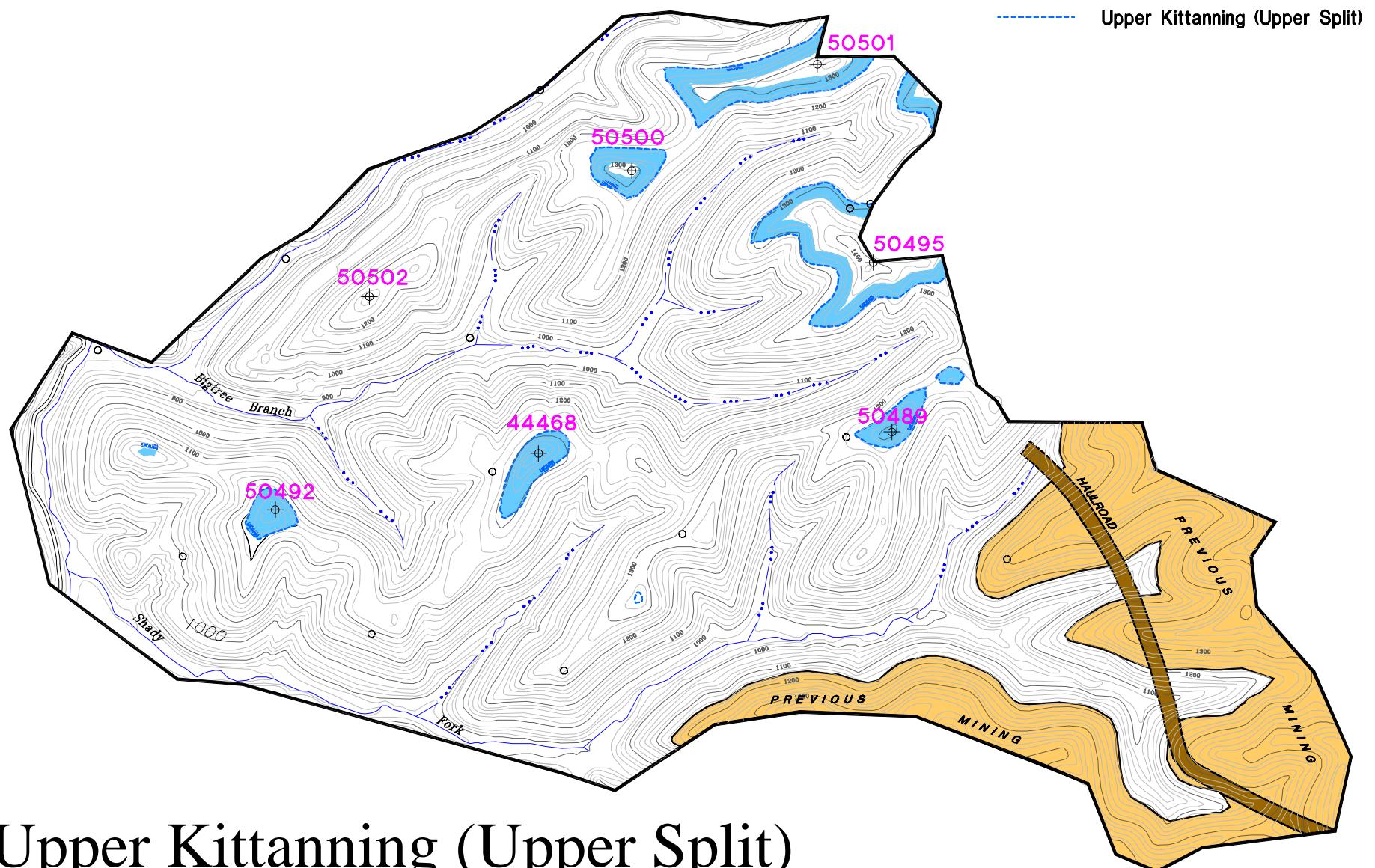
Upper and Middle Stockton
Mountaintop Area

CONTOUR / AREA / HIGHWALL MINING

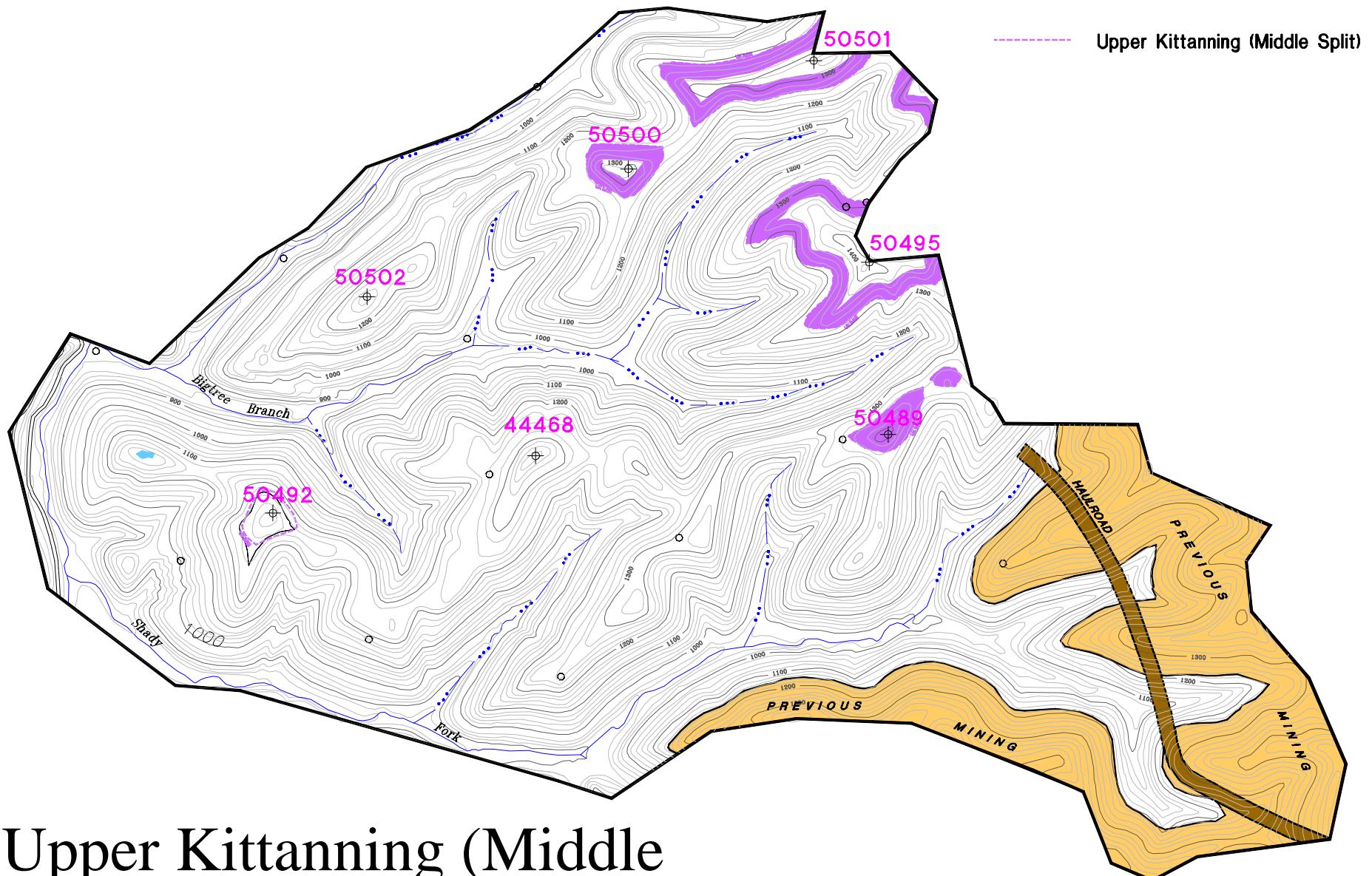
- **Assign Mining Method to Each Seam**
- **Define Economic Extent of Mining per Seam**
- **Estimate Coal Recovery as Tonnage and Quality Per Specific Seam**
- **Construct Preliminary Layout**
 - **General Mine Sequence**
 - **Preliminary Regraded Configuration**
 - **Preliminary Spoil Balance**
 - **Preliminary Drainage Control Plan**
- **Define Specific Assumptions / Constraints**

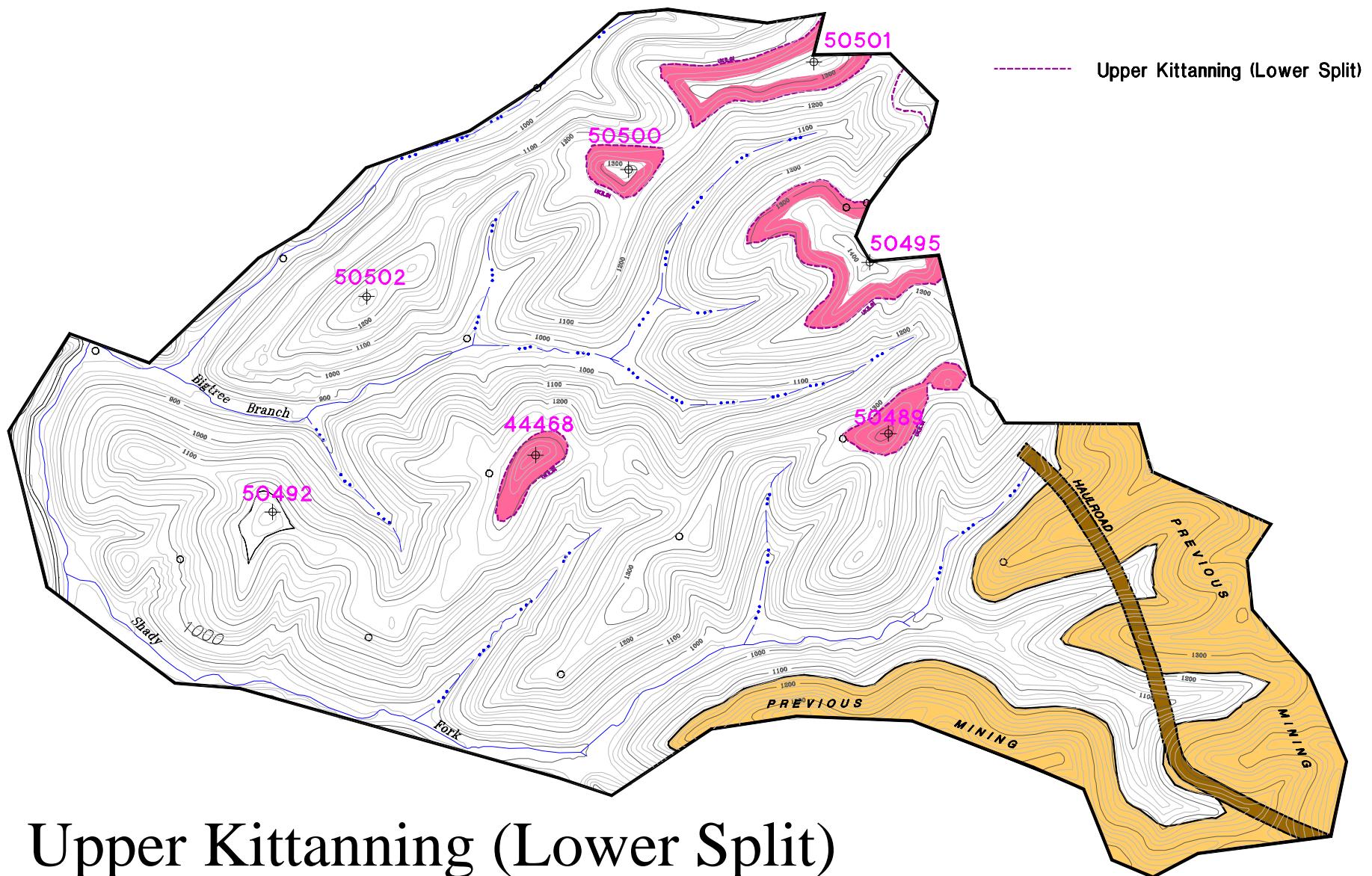
Contour Mining

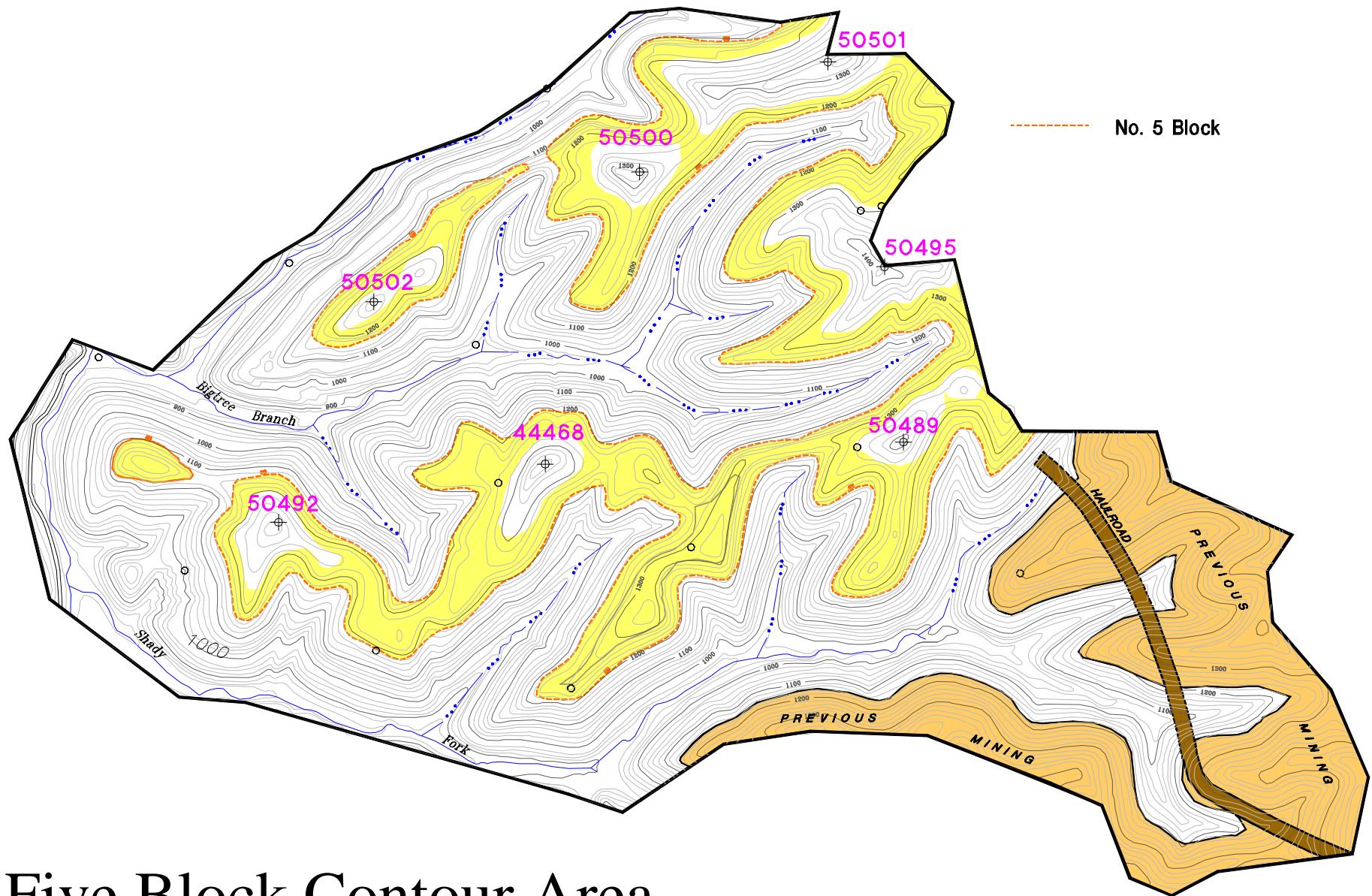




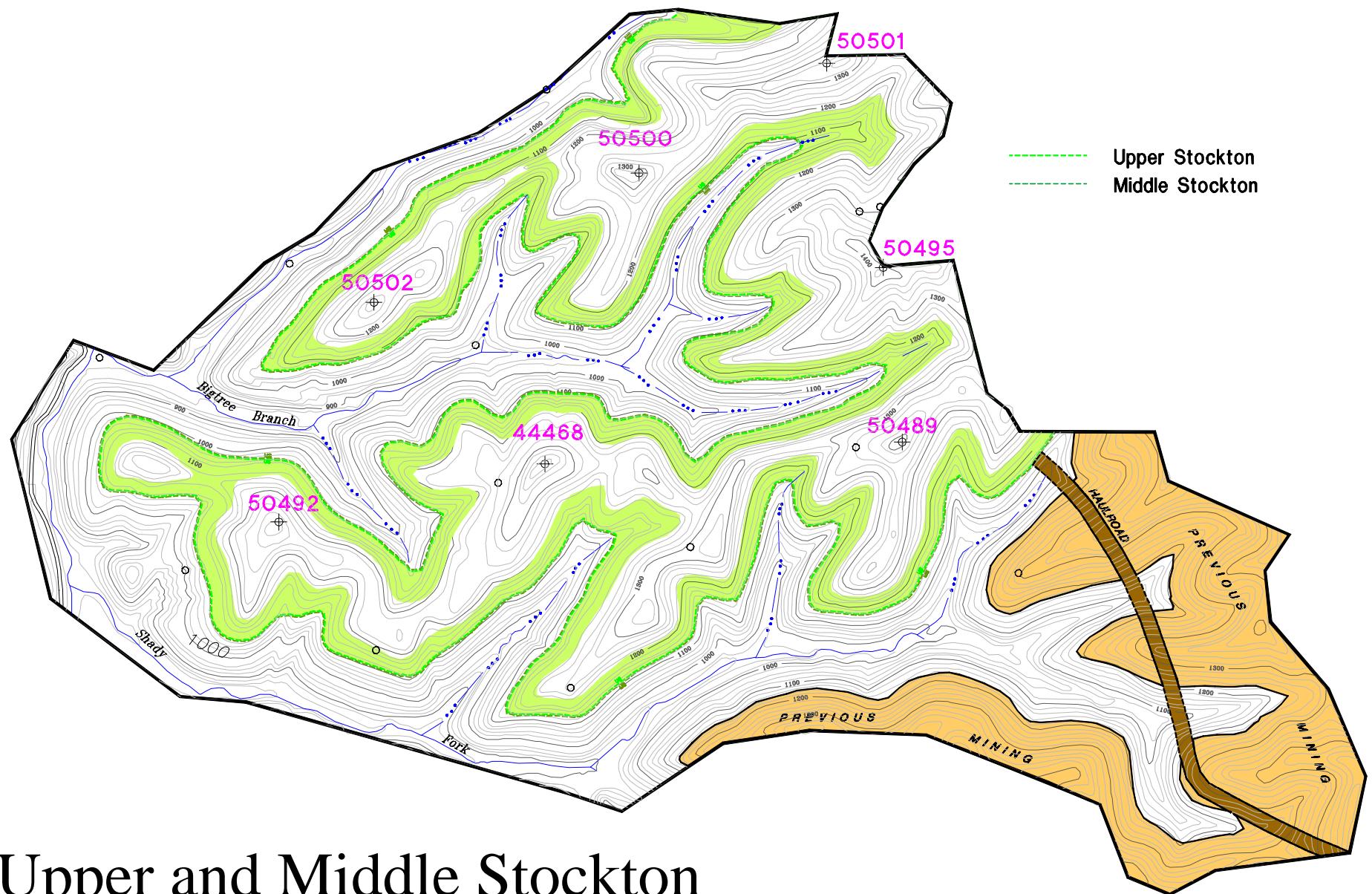
Upper Kittanning (Upper Split)
Contour



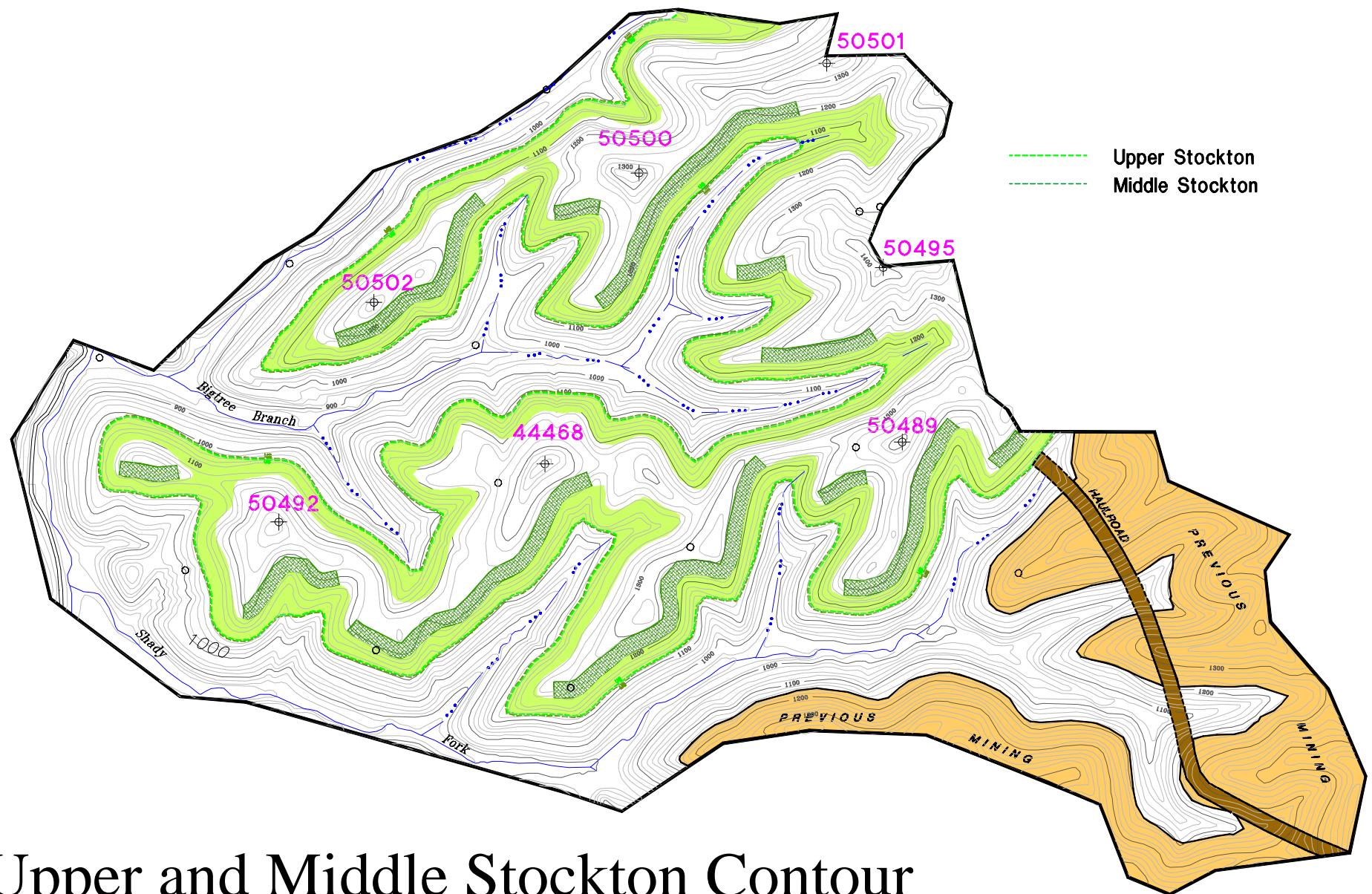




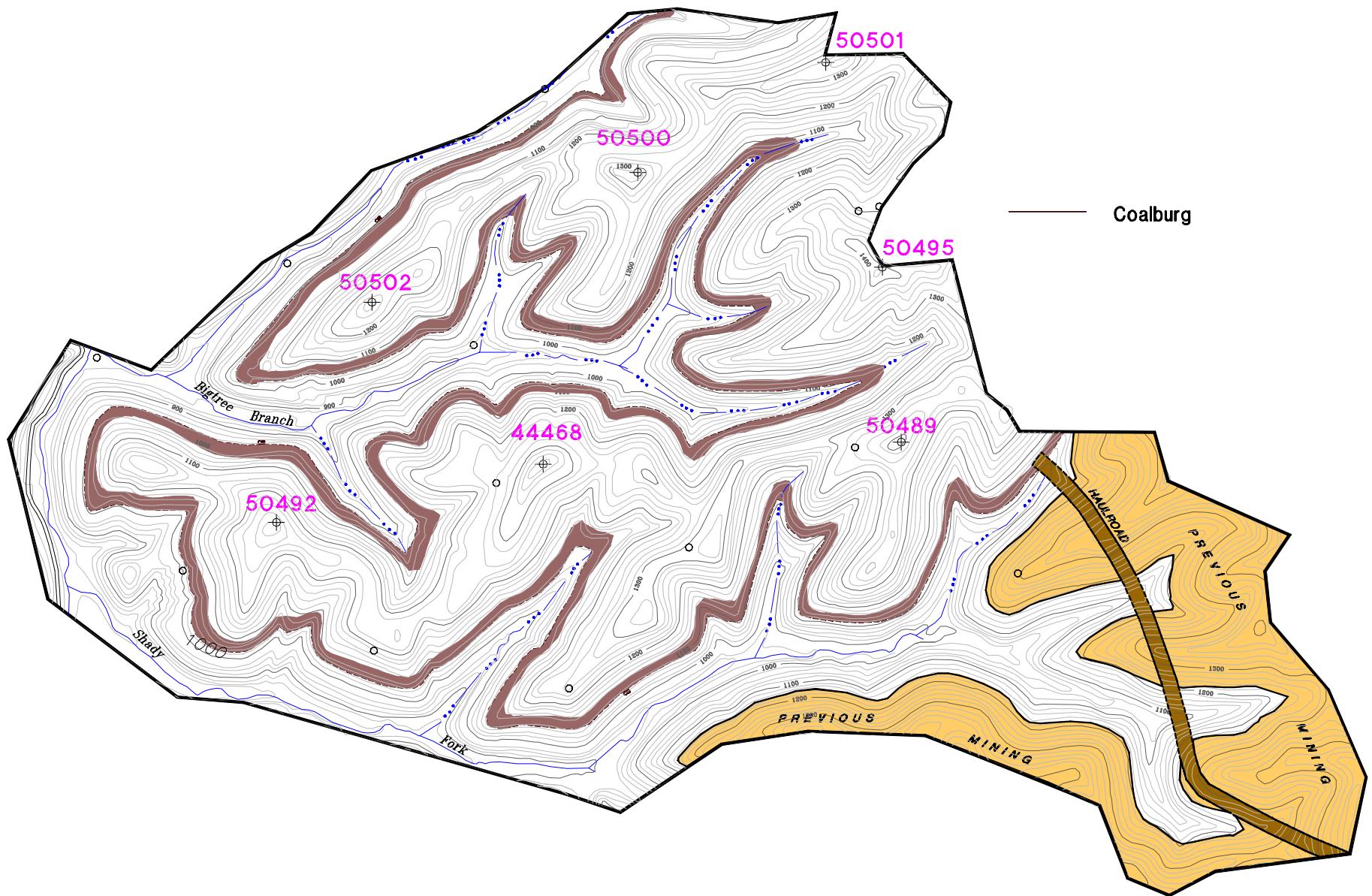
Five Block Contour Area



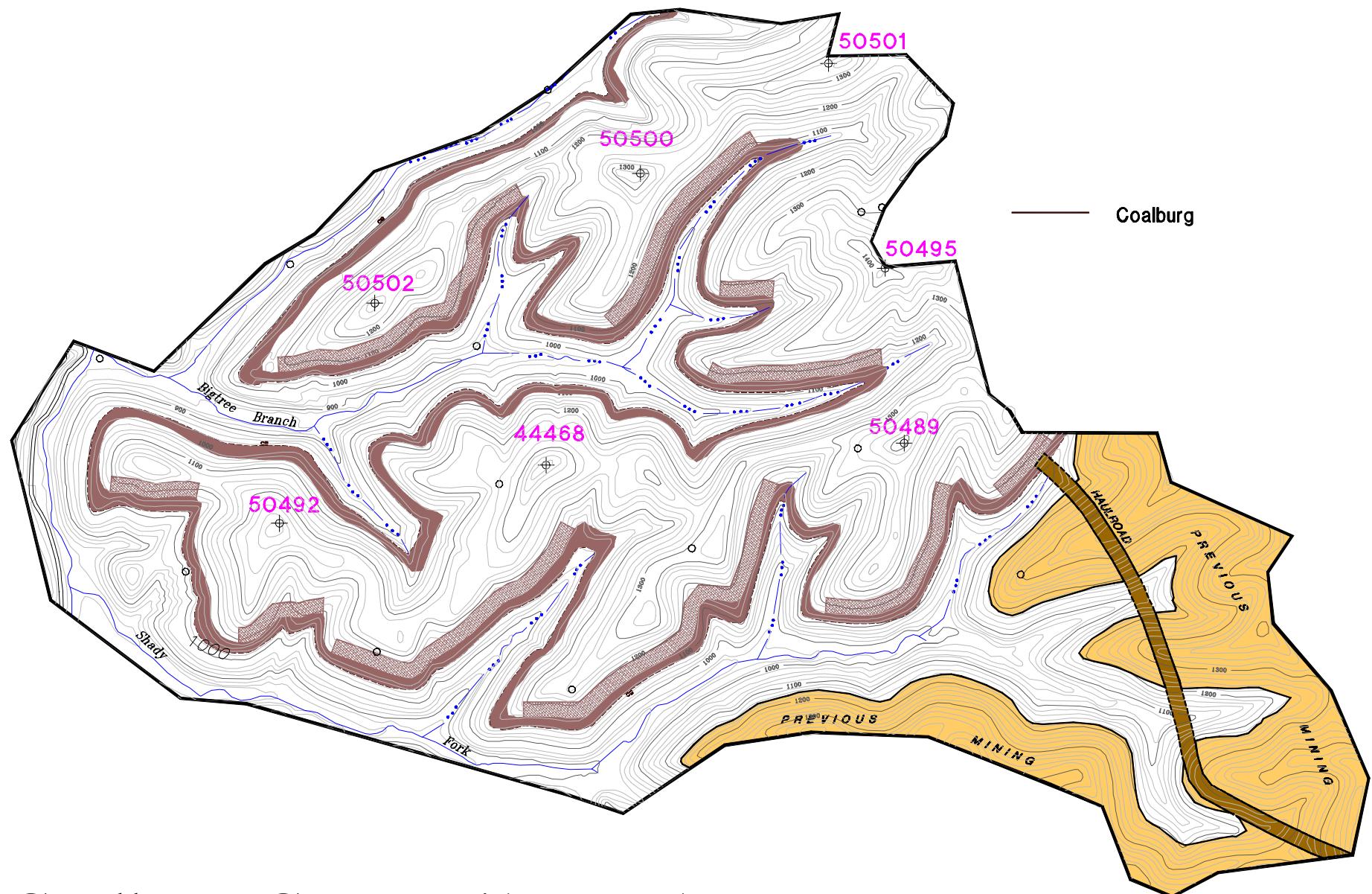
Upper and Middle Stockton
Contour Area



Upper and Middle Stockton Contour
Area/Upper Stockton Auger Area



Coalburg Contour Area

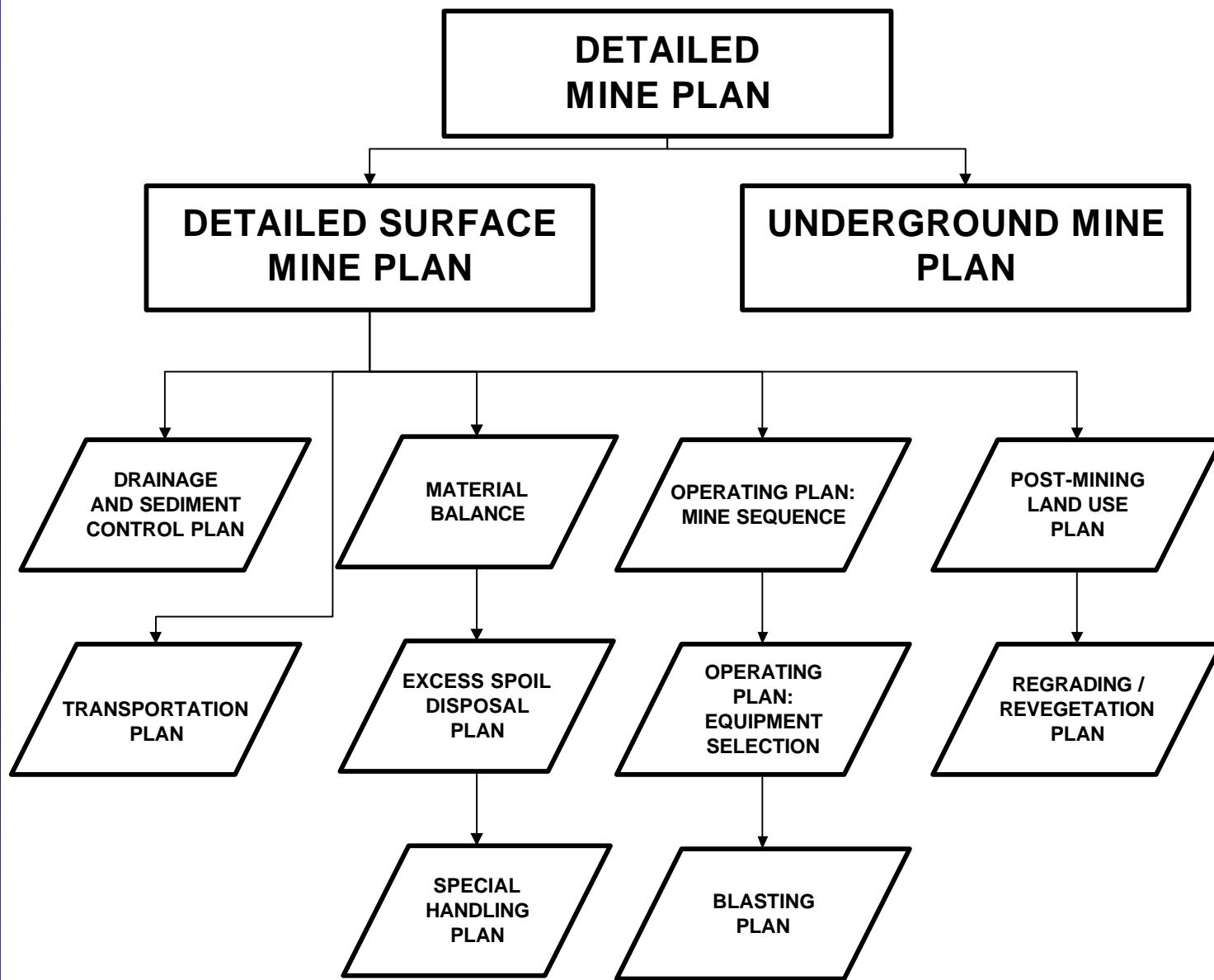


Coalburg Contour/Auger Area

COMBINED MOUNTAINTOP - CONTOUR - AREA - HWM

- **Assign Mining Method to Each Seam**
- **Define Economic Extent of Mining per Seam**
- **Estimate Coal Recovery as Tonnage and Quality Per Specific Seam**
- **Construct Preliminary Layout**
 - **General Mine Sequence**
 - **Preliminary Regraded Configuration**
 - **Preliminary Spoil Balance**
 - **Preliminary Drainage Control Plan**
- **Define Specific Assumptions / Constraints**

Detailed Mine Plan



Drainage and Sediment Control

- **Locate Primary Sediment Control Structures**
 - Ponds at Valley Fills
 - On-Bench Sediment Structures
- **Define Temporary Sediment Control Plan**
- **Complete Detailed Drainage Designs**
 - Sediment Ponds
 - Sediment Channels
 - Drainage Channels / Flumes
 - Culvert Designs (Roads, etc.)



* 6'85



Material Balance

- **Calculate Total Material to be Excavated**
- **Determine Volume of Coal to be Recovered**
- **Difference x Swell (typically 25%) Equals Total Spoil Material**
- **Determine Volume of Backfill to Achieve the Post-Mining Configuration**
- **Total Spoil Less Backfill Equals Excess Spoil**
- ***Location of Spoil Disposal Sites Relative to Spoil Generation Sites is Critical to Mine Plan***

Excess Spoil Disposal Plan

- **Define Needs / Constraints / Limitations**
 - **Volume Required Per Site**
 - **Section 404 Considerations**
- **Situate Excess Spoil Disposal Facilities**
 - **On-Bench Where Available and Practical**
 - **Valley Fills**
- **Design Details**
 - **Volume**
 - **Stability**
 - **Drainage (Internal and Surface)**

Location of Valley Fills

Volume Required

Profile of Existing Hollow

Contributing Drainage Area

Sediment Control Location

Sequence of Construction

Environmental Factors

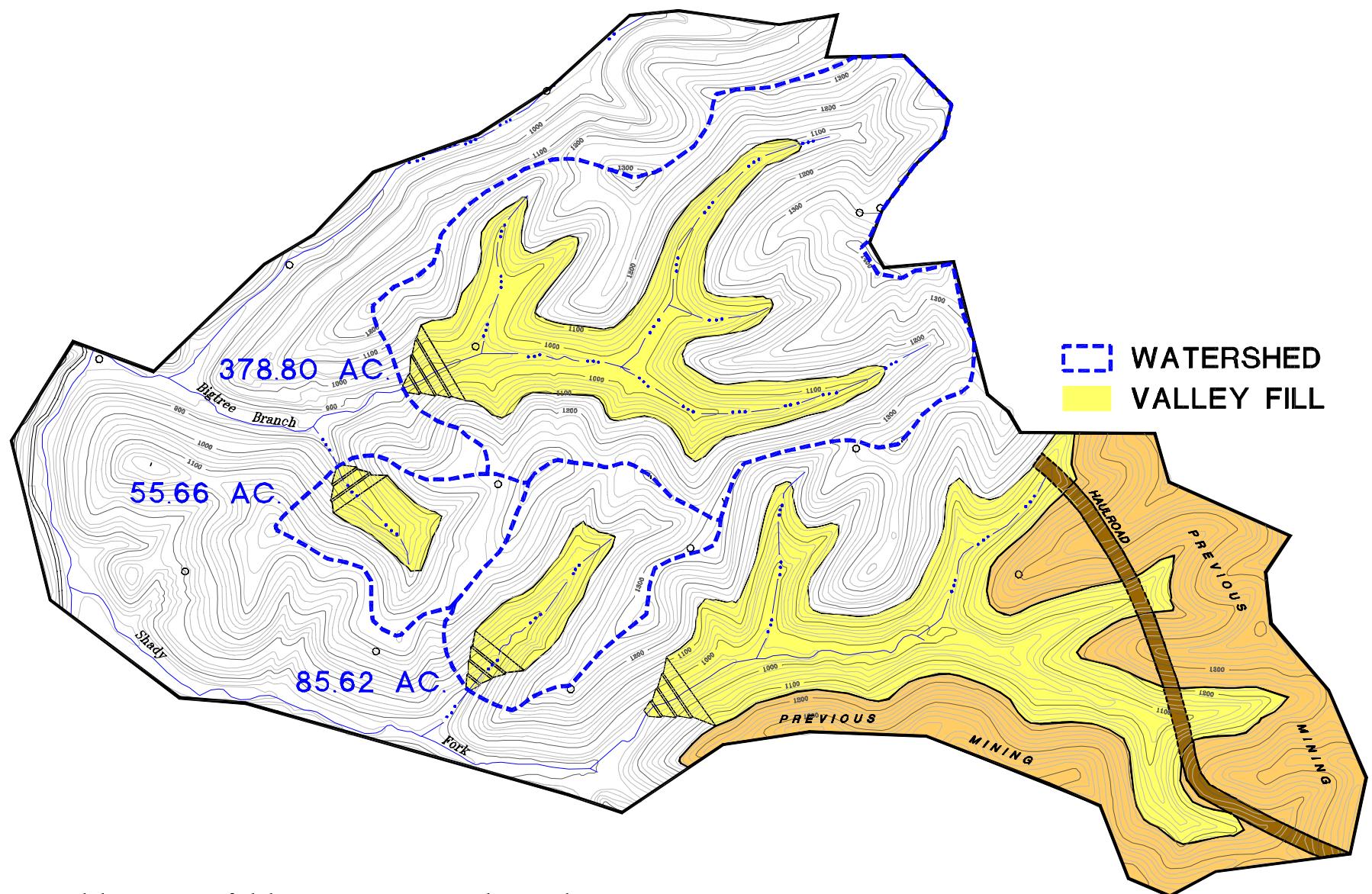
Aquatic Habitat

Benthic Survey

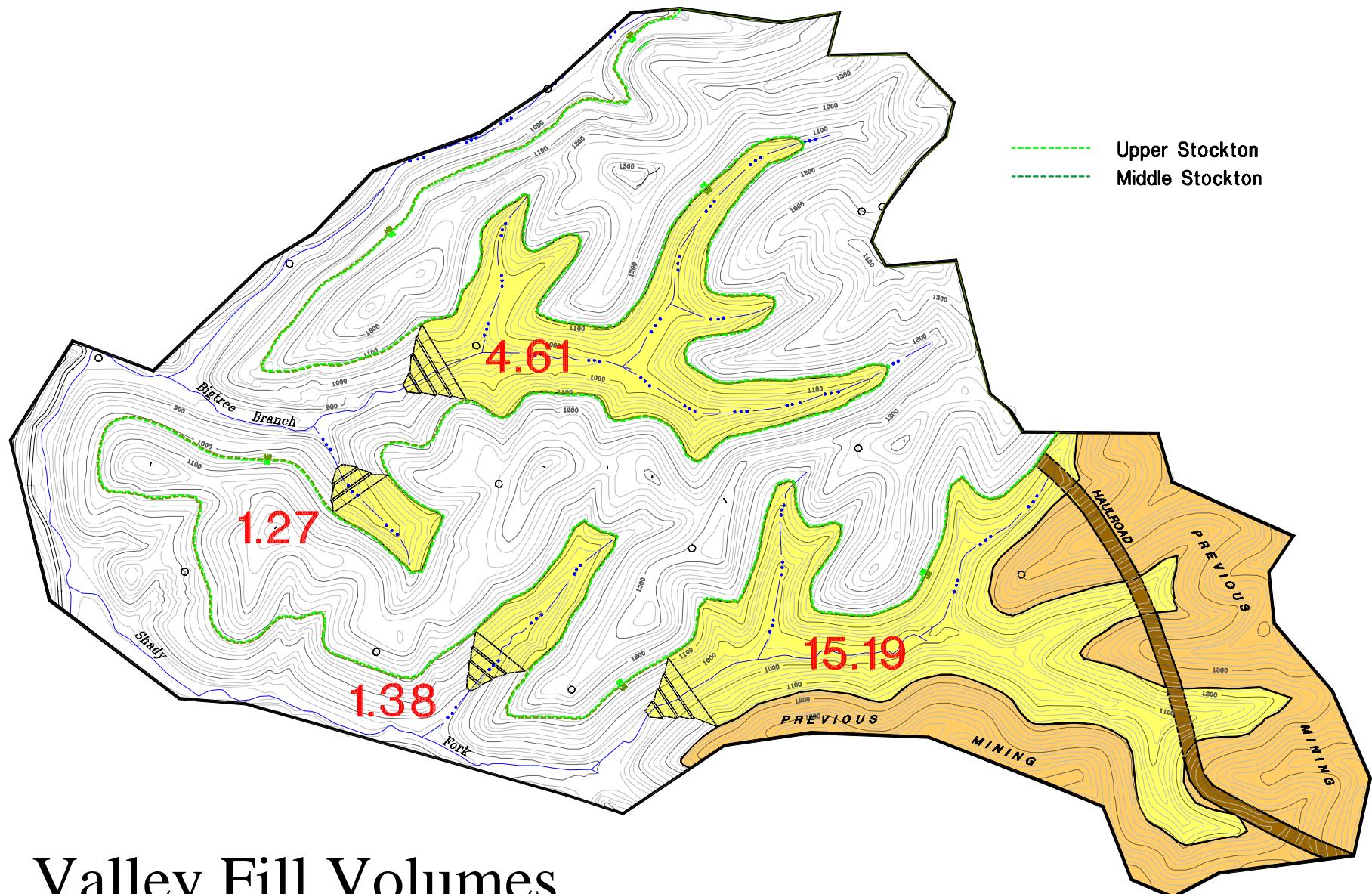
Stream Area Measurements

Mitigation/ Compensation

No Practical Alternative Demonstration



Valley Fill Watersheds



Valley Fill Volumes
(MMCY)



328'98

Special Handling Plan

- **Identify Stratum Requiring Special Handling**
 - Determined By Geologic Investigation
- **Blending, Isolation, or Encapsulation?**
 - Decision Generally Based on Potential Acidity Relative to Neutralization Potential
- **Design Details**
 - Volume of Potential Toxic Material
 - Availability and Volume of Containment or Blending Material
 - Drainage (Internal and Surface)

Operating Plan: Mine Sequence

- **Operating Plan Must Consider**
 - Logical Starting Point, Stopping Point
 - Multiple Seams with Varying Quality
 - Different Mining Methods Employed Per Seam
 - Overall Reserve Configuration
- **Develop Detailed “Cut” Sequence by Seam**
- **Contemporaneous Reclamation**
 - Based on Mining Methods and Equipment
 - *NOTE: Smaller Fills, Higher Backfill Conflict with Tighter Contemporaneous Reclamation*

Operating Plan: Equipment Selection

- **Evaluate Each Mining Horizon Based on Particular Characteristics**
 - Thickness
 - Material Type
 - Spoil Handling Requirements
- **Assign Appropriate Equipment to Each Horizon**
 - Front End Loader / Truck Spread
 - Hydraulic Shovel / Truck Spread
 - Electric Shovel / Truck Spread
 - Dozer Push Spread
 - Dragline

Operating Plan: Blasting Plan

- **Identify Blasting Constraints**
 - **Nearest Protected Structures**
 - **Deep Mines Within 500 Feet**
 - **Strata Requiring Special Handling Within Logical Horizon**
- **Develop General Blast Design For Each Horizon**
- **Determine Applicability of Cast Blasting**

Environmental Factors

Proximity to Residential Areas

Blasting Design

Location of Roads

Location of Fills

Erosion and Sediment Control Design

Pit Orientation and Sequence

Post-Mining Land Use Plan

- **Mountaintop Mining?**
 - Develop Higher and Better Post-Mining Land Use Per SMCRA
- **Select Post-Mining Land Use: Original or Alternate?**
- **Determine Required Configuration of Regraded Surface To Accommodate Chosen Use**
- **Factors To Consider**
 - Long-Term Access
 - Long-Term Maintenance
 - Measures of Success
 - Economics

Regrading / Revegetation Plan

- **Compatible With Post-Mining Land Use**
 - Land Forms and Drainage
 - Types of Vegetation
- **Regraded Configuration**
 - Varies Depending On Final Land Use
 - Must Be Durable and Stable
- **Revegetation**
 - Avoid Non-Native Species
 - Must Complement Post-Mining Land Use

Environmental Factors

Planting Plan

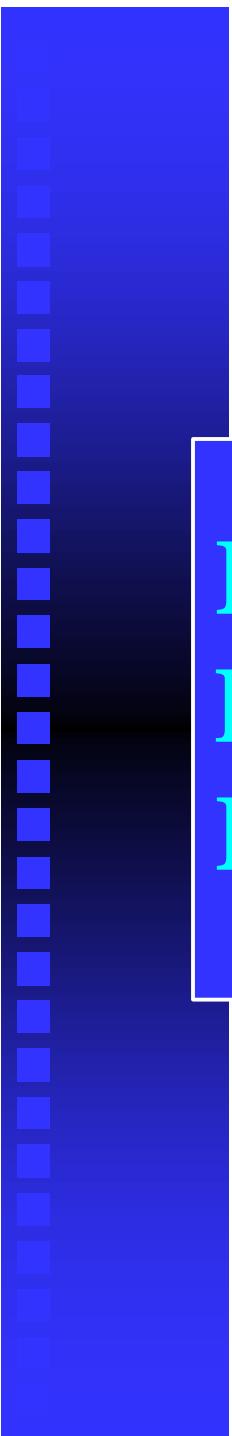
WV DNR Mining Biologist

Revegetation Plan

Erosion and Sediment Control Plan

Transportation Plan

- **Access To Mine Reserve Area From Existing Highways**
- **Internal Access**
- **Coal Transport From Site To Processing Plant or Shipping Point**
- **Coal Transport to Markets**
 - **Rail**
 - **Truck**
 - **River**



FINALLY Permitting

**Regulatory Review
Public Inspection and Comment
Regulatory Approval**

Permits Required

WV DEP Surface Mining Permit

WV OWR NPDES 402 Permit

Corps of Engineers 404 Permit

WV OWR 401 Certification

WV DNR Public Land Corporation

SUMMARY

Mining Method Analysis
Coal Reserves

Mining Method Reserve Summary

Seam	Acres Available for Mining				Seam Thickness (feet) Recovered			
	<u>Underground</u>	<u>Contour</u>	<u>Auger</u>	<u>Mountaintop</u>	<u>Underground</u>	<u>Contour</u>	<u>Auger</u>	<u>Mountaintop</u>
Upper Kittanning Rider	-	-	-	-	-	-	-	-
Upper Kittanning (Upper Split)	-	53.10	2.93	72.99	-	5.07	5.07	5.07
Upper Kittanning (Middle Split)	-	53.10	-	72.99	-	1.31	-	1.31
Upper Kittanning (Lower Split)	-	76.58	-	83.70	-	1.41	-	1.41
MiddleKittanning	-	28.14	-	28.14	-	2.47	2.47	2.47
No. 5 Block Seam	97.21	181.90	48.80	382.39	6.37	5.21	5.21	5.21
Upper Stockton Seam	521.52	236.18	64.16	641.40	4.88	4.44	4.44	4.44
Middle Stockton Seam	-	236.18	-	641.40	-	1.35	-	1.35
Coalburg Seam	-	131.61	65.66	757.43	-	1.62	1.62	1.62
Total	618.73	996.79	181.55	2,680.44	11.25	22.88	18.81	22.88
Seam	Mining Recovery				Wash Yield (with 92% Plant inefficiency)			
	<u>Underground</u>	<u>Contour</u>	<u>Auger</u>	<u>Mountaintop</u>	<u>Underground</u>	<u>Contour</u>	<u>Auger</u>	<u>Mountaintop</u>
Upper Kittanning Rider	-	-	-	-	-	-	-	-
Upper Kittanning (Upper Split)	-	85%	30%	85%	-	75.16%	75.16%	75.16%
Upper Kittanning (Middle Split)	-	85%	-	85%	-	76.70%	-	76.70%
Upper Kittanning (Lower Split)	-	85%	-	85%	-	47.55%	-	47.55%
MiddleKittanning	-	85%	-	85%	-	52.14%	-	52.14%
No. 5 Block Seam	60%	85%	30%	85%	46.43%	70.86%	70.86%	70.86%
Upper Stockton Seam	60%	85%	30%	85%	50.87%	79.10%	79.10%	79.10%
Middle Stockton Seam	-	85%	-	85%	-	83.12%	-	83.12%
Coalburg Seam	-	85%	30%	85%	-	58.71%	58.71%	58.71%
Seam	Specific Gravity				Saleable Tons Available by Mining Method			
	<u>Underground</u>	<u>Contour</u>	<u>Auger</u>	<u>Mountaintop</u>	<u>Underground</u>	<u>Contour</u>	<u>Auger</u>	<u>Mountaintop</u>
Upper Kittanning Rider	-	-	-	-	-	-	-	-
Upper Kittanning (Upper Split)	-	1.28	1.28	1.28	-	299,215	5,824	411,294
Upper Kittanning (Middle Split)	-	1.30	-	1.30	-	80,125	-	110,138
Upper Kittanning (Lower Split)	-	1.51	-	1.51	-	89,554	-	97,880
MiddleKittanning	-	1.67	1.67	1.67	-	69,910	-	69,910
No. 5 Block Seam	1.63	1.35	1.35	1.35	383,191	1,047,266	99,157	2,201,560
Upper Stockton Seam	1.58	1.24	1.24	1.24	1,671,041	1,188,213	113,925	3,226,861
Middle Stockton Seam	-	1.23	-	1.23	-	376,582	-	1,022,693
Coalburg Seam	-	1.34	1.34	1.34	-	193,783	34,122	1,115,242
Total					2,054,232	3,344,648	253,028	8,255,579

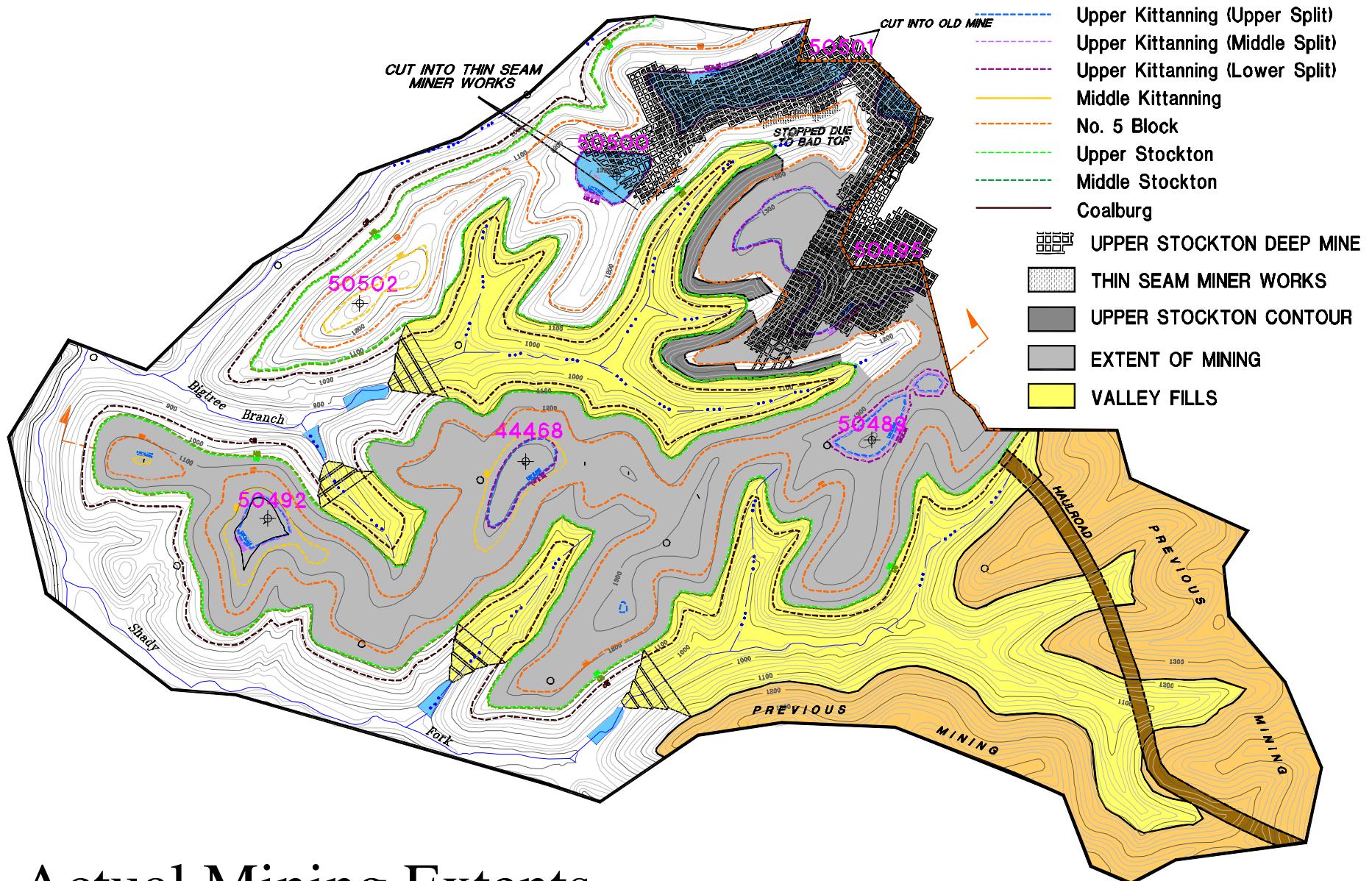
Mining Ratios by Method

CLEAN RATIOS

	BCY <u>Mountaintop</u>	Incr. Ratio <u>Mountaintop</u>	Cum. Ratio <u>Mountaintop</u>
Upper Kittanning Rider	-	-	-
Upper Kittanning (Upper Split)	4,685,843	11.39	11.39
Upper Kittanning (Middle Split)	2,654,562	24.10	14.08
Upper Kittanning (Lower Split)	1,216,455	12.43	13.82
Middle Kittanning	775,018	11.09	13.54
No. 5 Block Seam	32,913,744	14.95	14.61
Upper Stockton Seam	66,635,224	18.79	17.80
Middle Stockton Seam	6,200,739	6.06	16.12
Coalburg Seam	<u>30,764,467</u>	27.59	17.67
	145,846,052		

CLEAN RATIOS (No auger)

	BCY <u>Contour</u>	Incr. Ratio <u>Contour</u>	Cum. Ratio <u>Contour</u>
Upper Kittanning Rider	-	-	-
Upper Kittanning (Upper Split)	3,272,579	10.94	10.94
Upper Kittanning (Middle Split)	1,064,587	13.29	11.43
Upper Kittanning (Lower Split)	1,063,456	11.88	11.52
Middle Kittanning	775,018	11.09	11.46
No. 5 Block Seam	15,264,354	14.58	13.52
Upper Stockton Seam	15,151,366	12.75	13.19
Middle Stockton Seam	2,369,476	6.29	12.37
Coalburg Seam	<u>3,876,845</u>	20.01	12.81
	42,837,682		



Actual Mining Extents



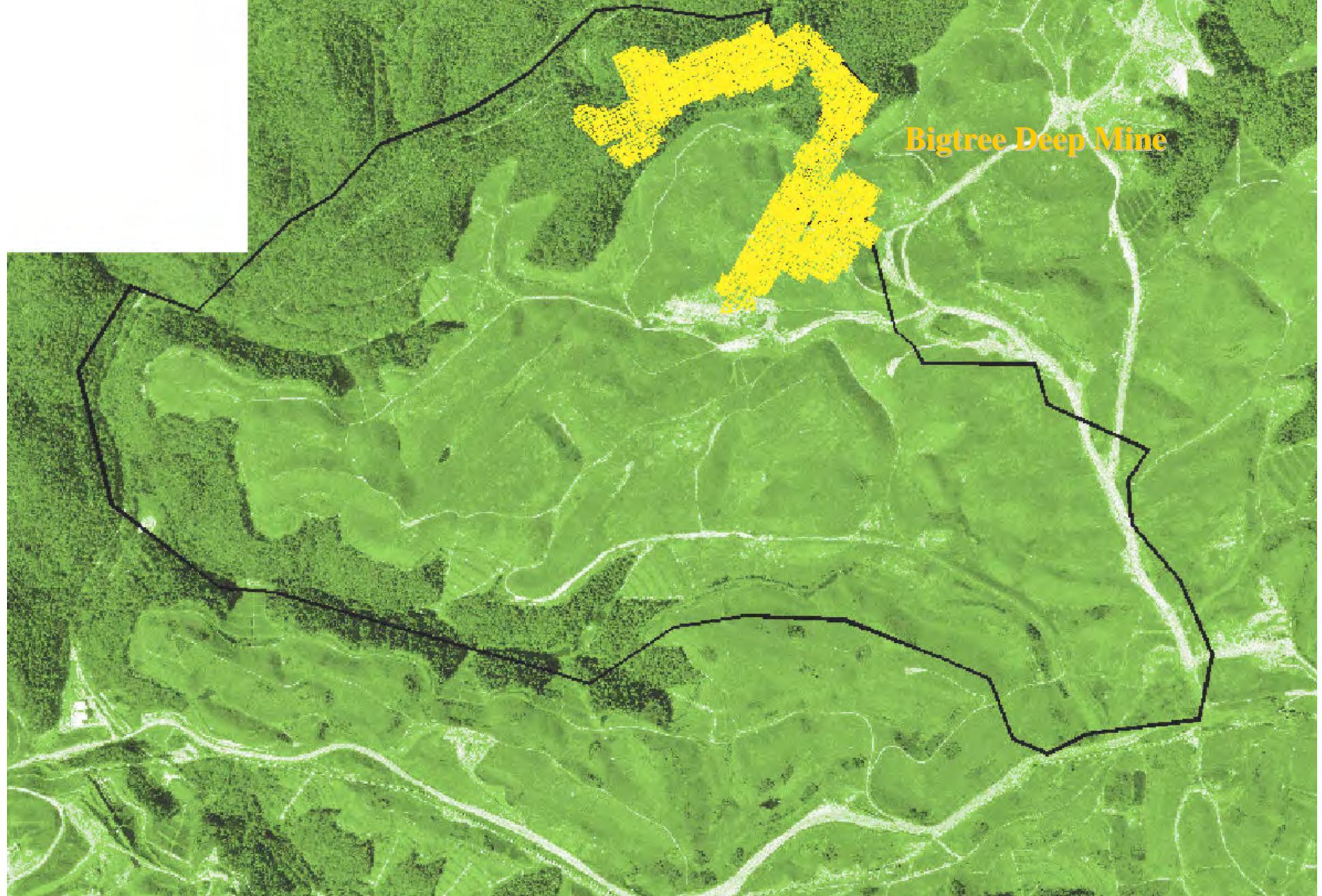








Post-Mining Aerial Photography



Alternative Contour Mining Ratio

<u>Seam/Ratio</u>	Overburden (BCY)			
	8:1	10:1	12:1	14:1
Upper Kittanning Rider	-	-	-	-
Upper Kittanning (All Splits)	-	5,099,600	8,937,720	11,561,760
MiddleKittanning	-	-	-	694,200
No. 5 Block Seam	9,258,624	16,805,880	25,707,456	37,059,120
Upper & Middle Stockton	-	9,809,100	-	-
Coalburg Seam	-	-	-	-
Total	9,258,624	31,714,580	34,645,176	49,315,080

<u>Seam/Ratio</u>	Overburden (LCY)			
	8:1	10:1	12:1	14:1
Upper Kittanning Rider	-	-	-	-
Upper Kittanning (All Splits)	-	6,374,500	11,172,150	14,452,200
MiddleKittanning	-	-	-	867,750
No. 5 Block Seam	11,573,280	21,007,350	32,134,320	46,323,900
Upper & Middle Stockton	-	12,261,375	-	-
Coalburg Seam	-	-	-	-
Total	11,573,280	39,643,225	43,306,470	61,643,850

Note: Material swelled 125%

Alternative Contour Mining Ratio

<u>Seam/Ratio</u>	Backfill (CY)			
	8:1	10:1	12:1	14:1
Upper Kittanning Rider	-	-	-	-
Upper Kittanning (All Splits)	-	3,651,072	7,380,346	10,296,411
MiddleKittanning	-	-	-	382,719
No. 5 Block Seam	5,714,491	11,772,086	19,478,455	30,222,920
Upper & Middle Stockton	-	6,538,550	-	-
Coalburg Seam	-	-	-	-
	5,714,491	21,961,708	26,858,801	40,902,050

<u>Seam/Ratio</u>	Excess Spoil (CY)			
	8:1	10:1	12:1	14:1
Upper Kittanning Rider	-	-	-	-
Upper Kittanning (All Splits)	-	2,723,428	3,791,804	4,155,789
MiddleKittanning	-	-	-	485,031
No. 5 Block Seam	5,858,789	9,235,264	12,655,865	16,100,980
Upper & Middle Stockton	-	5,722,825	-	-
Coalburg Seam	-	-	-	-
	5,858,789	17,681,517	16,447,669	20,741,800