MASTER

INTERIM REPORT ON REVISING THE RESOURCE
ALLOCATION AND MINE COSTING MODEL

McLEAN RESEARCH CENTER, INC.
6845 Elm Street
McLean, Virginia 22101

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THE RESOURCE ALLOCATION AND MINE COSTING MODEL

McLean Research Center, Inc.
6870 Elm Street
McLean, Virginia 22101

and

Synergic Resources Corporation
One Bala-Cynwyd Plaza
Bala-Cynwyd, Pennsylvania 19004

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Section 1

INTRODUCTION

The purpose of this contract is to provide the Coal and Electric Power Analysis Division (CEPAD), EIA, with a revised and fully documented Resource Allocation and Mine Costing (RAMC) model to be used in developing coal supply curves for use in the Mid-range Energy Forecasting System (MEFS) and the National Coal Model (NCM).

The project is structured in three phases, as follows:

- Phase I - Establish Conceptual Underpinnings of Revised Supply Curve Methodology
- Phase II - Revise Mine Costing Methodology
- Phase III - Revise Resource Allocation Methodology

The first three tasks in Phase I were to review and critique the current RAMC approach, review and critique the NUS deep mine and the Fluor Utah surface mine costing methodologies, and to propose revisions to the current approach. This Interim Report documents our findings under these three tasks. The fourth, and final, task in Phase I is to develop a detailed design and work plan for revising the mine costing methodology. A report describing the results of this task will be forthcoming in about six weeks.

This report is organized as follows. Section 2 presents a review and critique of the current RAMC approach. Sections 3 and 4 contain a review and critique of the Fluor Utah surface mine and NUS deep mine costing methodologies, respectively.

Our review of the current RAMC concludes that the resource allocation methodology is reasonable; however, the mine costing methodology has a number of deficiencies. Hence, Section 5 presents a number of alternative approaches for implementing an improved costing methodology in the RAMC model.

Although the resource allocation approach is reasonable, the data used to drive the model needs to be improved. The Appendices discuss a number of these data issues, affecting both mine costing and resource allocation.

Section 2

REVIEW AND CRITIQUE OF CURRENT RAMC APPROACH

Our review of the current RAMC model has focused primarily on the costing methodology. The first two sections discuss the surface and deep mine costing methodologies, respectively. A third subsection discusses several additional items, outside of the direct mine costing methodology, that should be addressed in a revised RAMC model.

We have also reviewed the current resource allocation methodology, and feel that the approach is a reasonable one. However, there are a number of problems associated with the input data used to drive the model. The Appendices to this report discuss a number of these data issues in some detail. Perhaps the most troubling data area is the demonstrated reserve base. We have found a number of shortcomings in the current reserve base used with the model (see Appendix C) that appear to relate directly to several problem areas that have been noted in National Coal Model projections of future U.S. coal use.

SURFACE MINE COSTING METHODOLOGY

Users of the National Coal Model suspect that regional coal supply patterns forecast by the model are implausible in that

- Supply forecasts for the Powder River Basin and the state of Illinois seem much too large, and
- Supply forecasts for some eastern states, such as Alabama, seem too small.

As part of an effort to identify causes of these problems, the surface coal mining cost model, which is a part of the Resource Allocation and Mine Costing (RAMC) model, was evaluated. In general, it was found that:

1. The model is a very crude representation of surface coal mining cost phenomena.
2. For eastern mines, especially small (100,000 tons-per-year) ones, the model over-estimates capital and operating costs by 40 to 100 percent.

3. For mines in other regions, cost estimates err by ± 10 to ± 15 percent, depending on the region, the mining method, and the annual tonnage output.
4. These kinds of errors cause the National Coal Model to over-estimate coal supply from the Powder River Basin and under-estimate supply from eastern mines, especially small ones.
5. The main causes of cost forecast errors are the unsatisfactory assumptions that:
 - All surface coal is mined by the area method, when in fact, in 1979, contour mining accounted for 25 percent and shovel-truck mining accounted for 10 percent.*
 - Capital and operating costs vary only in proportion to overburden ratio and annual tonnage output, when in fact they also vary substantially with mining method, coal seam thickness, and a host of regional factors such as topography and overburden characteristics.
 - Capital and operating costs vary linearly with overburden ratio and annual tonnage output, when in fact the relationships are non-linear for a regional cross-section of mines.

To illustrate the above points a mathematical statement of the existing surface coal mine model (Table 2-1) and a list of baseline assumptions (Table 2-2) were prepared. Using this model and baseline data, Table 1 was constructed. It shows actual 1976 statewide averages for selected surface coal mine characteristics, coupled with existing-model cost and productivity estimates for mines with those characteristics. From Table 2-3, one can infer that:

- Productivity estimates for eastern mines are much too low. For example, estimated productivity for an average East Kentucky mine in 1976 is 0.6 tons per man-day. Actual productivity was 22.8 tons per man-day. The present model does not build mines as small as the East Kentucky average of .038 million tons. However, the productivity for the smallest model mine of .1 million tons would be estimated as 2.5 tons per man-shift. This number is still far below the actual average.

* We include the mountaintop removal method in the contour mining category.

- For small and medium-sized eastern mines, capital requirement estimates are too high. For example, the estimated initial capital required for a 100,000 tpy eastern mine is about \$14 million. Actual capital required for such a mine is more like \$2-3 million.
- Productivity estimates for non-Powder River Basin mines in the West are too low.

Undoubtedly the foregoing distortions have the effect of over-allocating coal supply to mines in the Powder River Basin and Illinois. Similarly, supply from small eastern mines would be under-estimated, particularly for states like Alabama, where overburden ratios are high.

Table 2-1

MATHEMATICAL STATEMENT OF EXISTING SURFACE
COAL MINE COST MODEL

NOMENCLATURE

C_I	=	initial capital investment (\$MM)
C_D	=	total deferred capital investment (\$MM)
C_{PS}	=	annual power and supplies cost (\$MM/year)
C_L	=	total annual direct labor cost and welfare payment (\$MM/year)
C_{OHD}	=	annual payroll overhead cost (\$MM/year)
C_{IND}	=	annual indirect cost (\$MM/year)
C_{TI}	=	annual cost of property taxes and insurance (\$MM/year)
C_{RTL}	=	annual cost of royalties, state & local taxes, and licensing fees (\$MM/year)
C_{UW}	=	annual cost of union welfare payment (\$MM/year)
C_{SEV}	=	annual severance tax cost
T	=	annual mine output (millions of tons per year)
R	=	overburden ratio (bank cubic yards of overburden per ton of coal)
S	=	coal seam thickness (feet)
P	=	labor productivity (tons per man-shift)
W	=	average daily straight-time miners wage (\$/day)
R_B	=	overburden ratio for base case mine (cubic yards per ton)
S_B	=	coal seam thickness for base case mine (feet)
P	=	labor productivity (tons per man-shift)
P_B	=	labor productivity for base case mine (tons per man-shift)

Table 2-1 (con't)

EQUATIONS

Initial Capital Investment (C_I)

If $T \geq 1$,

$$(1a) C_I = [20.3 + 1.2 (R-10)] \times T \times [1 - (T-1)/20].$$

If $T < 1$,

$$(1b) C_I = [20.3 + 1.2 (R-10)] \times [1 - .05 (1-T)/0.1].$$

Deferred Capital Investment (C_D)

If $T \geq 1$,

$$(2a) C_D = [11.7 + .25 (R-10)] \times T \times [1 - (T-1)/20].$$

If $T < 1$,

$$(2b) C_D = [11.7 + .25 (R-10)] \times [1 - .05 (1-T)/.01].$$

Annual Power and Supplies Cost (C_{PS})

$$(3) C_{PS} = [1.226 + 0.03 (R-10)] \times T$$

Labor Productivity

$$(4) P = [40.8^* + 30 (T-1)] \times [1 - .02 (R-10)]$$

* In the present model this global value is adjusted to reflect regional differences in the average length of the work day.

Table 2-2

CHARACTERISTICS OF BASE CASE
SURFACE COAL MINE

VARIABLE		UNITS	VALUE FOR BASE CASE
SYMBOL	NAME		
T	Annual Mine Output	Millions of Tons	1
R	Overburden Ratio	Cu. Yds. Per Ton	10
S	Coal Seam Thickness	Feet	6
C _I	Initial Capital Investment	\$MM	20.3
C _D	Deferred Capital Investment	\$MM	11.7
C _{PS}	Annual Power and Supplies Cost	\$MM/Yr.	1.226
P	Labor Productivity	Tons Per Man-Shift	40.8

Table 2-3. Model-Derived Estimates of Capital Costs and Labor Productivity for "Average" Surface Coal Mines

Region	State	1976 State Averages			Predicted Initial Capital Investment (\$MM)	Predicted Deferred Capital Investment (\$MM)	Predicted Power & Supplies Cost (\$MM/Yr.)	Predicted Productivity (Tons/Man-Shift)	Percent Error In Predicted Productivity
		Annual Output (Million Tons)	Overburden Ratio (Cu. Yd./Ton)	Productivity (Tons/Man-Shift)					
East	Alabama	0.06	18.1	15.8	14.68	7.02	0.09	10.6	-33
	Ky. (East)	0.038	8.4	22.3	9.13	5.87	0.04	12.3	-45
	Ohio	0.112	18.7	22.8	15.56	7.44	0.17	11.7	-49
	Pa.	0.059	16.5	17.6	13.76	6.83	0.08	10.9	-38
	Tenn.	0.044	13.8	13.4	12.05	6.39	0.06	11.2	-16
	W. Va.	0.061	11.4	16.2	10.88	6.22	0.08	12.3	-24
Central	Illinois	0.70	13.8	22.8	19.62	10.44	0.94	29.4	29
	Indiana	0.40	12.2	28.3	14.96	8.35	0.52	21.8	-23
	Ky. (West)	0.22	13.2	31.5	13.69	7.41	0.29	16.3	-48
West	Colorado	0.41	5.2	58.2	9.8	7.3	0.44	25.3	-57
	Montana	3.75	2.3	120.7	28.94	31.41	3.73	142.3	18
	N.D.	1.01	3.8	93.7	12.49	10.05	1.05	46.2	-51
	Wyoming	1.78	3.5	57.4	20.61	17.07	1.84	72.5	26

DEEP MINE COSTING METHODOLOGY

The current underground mine costing methodology in RAMC uses the following four characteristics of an underground mine to determine production costs by extrapolation from the base case model mine:

- Seam Thickness
- Seam Depth
- Mine Size
- Type of Opening

The current methodology and base case assumptions do not effectively predict future coal production and prices. The following paragraphs will discuss some of the specific reasons for this.

The Base Case Mine Provides a Distorted View of Underground Mining

Some of the characteristics of the base case mine do not reflect real-world mining very well. For example:

- A seam depth of 700 feet was selected as the standard. This value was selected not because this is the average depth of underground mines, but for a supposed economic cut-off at the 700 foot level for slope entrance mining.
- The base case mine assumes the use of unit train facilities. However, because of the mountainous terrain in the Appalachian area and short-sighted planning in the Central and Mid-West regions, very few mines are sufficiently large (1 MMTPY or larger) to support such facilities.

In addition to the unrealistic nature of the base case mine itself, a number of other assumptions are made that are questionable at best. For example:

- Capital costs, power and supply costs, and productivity are assumed to vary linearly with seam thickness. This assumption is fallacious as will be shown below.
- A drift mine will not necessarily have 10% higher productivity (as is currently assumed) simply because of its initial development method.

- Seam depth is a large factor in the costs associated with ventilation, power, and drainage. The model currently ignores this relationship.
- Land acquisition costs are not included.
- Fixed mine lives of 20 or 30 years grossly represent actual practice.
- Constant annual production is assumed over the entire mine life, yet even the smallest mines have a significant start-up time before reaching full production.

Regional Model Mines are Mandatory

Aside from the fact that the current model mine is not representative of any known underground mining operation in existence, trying to develop cost estimating relationships for all mining systems from one base mine is foolhardy. Initial and deferred capital costs are currently adjusted from the base case mine using the following assumptions:

- Each 1 foot decrease in seam thickness from the standard requires 6% increases in both initial and deferred capital requirements.
- Each 1 foot decrease in standard seam height requires an increase of \$0.15 per ton in the cost of power and supplies.
- Economies of scale require the output to decrease by 1 ton per man-day for every foot decrease in seam thickness.
- Each million ton increase in capacity requires a 30% increase in initial capital.
- Deferred capital costs increase by 15% for each million ton increase in capacity.
- For every 100,000 ton increase in annual output from the standard mine, productivity is assumed to increase by $\frac{1}{2}$ ton per man-day.
- For drift mines, initial capital costs are reduced to \$6,000,000 from the standard mine.
- Deferred capital costs for a drift mine are \$3,000,000 lower than the base case mine.
- Capacity per day is 10% higher in a drift mine than the base case mine.

As evidenced by the above, all adjustment factors are related to mine size, seam thickness, or type of opening. In actual practice, the most significant factors influencing initial and deferred capital costs are depth of cover, mining method, topography, and roof and floor geology.

Many of the adjustment factors in the RAMC are based on a perceived relationship between seam height and labor productivity. For instance, the assumption that each one-foot decrease in seam height leads to a 6% increase in initial and deferred capital is predicted on the belief that labor productivity decreases in thinner seams and therefore additional production sections are necessary to achieve a fixed level of output. This assumption is not well founded. Most productivity studies show mining method and basic operating conditions to be more important than seam height. This fact is further evidenced by the following table showing 1977 productivity by seam height category for all underground mines in Pennsylvania.

<u>Seam Height Inches</u>	<u>Sample Size</u>	<u>Average Productivity (Tons/Manshift)</u>
<36	6	11.35
36 - 48	38	11.16
49 - 60	15	11.71
61 - 72	23	10.19
73 - 100	23	8.28

A second major assumption is that increasing mine size has a positive effect on productivity. Again, the data for Pennsylvania do not confirm this assumption.

<u>Mine Size (000 Tons)</u>	<u>Sample Size</u>	<u>Average Productivity (Tons/Manshift)</u>
<100	29	13.04
100 - 200	23	11.87
200 - 500	34	9.54
500 - 1000	19	9.45

In summary, the present RAMC provides crude estimates for underground mine cost. It is apparent that the relationships used by the model are in error and it almost appears that the logic behind their development was based on the fact that seam height and mine size are easily measured and not because they represent differences in the mining process. Correction of these inherent problems is not a simple task. Unlike surface mining, where it is relatively easy to develop unit cost estimates for various mining functions, underground mines are significantly more complex and require a more detailed level of analysis. Above all, one action item is necessary; namely, to develop several model mines to reflect regional variations in the underground mining process.

As with surface mining, although harder, it may be possible to develop simple process models for each base case mine relating capital costs and labor productivity to:

- Mining Method
- Seam Characteristics
- Type Opening
- Annual Production
- Working Schedule.

To accomplish this task, it would be necessary to process the EIA-7 data base to develop the relationships between productivity and various system parameters.

ADDITIONAL ITEMS WHICH SHOULD BE ADDRESSED

There are several assumptions used by the RAMC model outside of the direct mine costing methodology which do not reflect actual mining practice and should be given consideration within the context of this contract. Among these items are:

- Fixed mine lives for all underground and surface mines. A distribution of mine lives by size category should be developed and incorporated into the mine cost and resource allocation estimates.
- Fixed recovery factors for all surface and underground mines. Recovery factor is influenced greatly by region and mining method. Because significant differences do exist, consideration should be given to including multiple recovery factors in the model.
- Allocation of resources to mine depth for underground mines and mine sizes for surface mines. The underground marginal mine distributions need to be examined for all regions and updated to reflect current and projected mine plans where needed. In the case of surface mines, the mine size distributions currently used in the RAMC should be adjusted to correspond to actual regional practice.
- The demonstrated reserve base. Many of the problems present in the RAMC can be linked directly to the demonstrated reserve base (see Appendix C). Given that selective changes are undesirable, a complete review and modification of this data should be performed.

Section 3

REVIEW AND CRITIQUE OF FLUOR UTAH SURFACE MINE COSTING METHODOLOGY

The Fluor Utah model is a large, process-type of mathematical model whose principal uses are to estimate equipment requirements, costs, and return-on-investment for large surface coal mines. Fluor Utah, at a cost of \$2.5 million, developed, programmed, and tested the model for ERDA. The model is programmed in FORTRAN and runs on a Xerox Sigma 7 computer. Fluor performed eight different test case studies using the model. The regions for these case studies are shown in Figure 3-1.

In summary, the model is a very detailed one that:

- Represents most, but not all, of the surface coal mining methods used in the United States.
- Provides good cost estimates.

The model runs at two levels, termed by Fluor Utah the macro and micro levels. The micro model is far too detailed for direct use in the RAMC model, and would require several thousand input data cards. The macro model, in contrast, requires less than 50 input data cards per case, with no more than a five percent loss of accuracy compared to the micro model. Accordingly, in what follows, we have evaluated only the macro model.

EVALUATION OF FLUOR UTAH MACRO MODEL

The macro model was evaluated from the standpoints of availability, applicability, and tractability. Overall we believe that it is not the best choice for developing surface mine cost estimates for the RAMC.

The Computer Programs are not Readily Available

The model is not now programmed for use on any DOE computer. It currently runs on a Xerox Sigma 7, and is available on the GE time sharing system, for a fee. Chuck Hayduk of the DOE Carbondale Mining

Technology Center, who is knowledgeable about the model, has stated that Carbondale plans to convert the model to CDC, and that the conversion should be completed by January 1981. There are no planned conversions to IBM. We estimate that up to a person-year of effort would be required to make the model operational on the EIA computer system. Thus, direct use of the Fluor Utah model in RAMC does not appear to be an attractive option.

Macro Model Applicability Would Have to be Extended

Although the macro model is very powerful, it does not represent all of the mining methods and regions needed for the National Coal Model. The methods and regions that are currently represented (see Figure 3-1 for regional definitions) are listed below:

- Area Mining With Draglines
 - Illinois
 - Texas Gulf
 - Four Corners
 - Fort Union
- Contour Mining With Draglines
 - State of Ohio
- Truck-and-Shovel Mining
 - Powder River Basin

The methods and regions that are not represented are:

- Area Mining With Draglines
 - Powder River Basin
 - Lower Missouri River
- Contour Mining With Draglines: States of
 - Pennsylvania
 - West Virginia (northern)
 - Alabama
- Steep-Slope Contour Mining with Front-End Loaders and Trucks: States of
 - West Virginia (southern)
 - Kentucky (eastern)
 - Virginia
 - Tennessee

Addition of the first two of these three method/region groups would not be difficult because all that would be required is the preparation of additional input data. But the lack of a model for the third method--steep-slope contour mining--is a serious flaw that would be expensive to remedy.

Macro Model is Tractable

One major advantage of the macro model--given its limited availability and applicability--is that it would be easy to use once set up. Case studies for each mining method could be performed and regional cost estimating relationships developed.

Section 4

REVIEW AND CRITIQUE OF NUS DEEP MINE COSTING METHODOLOGY

The Underground Mine Cost Model developed by NUS Corporation is, for the most part, a basic accounting model containing ten distinct steps for establishing production costs. The first step is what the model refers to as production sizing. This step defines a square coal deposit of size "x" based on mine life, mining method, production shifts and days worked. The number of working sections in a given mine is based on the desired annual production and labor productivity.

The productivity estimates, which are the most important element in the model, were derived through a series of parametric studies of underground production systems using a simulation model developed by Pennsylvania State University. The output of these studies was a set of curves and corresponding tables which relate shift production (tons per machine shift) to a series of seam characteristics (e.g., roof and floor conditions, gas emission, seam grade, and depth of cover). The resultant values are used as a basis for all further calculations in the model. Because of the importance of the productivity estimates, a review of the approach used is warranted.

Pennsylvania State University's Underground Materials Handling Simulator is an excellent tool for evaluating system changes, since the activities required to complete each step of the mining process are modeled in detail. In this model, equipment moves are progressed through time as a means to evaluate system behavior. Emphasis is placed on simulating single or multiple shifts with input variables that essentially are deterministic. Since economy precludes repeated runs, the probability distribution of production is not available. The important issue is that each shift is simulated only once. Although input values may be drawn randomly, the simulation is not Monte Carlo, since the shift is not repeated with alternative values from the unput distributions.

Because of this fact, it is important that the input data accurately represent the system being evaluated. In the case of the simulation runs made for the NUS cost model several assumptions were made which are not representative of actual mining practice and which tend to distort the simulation results.

The first of these assumptions is that all mining activity takes place in what is known as a 5-entry development system. Today, very little work is done on 5-entries -- conventional mining generally takes place on 7-entries and continuous varies anywhere between 3 and 7. Also, no retreat mining is modeled. This method greatly influences overall productivity.

Perhaps the biggest deficiency with the simulation as run for the NUS model is the assumption of 390 minutes of available mining time (face time). While this is a fair representation of the maximum amount of time available underground for production it in no way agrees with actual mining practice. This 390 minutes assumes maximum operator efficiency -- in actual practice, more than 50% of the available face time is lost to delay activities.

Lastly, simulation runs were made for seam thicknesses ranging between 3 and 7 feet. Because of this fact, productivity estimates are not available for thick seam western mines as well as thin seam operations mining in the 28 to 36 inch range. Also, longwall systems were not simulated. Productivity estimates for this mining technique are based on a regression equation with the independent variables being seam height, face length and depth of cover. This equation is crude at best and should only be used for very rough productivity estimates.

Step 2 of the NUS model involves the development of manpower cost estimates. Labor productivity (used to determine the number of sections and shifts needed to attain a desired level of production) is the key system parameter used in this step. A series of simple linear regressions were run with manpower requirements as the dependent variable and mining system (conventional, continuous), mine size, type opening,

haulage system and number of production sections/shifts as the independent variables. The best fit was with "shift production sections per day". The hourly personnel equation is:

$$y = 21.242 + 14.659 (x)$$

where x is the number of shift production sections. This equation yields the following table:

x	1	2	3	4	5	6
y	36	51	65	80	95	109

Salaried personnel requirements are given by

$$y = 11.219 + 2.373 (x)$$

and yield the following:

x	1	2	3	4	5	6
y	14	16	18	20	23	25

While the approach used by NUS may be adequate for providing rough estimates of manpower costs, close comparison with actual operations points to some significant problems. The first problem is defining shift production section. Does this term represent the total number of sections operating per day or the total number of production section shifts? If the latter definition is assumed (section shifts), then a one section mine operating one shift per day would have 36 hourly personnel and 14 supervisors. Clearly this is in error. On the other hand, if we assume the independent variable represents the number of production sections operating at a mine, and if we further assume that each section runs two shifts per day, then a six unit mine would only have 9 hourly and 2 salaried people per section shift. As before, these manpower estimates are not representative of actual mining operations.

Based on the above discussion, it is clear that some problems exist with the manpower costs as currently presented in the model. Also, it appears that the total workforce is assigned to a mine as

soon as it begins production. In actual practice, especially for larger mines, the workforce buildup is staggered over several years. This fact significantly impacts the annual cash flow projections.

Costs for equipment and construction are developed in step 3 of the model. As discussed before, a square coal deposit is assumed and is developed using a single mining plan for both continuous and conventional mining methods. The productivity estimates prepared in step 1 are used to develop the numbers of production equipment needed. Haulage costs are estimated by determining the dimensions of the main line development heading. Costs of outby support systems are purely subjective. Lastly, surface construction, ventilation and construction costs are estimated using the results of several simple linear regressions run on depth of cover and mine property dimensions.

Since all costs relate back to annual production of marketable coal, the percent reject experienced at a mine is an important consideration. The model currently assumes reject to be a function of mining method:

- Continuous Mining ---- 25%
- Conventional Mining -- 17%
- Longwall Mining ----- 21%

While it is true that the degree of mechanization effects dilution, other factors are generally more important in determining reject. Seam characteristics; whether rolls and pitches of the seam or middlemans of rock are present; roof and bottom conditions; and the skill of the operator to follow the coal seam during the mining cycle all affect reject percentage. These factors are not taken into account in the model and are thus excluded from consideration.

Steps 4 and 5 deal with supplies and power costs respectively and are related through a regression equation to labor cost per ton. In the case of supplies, this approach is valid given good production/productivity estimates. In the case of power costs, however, the

relationship is unclear. For example, longwall mining systems use few men but draw very large amounts of power. Also, the influence of mine depth on power costs, which is significant, is not covered by the current approach.

The remainder of the model steps deal with pre-mine development costs and the financial computations. The development costs are prepared from inputs generated in the preceding steps. In the case of the financial computation, a brief discussion of the methodological limitations, assumptions, and usefulness in cost projecting is provided below.

METHODOLOGICAL LIMITATIONS

Treatment of Return of Equity

The NUS model is based on the principal that production costs per ton will equal revenue per ton. Production costs/ton include the desired return on equity which is treated as a fixed cost. The desired return on equity is used to calculate the weighted average cost of capital. This approach builds in a profit that may be greater or less than the profit necessary to attract investment to open a new mine. The preferred approach would be to treat return on equity as a residual of discounted cash flow at given price levels. The discount rate would then equal the percent return on equity necessary to support the opening of a new mine. A high discount rate relative to other investments would attract sufficient capital to open new mines.

Land Acquisition Costs

The NUS models do not consider land acquisition costs except for royalty payments to land owners (\$.50/ton of cleaned coal). The new mine would need to purchase some land to construct surface facilities

such as offices, preparation plant, bathhouse, road and rail loading facilities. Royalty payments in lieu of mineral rights do not cover the cost of surface facility land and result in understating the cost/ton.

Development Costs

The length of development time for drift mines is 1.2 years vs. 2.2 years for shaft mines. The development period is rounded to the nearest year for calculation of development costs. This method may provide mathematical simplicity but over - or underestimates the actual costs per month of development due to rounding.

Salaried personnel costs during development are not phased with the increase in production sections. Salaried personnel are treated as a level cost from the start of development. This method overstates development costs.

The model accurately allocates deferred capital to year spent but treats all preproduction investment as having occurred in the first year. These costs should be spread over the construction and pre-development period, as is done in the calculation of Allowance for Funds During Construction.

The NUS models do not consider the value of accelerated depreciation or investment tax credits. These reduce tax liabilities in early years and, therefore, the model underestimates the present value of cash flows. This would overestimate the cost/ton over the life of the mine.

The cash flows of the mine are not calculated by generally accepted accounting principles. The model calculates an equal annual cash flow required to provide a desired rate of return on total capital. The preferred method would be to calculate expected revenues and expenditures for each year using actual or projected prices/ton. The model calculates the present worth of capital investment for each year over the life of the mine. The present worth is divided by uniform

present values to yield the average annual cash flow required to return the weighted average cost of capital. This method does not represent actual cash flows in any given year.

ASSUMPTIONS

- 1) 40% overhead rate.
- 2) 8% interest on debt capital (1975)
- 3) 50% tax rate composed of 48% Federal and 2% local.
- 4) \$20,000 annual salary for a salaried employee in 1975.
- 5) Production rate is constant. No new production units may be added or deleted, which implies unlimited demand for coal at the price (e.g., all production is sold for cost plus 15% Return on Equity).
- 6) Deferred capital equipment and reserve units are purchased at the beginning of the mine life rather than as needed in future years. Capital is considered spent at the beginning of development rather than when it enters the mine.

USEFULNESS IN COST PROJECTIONS

The NUS models have limited usefulness as a cost projection tool or as a supply model in response to market prices. The model may be updated to the current year by using construction, equipment and labor indexes respectively. This method would require projection of the indexes rather than the underlying components. Power costs, for instance, are updated as a function of labor cost indexes even though they are rising proportionately faster than labor costs.

Section 5

ALTERNATIVES FOR REVISED COSTING METHODOLOGY

In this section, we present a number of alternative approaches for improving the mine costing methodology in the RAMC model. All of the alternatives have a common characteristic; namely, the development of regionally based costing relationships. This is necessary because of the large regional differences in mining conditions and approaches, and will provide much better cost estimates than use of a single model mine for surface mining and another one for underground mining, as is the case in the current RAMC.

The following two subsections present alternative costing approaches for surface and deep mining, respectively.

SURFACE MINE COSTING

In Table 5-1, five alternatives for improving the accuracy of surface coal mining cost estimates are shown. All require development of a completely new model, since the current model does not provide an adequate base for modification. The alternatives are ranked in order of increasing accuracy and development cost. The estimates of accuracy and cost are subjective, but we believe reliable.

Quick Fix Will Improve Accuracy Substantially

As the lowest cost alternative, regional equations can be developed relating capital costs and labor productivity to:

- Mining Method
- Annual Coal Production
- Coal Seam Thickness
- Overburden Ratio

Table 5-1

QUICK FIX OR SIMPLE REGRESSION ALTERNATIVES TO RAMC
OFFER GOOD ACCURACY IMPROVEMENT AT LOWEST COST

ALTERNATIVE NO.	ALTERNATIVE NAME	DESCRIPTIONS	SUBJECTIVE ESTIMATES	
			ACCURACY IMPROVEMENT OVER CURRENT RAMC (%)	MODELING EFFORT (PERSON-DAYS)
1	Quick Fix	Hand formulation and solution of simple process models relating costs to coal tonnage, seam thickness, and overburden ratio.	60 - 70	20 - 40
2	Simple Regression	Design fractional factorial solution plan, and solve NUS model by hand for 12 cases. Use regression analysis on results to derive cost estimating relationship.	70 - 80	45 - 65
3	Full-Blown Regression	Design full factorial solution plan and run computer - based NUS model.	80 - 85	100 - 150
4	Off-Line Fluor Utah	Extend Fluor Utah data and models and run on GE for 180 cases (30 regions times six mine sizes per region).	85 - 90	350 - 450
5	On-Line Fluor Utah	Do work in No. 4 above plus convert model to IBM and integrate directly into RAMC.	85 - 90	600+

To accomplish this task it would be necessary to classify costs at two levels:

- Level 1: Type of Expenditure
 - Initial Capital
 - Deferred Capital
 - Operating
 - Uncontrollable
- Level 2: Type of Mining Function
 - Overburden Removal and Placement
 - Coal Handling and Processing
 - Reclamation

The modeling approach is simple:

1. Define overburden removal costs, per unit volume of overburden removed, by region, mining method, and overburden volume range.
2. Define coal handling and processing costs by region, mining method, and coal production range.
3. Define reclamation costs as a function of coal seam thickness and coal production rate.

Simple Regression Will Work Too

A second approach would be to use the model developed by NUS Corporation for The Electric Power Research Institute. This model is probably comparable to the Fluor Utah model in accuracy, but is also much easier to understand and use. One such use is to design an experiment, or "solution plan", choosing values of coal seam thickness, overburden ratio, and coal production rate according to formal experimental design procedures. Then solve the model by hand for each specified case, and fit cost estimating relationships to the results using multiple regression techniques.

A second use would be to do a full factorial design and run the NUS computer model, gaining a little more accuracy.

Fluor Utah Most Expensive

The remaining two alternatives are to use the Fluor Utah model in a direct solution mode, either off-line or on-line. These alternatives are probably not cost-effective, but do provide the greatest degree of accuracy.

DEEP MINE COSTING

The NUS Model Could be Used, But?

As with surface mining, the NUS Coal Mine Cost Model could be used to perform a full or limited factor experiment resulting in a set of cost estimating relationships for each regional model mine. Unlike the surface mine cost model, which for the most part provides accurate results, the underground portion has several drawbacks, the most significant being the productivity tables used in the model.

What are the Alternatives to the Current RAMC?

As of now, there are only a limited number of alternatives to the current underground cost portion of the RAMC:

1. Develop regional equations relating capital costs and productivity to various mining system components. This would require about 50 man-days of effort in addition to the processing of EIA-7. The expected accuracy improvement over the current model would be at least 50%.
2. Design a full or fractional experiment and use the NUS model to solve each case. Then through the use of regression techniques derive cost estimating relationships for each model mine. This effort would require about 100 man-days. The resulting accuracy improvement is hard to estimate due to questionable productivity estimates used in the NUS model.
3. The same as No. 2 above except correct the NUS productivity estimates before proceeding. This would be a high cost effort requiring about 200 man-days, however the accuracy improvement would be at least 80%.

Appendix A

RAMC SURFACE MINE PRODUCTIVITY ESTIMATES

Our review of the present RAMC surface mine productivity estimates has reached these conclusions:

- The revision of base case surface mine productivity for the 1978 ARC should have been accompanied by a change in the adjustment factor relating productivity to mine size.
- A brief analysis of the relationship of mine size to productivity, using the 1978 MSHA data and data from the Emory Ayers/SRC productivity study indicates that productivity estimates need further revision.

These conclusions are discussed further in the following paragraphs.

In a CEPAD memorandum of August 5, 1979, Michael Grillo states that the 1978 estimate of surface mine productivity for the base case surface mine was 40.8 tons per man-day. Thus, the base case surface mine productivity was reduced from the original value of 57.0 (CEUM documentation, Table III-23) 28.4 percent. However, no corresponding reduction was made in the adjustment factor of 3.0 tons per man-day increase/decrease for each 100,000 ton increase/decrease in mine size. The result is an additional penalty for surface mines less than one million tons per year relative to the base case mine, and a corresponding bonus for large mines. This can be seen from Table A-1. In order to maintain the relative performance of surface mines, the adjustment factor should have been reduced by the same percentage as the base case productivity. The new adjustment factor should therefore be 2.15.

Even with the alteration of the adjustment factor, the RAMC model may overstate large mine productivity and understate small mine productivity. To investigate the relationship between surface mine size and productivity, the 1977 MSHA data were used to determine productivity versus mine size for each state. This data was compared to the corresponding RAMC model estimates using the average 1977 state overburden ratios collected in the Emory Ayers/SRC productivity study, and using the adjustment factor of 2.15 tpmd. This comparison was complicated

by the fact that the MSHA data does not contain overburden ratios; however, it appears that the RAMC productivity formula overstates the impact of mine size on productivity. A better productivity formula, relating productivity to both mine size and overburden ratio, could be developed using EIA-7 data, since this data provides information on productivity, mine size, and overburden ratio on an individual mine basis.

Table A-1

RAMC PRODUCTIVITY ESTIMATES IN TONS PER MAN-DAY
FOR A SURFACE MINE WITH A 10:1 OVERBURDEN RATIO

Mine Size (million tons)	Base Case of 57.0 tpm	Base Case of 40.8 tpm
.1	30.0 (.53)	13.8 (.34)
.5	42.0 (.74)	25.8 (.63)
1.0	57.0 (1.00)	40.8 (1.00)
2.0	87.0 (1.53)	70.8 (1.74)
3.0	117.0 (2.05)	100.8 (2.47)
4.0	147.0 (2.58)	130.8 (3.21)

NOTE: (Numbers in parentheses are the ratio of the productivity to the base case value.)

Appendix B

RAMC ALLOCATION OF RESERVES TO MINE
DEPTH/MINE SIZE CATEGORIES

Appendix B

RAMC ALLOCATION OF RESERVES TO MINE DEPTH/MINE SIZE CATEGORIES

We have reviewed the distributions currently used in the RAMC model to allocate reserves to mine depth categories for new underground mines and to mine size categories for new surface mines. Our recommendations in these two areas are presented below.

UNDERGROUND MARGINAL MINES

The underground marginal mine distribution needs to be altered to provide for drift mines in the west. At present, no mines appear in this category. However, underground western mines visited in the Emory Ayers/SRC productivity study were, with one exception, drift mines. The 1978 Keystone Manual shows that 27 of 40 existing mines in the west (67.5 percent) are drift mines. The discrepancy probably occurred because these mines can be under considerable cover, even though they can be mined as drift mines.

Based on these figures, we recommend that the underground marginal mine distribution for mines in the Rockies be adjusted to place two-thirds of the mines in the drift category.

SURFACE MINE SIZE DISTRIBUTION

The present mine size distribution of surface mines was reviewed using the 1977 MSHA data on production. The results of this review are shown in Table B-1. Table B-2 shows the present RAMC mine size distribution.

Our recommendations are presented below, by region.

Appalachia

The present RAMC input appears to overstate the percentage of surface mines in the one million ton category for all states except Maryland. We recommend that the RAMC input be as follows:

Table B-1
FRACTION OF SURFACE PRODUCTION BY MINE SIZE (10^6 TONS)

Region	Mine Size					
	.1-.25	.251-.750	.751-1.50	1.51-2.5	2.51-3.5	≥ 3.5
Appalachia (PA, OH, MD, NV, SV, VA, EK, TN, AL)	.46	.43	.08	0	.03	0
Midwest (IL, IN, WK)	.07	.18	.19	.38	.18	0
Central West (IA, MO, KN, AR, OK)	.20	.27	.25	.28	0	0
Gulf (TX)	0	.01	0	.12	.18	.69
Northern Great Plains (ND, SD, EM, WM, CN)	.003	.05	.06	.09	.25	.54
Southwest (AZ, NM)	0	.03	.06	.09	0	.82

Source: MSHA 1977 Production Data

Table B-2

PRESENT RAMC SURFACE MINE SIZE DISTRIBUTION

Region	NCM Region	Mine Size					
		.1	.5	1.0	2.0	3.0	4.0
Appalachia	PA, OH, NV, SV, VA, EK, TN, AL	.334	.333	.333	-	-	-
Appalachia	MD	.50	.50	-	-	-	-
Midwest	IL, IN, WK	.20	.20	.20	.20	.02	-
Central West	IA, MO	.334	.333	.333	-	-	-
Central West	AR, OK, KN	.50	.50	-	-	-	-
Northern Great Plains	ND, SD, EM, WM, WY, CN	0	0	.10	.20	.30	.40
Southwest	AZ, NM	.05	.05	.30	.30	.30	0

<u>Region</u>	<u>.1</u>	<u>.5</u>	<u>Mine Sizes</u>		
			<u>1.0</u>	<u>2.0</u>	<u>3.0</u>
MD	.50	.50	-	-	-
PA, NV, SV, VA, EK, TN, AZ	.45	.45	.10	-	-
OH	.30	.30	.20	.20	-

The Ohio figures in this table reflect the 1977 distribution of surface mines in Ohio.

Midwest

The Illinois basin appears to have fewer mines in the .1 million ton range than the present model inputs. We recommend following the 1977 distribution closely, as follows:

<u>Region</u>	<u>.1</u>	<u>.5</u>	<u>Mine Sizes</u>		
			<u>1.0</u>	<u>2.0</u>	<u>3.0</u>
IL, IN, WK	.10	.20	.20	.30	.20

Central West

The 1977 distribution shows mines in the 2.0 million ton category--one mine in Missouri, and one mine in Oklahoma. We therefore recommend the following mine size categories:

<u>Region</u>	<u>.1</u>	<u>.5</u>	<u>Mine Sizes</u>		
			<u>1.0</u>	<u>2.0</u>	<u>3.0</u>
OK, MO	.30	.30	.30	.10	-
AR, KN	.50	.50	-	-	-

Northern Great Plains and Gulf

Within the limits of the data, the present mine size distribution appears to be adequate, although it may slightly understate the percentage of reserves in the 3 and 4 million ton categories.

Southwest

The data indicate the presence of very large mines, and the input should at least reflect the possibility of opening such mines. We recommend the following values.

<u>Region</u>	<u>.1</u>	<u>.5</u>	<u>Mine Sizes</u>		<u>3.0</u>	<u>4.0</u>
			<u>1.0</u>	<u>2.0</u>		
AZ, NM	0	.05	.20	.20	.25	.30

Appendix C

RESERVE BASE ESTIMATES FOR RAMC

Appendix C

RESERVE BASE ESTIMATES FOR RAMC

The reserve base estimates discussed in this appendix were selected because they were potential causes for four problem areas that have been noted in NCM outputs. Specifically, the following areas are discussed:

- The comparatively slow expansion of coal production in the Rockies;
- The significant amount of medium sulfur coal produced in the Midwest;
- The exhaustion of lignite reserves in the Gulf region; and
- The decline of coal production in Southern Appalachia.

Each of these problem areas is discussed below. For each area, we discuss the approach taken, the findings, and our recommendations. The approach was limited by time; in general, a representative state was selected for analysis, either because questions had been raised about the reserve estimates, or the state appeared to be the most likely source of the problem.

PROBLEM AREA 1: SLOW EXPANSION IN THE ROCKIES

The Utah reserve base data were selected for review, because Utah has the highest deep production in the Rockies and Utah was mentioned as a state where reserve base data were particularly problematic. The Utah Geological Survey was contacted and the BOM IC 8693 was compared with the present model inputs.

Findings

Utah Geological and Mineralogical Survey Monograph Series No. 3 reports 24 billion tons of "principal" reserves. "Principal" reserves include all coal in seams greater than or equal to four feet in thickness with up to 3000 feet of cover, in the measured, indicated, and inferred categories. The distribution of these reserves by NCM coal type is shown in Table C-1. The coal types in Table C-1 were assigned using average BTU and sulfur content categories for each coal field and area in Utah.

Table C-1
UTAH RESERVES BY COAL TYPE
(10⁶ TONS, THICK SEAMS)

Coal Type	Principal Reserves	<3000 Ft.	<1000 Ft.
HA	865.8	700.4	240.9
HB	8,502.7	5,073.5	2,007.0
HC	3,653.1	1,822.8	1,173.0
HD	2.0	-	-
HE	4,169.0	2,314.9	1,391.7
HF	1,064.3	408.3	278.1
HG	44.1	38.7	38.7
MA	86.4	45.4	36.3
MB	293.6	157.1	79.6
ME	2,599.6	1,337.5	1,016.5
MF	623.8	350.2	199.1
MG	1,339.5	471.5	110.8
MH	687.0	249.7	136.3
SD	1.1	1.1	1.1
SE	76.1	41.0	13.7
SF	339.5	177.0	80.6
SH	1.3	-	-
Total	24,348.9	13,189.1	16,722.8

Source: Utah Geological and Mineralogical Survey Mongraph Series No. 3, 1972 pp. 458-9.

Since the Utah data include coal more than 1000 feet below the surface and coal in the inferred category, these principal reserves are computed on a different basis than the BOM demonstrated reserve base. The principal reserves must be adjusted for any comparison with the BOM demonstrated reserves. Columns 2 and 3 of Table C-1 show the measured and indicated Utah reserves less than 3000 feet and less than 1000 feet deep, respectively. These figures were computed from the principal reserve figure using the percentage of principal reserves in each field falling in the category.

Even the last column of Table C-1 cannot be used for direct comparison with the present RAMC figures, because (1) surface and deep reserves are combined and (2) the reserve figures are for coal in the ground with no reduction for depleted production. The Utah monograph estimates depletion through 1970 at 960 million tons.

The present RAMC inputs are shown in Table C-2. Although Tables C-1 and C-2 cannot be directly compared, the differences point to some general conclusions. First, there is a much greater range of coal types in Table C-1. This arises from the limited information on sulfur content on the BOM data tape. In the known quality deep reserves, for example, almost all the reserves (766.7 of 777.9 million tons) are placed in coal type HB. An examination of the detailed published data in BOM IC 8693 revealed that all the HB coal fell in a single bed in Carbon county, on which 41 analyses were performed. Many more analyses were performed on Utah coal (see below), but these are not included in the demonstrated reserve base tape.

Second, the BOM restriction of reserves to resources within 1000 feet of the surface eliminated a tremendous amount of Utah coal. This restriction is particularly problematic in Utah (and the Rockies generally) because the geology and topography of the region makes the restriction virtually meaningless from an economic standpoint. Coal is generally mined in drift mines at outcrops which may easily have cover greater than 1000 feet. For example, Kaiser Steel Corporation Sunnyside No. 3 Mine in Carbon county is a drift mine with 2,500 feet of cover at the portal. The mineability of such seams is reinforced

by examining the detailed data in BOM IC 8693. In Carbon county, 7538 analyses have been reported, but only 41 of these fall in the one seam which is included in the BOM demonstrated reserve base. The seams on which all the analyses have been performed appear to be deeper than the 1000 feet reserve base limit. The Utah monograph reports 5 billion tons of principal reserves in Carbon county; many of these reserves are sufficiently economic to warrant extensive analysis, but failed to meet demonstrated reserve base criteria.

Finally, the RAMC inputs differ considerably from the IC 8693 data on Utah reserves. The published IC 8693 figures are shown in Table C-3. The published data show a wider range of sulfur content, and a higher percentage in the known categories. Also, far fewer reserves in the published data are in the surface category (and, correspondingly, more in the deep category), than are included in the known plus unknown RAMC inputs. The published data thus appear closer to the Utah monograph figures for the distribution of coal types in the reserve base.

Recommendations

We have the following two recommendations as a result of the above review of the Utah reserve base:

- In the long run, all deep coal up to 3000 feet in the Rockies should be included in the reserve base. This calculation is beyond the scope of the present work; however, it may be possible to perform this calculation systematically by using the USGS National Coal Resources Data System. This alternative should be considered for a future study.
- In the short run, as a minimum, the published data in IC 8693 should be used for the Utah reserve base in place of the present RAMC inputs. This would result in a more realistic estimate of quality distribution.

We have recalculated the RAMC input, based on the BTU and sulfur distributions in IC 8693. Where the sulfur categories in IC 8693 overlapped NCM sulfur categories, a uniform distribution was assumed as an approximation. The results of this recalculation are shown in Table C-4. We want to emphasize that even these figures considerably understate Utah reserves, and that further analysis of coal reserves in the Rockies is required.

Table C-2
PRESENT RAMC INPUTS FOR UTAH RESERVES (10⁶ TONS)

Coal Type	Known Deep	Quantity Surface	Known and Unknown Deep	Quality Surface
HA	5.54	10.00	34	10
HB	766.70	0	2,936	0
HF	0	10.00	0	39
SD	5.67	24.00	35	82
SF	0	200.00	0	778

Table C-3
IC 8693 DATA ON UTAH RESERVES (10⁶ TONS)

Sulfur Content	Deep Reserves	Surface Reserves
<1.0	1,916.2	52.3
1.1-3.0	1,397.6	149.2
>3.0	6.8	42.6
Unknown	460.3	18.0

Table C-4
RECOMMENDED RESERVE INPUTS FOR UTAH (10⁶ TONS)

Coal Type	Deep		Surface	
	Known	Known & Unknown	Known	Known & Unknown
HA	772.2	879.3	10.0	10.7
HF	23.0	26.2	10.0	10.7
HG	4.2	4.8		
MA	237.5	270.4		
MC	71.7	81.6		
MD	119.9	136.5		
ME	560.4	638.1		
MF	319.9	364.3		
MG	22.8	26.0		
MH	5.4	6.1		
SC	5.7	6.5	24.0	25.8
SD	359.2	409.0		
SE	491.6	559.8		
SF	326.7	372.0	200.0	214.8

PROBLEM AREA 2: THE SIGNIFICANT AMOUNT OF MEDIUM SULFUR COAL PRODUCED IN THE MIDWEST

Approach

Since most of the Midwest coal reserves in the Illinois coal basin are found in the state of Illinois, the Illinois reserve base data were reviewed to determine whether the present RAMC inputs overstate low and medium sulfur reserves. This approach took the following steps:

- Review of Illinois Geological Survey Circular 504/1978, Reserves and Resources of Surface Minable Coal in Illinois.
- Contact with the Illinois Geological Survey for any further estimates regarding the sulfur content of Illinois coal.
- Comparison of present RAMC inputs with the published BOM Information Circular 8680.

Findings

The present RAMC reserve data for Illinois are shown in Tables C-5 and C-6. The first item to note concerning these data is that they show considerably more low and medium sulfur coal than the published BOM data. Comparing the RAMC input with the BOM data in IC 8680 yields the following:

Comparison of Known Quality Reserves in IC 8680 and RAMC Input Data

	<u>Surface</u>		<u>Deep (Total)</u>	
	<u>IC 8680</u>	<u>RAMC</u>	<u>IC 8680</u>	<u>RAMC</u>
≤3.0 Percent Sulfur	1,553 (14.3%)	6,022 (77.9%)	6,883 (17.0%)	21,104 (68.7%)
>3.0 Percent Sulfur	9,321 (85.7%)	1,707 (22.1%)	33,648 (83.0%)	9,637 (31.3%)
Total	10,874	7,729	40,531	30,741

The data for the RAMC input were calculated by assuming sulfur categories A through G were less than three percent sulfur by weight. This provides a conservative estimate of the amount of medium sulfur coal in the RAMC since the largest reserves are in the 'M' coal type, having a BTU content of 20.00 to 22.99 MMBTUs per ton. At an average of 21.5 MMBTUs per ton, the 2.5 pounds sulfur per million BTU used as the upper limit for the 'G' sulfur content category is approximately

Table C-5
PRESENT RAMC RESERVE DATA FOR ILLINOIS
RESERVES OF KNOWN QUALITY (10⁶ TONS)

Coal Type	Surface	Deep (Thin)	Deep (Thick)	Total Deep
HD	50	7	1,901	1,908
HE	0	5	1,301	1,306
HF	358	0	1,604	1,604
HG	900	61	1,895	1,956
HH	157	3	6	9
MF	134	183	495	678
MG	4,580	969	12,683	13,652
MH	1,550	688	8,940	9,628
Total	7,729	1,916	28,825	30,741

Table C-6
PRESENT RAMC RESERVE DATA FOR ILLINOIS
RESERVES OF KNOWN AND UNKNOWN QUALITY (10⁶ TONS)

Coal Type	Surface	Deep (Thin)	Deep (Thick)	Total Deep
HD	50	7	3,253	3,260
HE	0	5	2,112	2,117
HF	629	0	2,685	2,685
HG	1,440	332	3,247	3,579
HH	157	3	6	9
MF	134	183	766	949
MG	7,825	1,781	21,607	23,388
MH	2,632	1,229	15,160	16,389
Total	12,867	3,540	48,836	52,376

2.7 percent sulfur on a percent-weight basis. ($2.5 \times 21.5 \div 2000$ pounds = 2.69 percent sulfur). The differences in the total tonnage figures are the result of differences in the amount of coal in the "unknown quality" category between the published BOM data and the BOM data tape used for the RAMC (CEUM Documentation, Page III-6).

Based on contacts with the Illinois Geological Survey, it appears that the BOM published data are closer to the actual sulfur distribution. The Illinois survey believes that the published data also overestimates sulfur content, because the BOM data are based on the number of analyses of quality and many more analyses are performed on low and medium sulfur coals. The Illinois survey has not published any comprehensive survey of sulfur content of the reserve base; however, some indication of the sulfur content of the total resource base can be found in the 1978 Keystone Coal Industry Manual. In this article, the Illinois survey estimated the total resource base of low sulfur coal (<2.5% sulfur) in the Herrin and Harrisburg-Springfield seams to be 1,727 and 2,738 million tons, respectively. These two seams contribute 85-90 percent of Illinois production and comprise 73.6 percent of the Illinois coal resource base. Inflating the low-sulfur estimates for the Herrin and Harrisburg-Springfield seams to the total Illinois resource base gives a total estimate of 6,067 million tons of coal in the ground in the <2.5 percent sulfur category.

Further work is required if the later estimates by the Illinois Geological Survey are to be used as a basis for the RAMC input. In their present form, they provide only estimates for coal less than 2.5 percent sulfur, and only for the total resources in the ground. However, they do confirm that the published BOM data are a closer approximation to the medium sulfur reserve base than the present RAMC inputs.

With respect to the total reserve base of surface-minable coal, Illinois State Geological Survey Circular 504 estimates 6,092 million tons of surface-minable coals, compared with the 12,223 million tons of known and unknown quality surface reserves in the IC 8680. (Present RAMC input is 12,867 tons). The Illinois survey estimate is more recent than the BOM figures and is hence a better estimate of total surface reserves in Illinois.

Recommendations

The problem of the Illinois reserve base clearly requires further study. ICF has conducted a project for EPRI which includes re-estimation of Illinois reserve figures. Until this data is available in published form, we recommend the following:

- Use the BOM published reserve base figures for the distribution of sulfur content. Table C-7 shows the recalculation of RAMC input data if the percentage of coal reserves under 3.0 percent sulfur are assumed to be as given in IC 8680.
- Reduce all coal types of surface mineable coal by the ratio of the latest Illinois survey estimate (6,092 million tons) to the present RAMC input (12,867 million tons). All surface reserves will then be 47.4 percent of their present value. Table C-7 includes this reduction for surface reserves.

Table C-7 was derived from Tables C-5 and C-6 as follows. First, the total figures for surface, deep thin and deep thick were assumed to be the present RAMC values. Then the high sulfur coal totals ('H' coals) were computed using the BOM percentages of coal greater than 3.0 percent sulfur. The totals for high sulfur coal were distributed to BTU categories based on the percentage distribution in the present RAMC data. Those calculations were then repeated for the lower sulfur categories ('A' through 'G').

Finally, the surface reserves were reduced by the percentage figure given above. However, the Illinois survey has explicitly removed areas of illegal or impossible to mine coal (e.g. coal under populated areas), so that the illegal to mine fraction for Illinois should be zero (rather than .25) if the Illinois survey data are used.

PROBLEM AREA 3: THE EXHAUSTION OF LIGNITE RESERVES IN THE GULF

Approach

Examine estimates of lignite reserves in Texas, Arkansas, and Louisiana through contact with state geological surveys.

Findings

From our previous work with the Ozarks Regional Commission, we know that significant reserves of lignite exist in Arkansas and Louisiana, even though Arkansas has no such reserves in the model, and Louisiana is

Table C-7

RECOMMENDED RAMC RESERVE DATA FOR ILLINOIS

Coal Type	Surface*	Deep Thin	Deep Thick
HD - Known	2	2	468
Known & Unknown	4	2	802
HE - Known	0	1	321
Known & Unknown	0	1	521
HF - Known	31	0	395
Known & Unknown	54	0	662
HG - Known	78	16	467
Known & Unknown	125	87	801
HH - Known	288	7	17
Known & Unknown	294	7	17
MF - Known	12	49	122
Known & Unknown	12	49	188
MG - Known	400	258	3,127
Known & Unknown	676	463	5,327
MH - Known	2,848	1,583	23,908
Known & Unknown	4,926	2,931	40,518

*Illegal to mine fraction should be set to zero.

not included in any supply region. The reserve estimates for these lignite reserves are rough, since knowledge of them is very recent. Our findings were as follows:

- Arkansas has measured or indicated lignite reserves of 3 billion tons, and speculative reserves of at least 7 billion tons. Although no coal quality information was available, the reserves were reported to be "remarkably" similar to the Texas lignite in quality.
- The Texas geological survey reports lignite reserves of 7 billion tons, approximately twice the current input of 3,272 billion tons (known plus unknown quality).
- Louisiana has measured and indicated lignite reserves of 1 billion tons. No quality data are available.

Recommendations

Since there is no current NCM supply region for Louisiana, the Louisiana estimate is included primarily for future reference.

The Texas data could be altered to provide for 7 billion tons of LF coal rather than the present 3,272 known plus unknown reserves. Using the same known to unknown ratio, the known reserves would be 6.05 billion tons. However, the Texas figure may be considered too rough for present use.

The Arkansas data presents a dilemma. Since lignite is being developed in Arkansas (Arkansas-Missouri power company is planning to open a mine-mouth plant using lignite) the present RAMC input is clearly wrong and should be changed. However, the Arkansas data, like the Texas data, are based on a rough state estimate. In this case, we feel it is better to be roughly correct than obviously wrong; i.e. we feel the Arkansas estimate should be used as input for coal type LF. If the Texas known-to-unknown ratio is used, 2.59 billion tons would fall in the known quality category.

PROBLEM AREA 4: THE DECLINE OF PRODUCTION IN SOUTHERN APPALACHIA

Approach

Examination of the present RAMC data base revealed that total committed surface production for Alabama was greater than the surface reserve base. The BOM circular IC 8680 reports only 157 million tons of reserves, but the RAMC input contains 228 million tons of committed

reserves. The Alabama geological survey was contacted to determine if more recent estimates were available.

Findings

A study of the reserve base is underway, but is not yet available. The preliminary figure provided was 2 billion tons of strippable bituminous coal.

Recommendations

We face the same dilemma here as in Arkansas: estimates are rough, but present inputs are obviously in error and, in this case, internally inconsistent. We therefore recommend using the 2 billion ton figure as the total known plus unknown quality reserves. If the present known-to-unknown quality ratio is used, the total known quality reserves would be 1.19 billion tons. If these are distributed by the present coal type distribution, the reserves by coal type would be (in millions of tons):

ZB - 65	HB - 262
ZD - 221	HD - 144
ZE - 26	HF - 336
ZF - 135	

Appendix D

REVISED ESTIMATES OF PRODUCTION
AND COMMITTED RESERVES

Appendix D

REVISED ESTIMATES OF PRODUCTION AND COMMITTED RESERVES

The present RAMC data on committed reserves were obtained from the ICF CEUM Documentation. These data were calculated in the following steps:

1. Estimate 1975 production capacity from BOM weekly production reports, and coal quality from FPC Form 423 for 1974 (CEUM, p. III-7);
2. Estimate 1980 production from existing (1975) mines using calculated regional depletion rates (CEUM, p. III-23); and
3. Sum production through 1990 for existing mines to obtain an estimate of committed reserves.

The EIA-7 production data were used to update the production and committed reserve information. A computer program was written to perform the following calculations for each supply region:

1. Compute 1975 through 1978 cumulative production by sulfur content, and
2. Compute remaining reserves committed to existing mines using the 1978 EIA-7 estimates of recoverable reserves in each mine.

The results of the computer program are shown in Tables D-1 and D-2.

Table D-1
PRODUCTION AND REMAINING RESERVES (10⁶ TONS)
(Deep Mines)

NCM Region	1975-1978 Production by Sulfur Category								Total	Remaining Reserves
	A	B	C	D	E	F	G	H		
Pennsylvania	0.1	0.1	0.5	1.1	4.6	18.3	18.4	1.7	45.0	1308.7
Ohio	0.0	0.0	0.0	0.0	0.0	0.0	2.1	13.6	15.7	137.6
Maryland	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.0	0.9	18.1
W. VA, North	0.3	1.1	2.2	3.9	3.7	10.2	26.0	43.4	90.8	1048.2
W. VA, South	0.9	36.0	27.0	64.5	13.6	24.1	5.7	1.0	172.0	1554.3
Virginia	0.5	13.0	17.1	25.2	7.8	5.6	5.6	0.7	75.5	632.8
Kentucky, E.	0.6	18.9	21.3	38.4	29.0	27.7	4.0	2.2	142.3	885.7
Tennessee	0.0	0.7	2.6	3.7	2.9	5.1	3.5	3.8	21.3	331.5
Alabama	0.0	0.8	0.0	4.7	0.0	1.8	0.8	0.7	8.8	47.3
Illinois	0.0	0.0	0.0	0.0	0.0	34.0	13.3	118.9	166.2	1142.4
Indiana	0.0	0.0	0.0	0.0	0.0	0.0	2.3	6.9	9.1	53.5
Kentucky, W.	0.0	0.3	0.0	0.0	0.3	0.7	0.4	15.4	17.1	137.3
Iowa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
Missouri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kansas	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.5	1.3	0.1
Arkansas	0.0	0.0	0.0	0.4	0.1	0.2	0.0	0.0	0.7	11.8
Oklahoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Texas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
North Dakota	0.5	1.3	0.0	3.0	6.8	0.0	0.0	0.0	11.6	5.0
South Dakota	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montana, E.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montana, W.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wyoming	0.0	35.7	8.2	0.2	0.7	0.0	0.0	0.0	44.8	294.0
Colorado, N.	1.2	11.2	4.1	0.0	0.0	0.0	0.0	1.1	17.7	251.0
Colorado, S.	2.4	0.0	0.0	0.0	0.0	0.1	0.0	0.0	2.5	0.0
Utah	2.4	21.2	2.8	4.4	1.0	0.5	0.0	0.2	32.6	448.8
Arizona	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Mexico	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Washington	0.0	17.6	0.0	0.0	0.0	0.0	0.0	0.0	17.6	65.3
Alaska	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: EIA-7 Data

Table D-2
PRODUCTION AND REMAINING RESERVES (10⁶ TONS)
(Surface Mines)

NCM Region	1975-1978 Production by Sulfur Category								Total	Remaining Reserves
	A	B	C	D	E	F	G	H		
Pennsylvania	0.7	1.1	0.2	8.4	19.1	103.8	114.2	19.8	267.3	1524.2
Ohio	0.1	0.0	0.1	0.1	0.2	3.3	30.8	125.9	160.5	710.4
Maryland	0.0	0.0	0.1	0.7	0.9	5.4	2.7	1.4	11.2	57.6
W. VA, North	0.1	1.2	5.4	5.7	1.3	10.6	31.1	19.4	74.8	387.0
W. VA, South	0.0	10.5	13.6	18.6	4.7	5.9	1.0	0.0	54.3	135.0
Virginia	0.4	7.1	14.3	21.4	5.7	6.9	0.2	0.0	56.0	142.3
Kentucky, E.	10.4	12.6	15.3	52.3	45.0	43.9	14.5	6.9	200.9	481.1
Tennessee	0.0	0.2	0.3	2.5	1.7	4.9	4.0	2.1	15.6	808.4
Alabama	0.0	1.3	2.9	20.7	9.6	29.7	12.6	0.7	77.6	469.0
Illinois	0.0	0.0	2.5	5.0	1.8	2.6	6.7	35.1	53.7	472.7
Indiana	0.0	0.2	0.0	0.2	0.1	1.1	40.8	50.8	93.2	354.7
Kentucky, W.	0.1	0.0	0.1	0.5	0.9	22.6	23.1	153.3	200.6	572.5
Iowa	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.0	2.1	2.2
Missouri	0.0	0.0	0.0	0.0	0.0	0.0	1.0	21.5	22.5	196.0
Kansas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.2	9.9
Arkansas	0.0	0.0	0.0	0.3	0.2	0.3	0.2	0.3	1.4	16.6
Oklahoma	0.0	2.1	0.0	0.7	1.4	1.6	1.7	10.7	18.3	99.8
Texas	15.9	10.9	0.0	15.6	6.6	11.8	0.0	0.0	61.0	732.4
North Dakota	10.1	4.6	9.5	7.7	1.2	0.5	0.0	0.0	33.7	1018.4
South Dakota	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montana, E.	0.0	0.0	0.3	0.9	0.0	0.0	0.0	0.0	1.2	0.0
Montana, W.	31.9	0.1	12.7	29.4	2.1	18.0	0.0	6.8	100.9	1116.4
Wyoming	12.8	74.6	8.8	6.4	8.6	3.0	0.0	0.0	114.2	3647.6
Colorado, N.	2.3	17.1	2.3	0.1	0.0	0.0	0.0	0.0	21.9	203.8
Colorado, S.	0.1	0.5	0.2	0.3	0.0	0.1	0.0	0.0	1.1	22.3
Utah	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Arizona	0.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0	37.5	0.0
New Mexico	0.0	16.1	0.0	25.9	0.3	0.0	0.0	0.0	42.3	230.9
Washington	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Alaska	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	120.0

Source: EIA-7 Data

Appendix E

RECLAMATION COSTS

Appendix E

RECLAMATION COSTS

The RAMC currently estimates reclamation costs from an EPA study prepared by ICF ("Energy and Economic Impacts of H.R. 13950") and an August 18, 1977, ICF memorandum entitled "Reclamation Costs for ICF's Coal and Electric Utilities Model." A review of these costs indicates problems in several areas.

The reclamation cost estimates presented in this memorandum improve on the ICF work. These figures, however, are still approximate and should be treated as such. The following paragraphs, organized by component costs, present ICF's findings and appropriate modifications.

PERMIT PLANNING ACTIVITIES

The permit planning activities as defined in the EPA report consist of test/core drilling, surface hydrologic assessment, subsurface hydrologic assessment, and the preparation of cross-section maps. The costs associated with these activities were as follows:

- Test drilling - \$24/ft of hole drilled; 1 hole each 320 acres
- Surface hydrology - \$5,000 per mine
- Subsurface hydrology - \$20,000 per mine
- Cross-section maps - \$5,000 per mine.

A review of the RAMC input values points to two problems. The first is that while ICF recognized the small mine exemption (small mine defined as less than 250 MT/Y) for test drilling and hydrologic assessment studies, these costs were included in the estimates for Appalachian mines. Since by definition Appalachian surface mines are "small" this component cost should simply be the cost of preparing cross-section maps divided by the annual output.

For the West, \$25,000 appears to be an understatement of hydrologic study cost. Consolidation Coal Company* estimates that the costs of

*CONSOL Comments on the OSM Interim Regulatory Program for Surface Mining, Consolidation Coal Company, Dec. 1979.

hydrologic compliance can run as high as \$83,000 for a one million ton per year western surface mine. Also the current RAMC inputs do not consider the special problems encountered by western operators in preparing premining environmental impact statements. In addition to the surface and subsurface water assessments, companies are required to perform detailed wildlife studies of the proposed mining area, determine the potential archeological significance of the mine site and perform more complete soil and vegetation analyses than East or Mid-West mines.

While the amount of empirical data on Western mining permit planning costs is limited it is felt that a doubling of the ICF numbers from \$30,000 to \$60,000 per mine is in order. This new figure is believed still to be conservative and does not include costs associated with development delays or resource losses resulting from the environmental studies.

BONDING FEES

Since the enactment of the 1977 Surface Mine Control and Reclamation Act all mines are required to post a performance bond of sufficient size to assure completion of the reclamation plan. The current RAMC input value is computed by multiplying the per year acreage by a constant cost per acre and dividing by the annual output. Overall the RAMC values appear reasonable and do not warrant further investigation.

REGRADING COSTS

Regrading, in many cases, is the single largest reclamation cost element. ICF, in estimating these costs for Appalachia, used a mine costing model developed by Oak Ridge National Laboratory.* This model generates per acre operating costs for various mining slopes. Using the model output and seam height and overburden estimates a regrading cost per ton was computed for each Appalachian region and overburden category as defined by the RAMC.

*Costs of Coal Surface Mining and Reclamation in Appalachia, Oak Ridge National Laboratory, Jan. 1976.

Since the existing documentation prohibits recreation of the input values the following estimates were prepared in Table E-1.

Table E-1
REGRADING COSTS
(\$ 1978)

Region	Overburden Ratio						
	5:1	10:1	15:1	20:1	25:1	30:1	45:1
Northern Appalachian							
PA	.60	1.06	1.39	1.80	2.17	2.55	3.67
OH	.58	.97	1.39	1.79	2.15	2.52	3.63
MD	.59	1.03	1.41	1.79	2.16	2.54	3.66
NV	.53	.95	1.36	1.72	2.09	2.47	3.58
Central Appalachian							
SV	.98	1.59	2.08	2.58	3.08	3.57	4.60
VA	1.04	1.66	2.15	2.65	3.15	3.64	5.13
EK	.94	1.54	2.03	2.55	3.03	3.53	5.02
TN	1.23	1.86	2.39	2.85	3.35	3.85	5.34
Southern Appalachian							
AL	.71	1.16	1.54	1.92	2.29	2.67	3.80

To compute the above values average seam height data was used to determine recoverable tons per acre for each state. These were divided into the cost per acre for each overburden and slope classification determined by linear extrapolation from the Oak Ridge/ICF estimates. One significant difference in these estimates is that costs for very steep mining (30° slopes) were not used as was the case in ICF estimates for Central Appalachia.

Very steep slope mining is generally defined as those areas where the slope exceeds 25 degrees. Since the average slope in

Eastern Kentucky, the steepest of the Central Appalachian states, is less than 22 degrees the use of this category unduly penalizes this region.

Time did not permit a check on the validity of the Oak Ridge model output. Given that regrading costs make-up such a large portion of overall reclamation costs this check should be considered as a future action item.

Regrading costs for non-Appalachian states were computed by ICF using a uniform cost of \$1,000 per acre coupled with estimates of seam thickness. As stated in the ICF memorandum of August 18, 1977 area mining regrading costs are not a direct function of overburden depth. However, a \$1,000 per acre regrading cost for both the Mid-West and West appears conservative. Again, because of time and resource constraints no attempt was made to modify this assumption.

Capital costs for regrading were derived by multiplying operating costs by 1.39 and 1.5 for Appalachia and Non-Appalachia, respectively. This approach was not modified.

WATER POLLUTION CONTROL COSTS

The input values for water pollution control were developed from EPA estimates.* The issue of water pollution control is very controversial and complex. In many areas of Appalachia and the West the natural run-off exceeds EPA standards for suspended solids and dissolved minerals. Because of this fact and current limitations, no modifications were attempted. Since, however, the EPA numbers were prepared in 1974 a complete review on this cost component should be undertaken.

TOPSOIL HANDLING COSTS

There are severe limitations with the estimates currently used for topsoil rehandling. The model now estimates these costs to range between \$400-\$750 per acre for Appalachia and \$350 per acre elsewhere.

*Economic Impact of Interim Final and Proposed Effluent Guidelines: Coal Mining, EPA, May 1976.

These figures severely understate the impact in the Mid-West and West. For example, using the current methodology a one MMTPY Illinois mine would have a topsoil handling cost of about \$0.06 per ton. CONSOL estimates the cost to range between \$0.72 and \$0.96 per ton. In the West CONSOL figures the cost to be about \$0.25 per ton while ICF estimates an impact of less than \$0.01 per ton. Given that all topsoil must be removed and segregated by horizon (quality), re-spread and seeded to prevent erosion, and eventually put back by horizon it is clear that the industry figures are more realistic.

Because time constraints prohibit a detailed analysis of this cost component some subjective decisions are necessary. Based on the CONSOL report, discussion with Peabody Coal, Midland Coal, and in-house expertise, ICF topsoil rehandling cost estimates were increased 10 and 15 fold for the Mid-West and West, respectively.

REVEGETATION COSTS

Currently the model uses completely subjective costs for revegetation. In general these costs are relatively small and therefore no attempt was made at validation or modification.

COSTS CURRENTLY NOT CONSIDERED

The current RAMC reclamation cost values are based only on the aforementioned cost components. Not considered by the estimates are items such as road construction, cost implications of alluvial valley floor restrictions, and fugitive dust control among others. Many of these items have a direct impact on the West and for a true appraisal of reclamation costs they should be studied; however, such a task is beyond the scope of this effort.

SUMMARY

The intent and purpose of this review was to take a broad look at the reclamation costs currently used in the RAMC and to make selected changes where deemed appropriate.

The changes made to-date are:

- Elimination of the drilling and hydrologic assessment costs for Appalachian mines
- Doubling of the hydrologic assessment costs for Mid-Western and Western mines
- Elimination of the "very steep" category and a recomputation of Appalachian regrading costs
- Ten and fifteen fold increases in topsoil handling costs for the Mid-West and West, respectively.

The results of these changes are shown in Table E-2. To obtain better estimates this analysis must be expanded to cover additional Cost Components in addition to a more thorough scrutiny of selected items.

Table E-2
RECLAMATION COSTS
(Fixed Costs, 1975 \$/Annual Ton)

Region/State	Overburden Ratios						
	5:1	10:1	15:1	20:1	25:1	30:1	45:1
Northern Appalachia							
PA	0.75	1.29	1.68	2.16	2.60	3.04	4.36
OH	0.75	1.21	1.70	2.18	2.60	3.03	4.34
MD	0.74	1.25	1.70	2.15	2.58	3.03	4.35
NV	0.67	1.16	1.64	2.07	2.51	2.95	4.26
Central Appalachia							
SV	1.19	1.91	2.49	3.08	3.67	4.24	5.45
VA	1.27	2.00	2.57	3.16	3.75	4.33	4.26
EK	1.15	1.85	2.43	3.04	3.61	4.20	5.95
TN	1.49	2.24	2.85	3.40	3.99	4.57	6.32
Southern Appalachia							
AL	0.88	1.41	1.85	2.30	2.73	3.18	4.51
Mid-West							
IL	0.20	0.30	0.39	0.46	0.53	0.58	0.63
IN	0.24	0.34	0.44	0.51	0.59	0.63	0.69
WK	0.25	0.39	0.51	0.58	0.66	0.72	0.78
Central West							
IA	0.35	0.46	0.57	0.64	0.73	0.79	0.84
MO	0.44	0.62	0.80	0.91	1.06	1.12	1.24
KS	0.59	0.78	0.97	1.09	1.24	1.31	1.43
AR	0.51	0.70	0.87	0.99	1.02	1.08	1.16
OK	0.51	0.71	0.91	1.05	1.22	1.29	1.39
Gulf							
TX	0.12	0.19	0.25	0.29	0.33	0.36	0.40
Eastern Northern Great Plains							
ND	0.14	0.22	0.27	0.30	0.36	0.39	0.42
SD	0.14	0.22	0.27	0.30	0.36	0.39	0.42
EM	0.08	0.13	0.18	0.21	0.25	0.26	0.30
Western Northern Great Plains							
WM	0.08	0.13	0.18	0.21	0.25	0.26	0.30
WY	0.08	0.12	0.16	0.19	0.22	0.25	0.26
Rockies							
CN	0.19	0.26	0.34	0.38	0.45	0.48	0.52
CS	0.19	0.27	0.34	0.38	0.45	0.48	0.52
UT	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Southwest							
AZ	0.10	0.16	0.21	0.25	0.30	0.32	0.35
NM	0.13	0.19	0.25	0.28	0.33	0.36	0.38
Northwest							
WA	0.10	0.15	0.20	0.24	0.28	0.30	0.33
Alaska							
AK	0.07	0.09	0.12	0.14	0.15	0.17	0.18

Table E-2 (Continued)
RECLAMATION COSTS
(Variable Costs, 1975 \$/Annual Ton)

Region/State	Overburden Ratios						
	5:1	10:1	15:1	20:1	25:1	30:1	45:1
Northern Appalachia							
PA	0.64	1.02	1.30	1.65	1.96	2.29	3.23
OH	0.61	0.94	1.30	1.63	1.94	2.25	3.19
MD	0.60	0.97	1.30	1.62	1.93	2.55	3.12
NV	0.58	0.93	1.28	1.58	1.90	2.22	3.16
Central Appalachia							
SV	0.95	1.48	1.90	2.32	2.74	3.16	4.03
VA	1.02	1.54	1.96	2.38	2.80	3.22	4.48
EK	0.93	1.44	1.85	2.29	1.85	3.12	4.39
TN	1.19	1.72	2.17	2.56	2.98	3.40	4.67
Southern Appalachia							
AL	0.75	1.13	1.45	1.77	2.08	2.40	3.36
Mid-West							
IL	0.69	0.71	0.73	0.75	0.80	0.84	0.86
IN	0.73	0.75	0.77	0.80	0.83	0.86	0.88
WK	0.69	0.71	0.73	0.75	0.84	0.84	0.86
Central West							
IA	0.41	0.44	0.47	0.50	0.52	0.54	0.58
MO	0.46	0.49	0.52	0.53	0.57	0.60	0.63
KS	0.54	0.58	0.61	0.64	0.67	0.69	0.71
AR	0.52	0.56	0.58	0.61	0.64	0.68	0.69
OK	0.57	0.60	0.62	0.64	0.66	0.69	0.71
Gulf							
TX	0.26	0.30	0.32	0.35	0.38	0.41	0.43
Eastern Northern Great Plains							
ND	0.27	0.31	0.34	0.36	0.38	0.41	0.43
SD	0.27	0.31	0.34	0.36	0.38	0.41	0.43
EM	0.24	0.28	0.30	0.31	0.34	0.36	0.38
West Northern Great Plains							
WM	0.24	0.28	0.30	0.31	0.34	0.36	0.38
WY	0.23	0.26	0.29	0.30	0.33	0.35	0.37
Rockies							
CN	0.29	0.30	0.32	0.35	0.36	0.38	0.41
CS	0.29	0.32	0.32	0.35	0.36	0.38	0.41
UT	0.30	0.31	0.33	0.36	0.38	0.40	0.41
Southwest							
AZ	0.25	0.29	0.30	0.32	0.38	0.37	0.40
NM	0.26	0.28	0.30	0.31	0.35	0.36	0.38
Northwest							
WA	0.19	0.20	0.22	0.24	0.25	0.28	0.30
Alaska							
AK	0.17	0.19	0.21	0.23	0.25	0.27	0.29

Appendix F

STATE SEVERANCE TAXES

Appendix F

STATE SEVERANCE TAXES

We have updated the state severance tax inputs for the RAMC model. Table F-1 presents a summary of the results of this effort. The table shows the present RAMC input values and the recommended updated values. The updated values were derived from information obtained through contacts with the appropriate state offices. Inputs for nine states have changed; inputs for the remaining states were confirmed to be the same as present RAMC inputs.

The detailed calculations used to derive the updated input values are given below. The format used is the same as that used by Michael Grillot (DOE) in his severance tax memorandum dated 12/3/78. Thus, for each state with a coal severance tax, we list the appropriate person to contact, the tax information given, any necessary calculations, and a conclusion section in which the severance tax is expressed either as a fixed sum per ton of coal (expressed in 1979 dollars) or as a percentage of sales.

1. Alabama

A. Contact: Melvin Johnson (205) 832-6740

B. Information: State Coal Severance Tax = \$0.335/ton
DeKalb County Severance Tax = \$0.500/ton
Jackson County Severance Tax = \$0.500/ton

FY 78 Production of Coal (tons):

DeKalb County	=	134,031
Jackson County	=	<u>1,311,313</u>
		1,445,344
State Production	=	23,383,160

Table F-1
STATE SEVERANCE TAXES ON COAL, SUMMARY
% = % of sales; \$ = \$/ton

State	Severance Tax		Changes	Telephone No.	Name
	12/78	11/79			
1 Alabama	\$.34	\$.34	<--	205-832-6740	Melvin Johnson
2 Alaska	1%	1%		907-465-2309	Bob Elliot
3 Arkansas	\$.02	\$.02		501-371-1486	Ms. Calder
4 Colorado	\$.31/\$.62	\$.67/\$.34	<--	303-839-3089	Statistics Branch
5 Kentucky	4.5%	4.1%	<--	502-564-4920	Sales Tax Division
6 Louisiana	0	\$.10	<--	504-342-6224	Ms. Sartin
7 Maryland	0	\$.15	<--	301-359-3057	Mr. Abar
8 Montana	30%	24.62%	<--	406-449-2981	Al Davis, ext. 211
9 New Mexico	\$ 0.45	\$ 0.50	<--	505-827-3221	John Romero, Tax Research Section
10 North Dakota	\$.83	\$.85	<--	701-224-2770	Barry Hast
11 Ohio	\$.04	\$.04	<--	614-466-7026	Mr. Dern
12 South Dakota	1%	1%		605-773-3311	Dept. of Revenue
13 Tennessee	\$.20	\$.20		615-741-2011	Misc. Tax Division
14 West Virginia	3.85%	3.85%		304-348-4030	Mr. Snyder
15 Wyoming	14.6%*	13.57%	<--	307-777-7215	Mr. Bauer

*Reduced apparently because deductions have increased the difference between assessed value and gross value.

- C. Calculations: The two counties imposing a local severance tax account for 6.18 percent of state production.
 $\$.50 \cdot 0.0618 = \0.031
 (State severance tax) + (local severance tax effect) =
 $\$0.335 + \$0.031 = \$0.366$
 $= \$0.37$
- D. Conclusion: Alabama's coal severance tax should be \$0.37/ton. The previous RAMC input was \$0.34/ton.

2. Alaska

- A. Contact: Bob Elliot (907)465-2309
- B. Information: Mining License Tax Schedule

Net Income from Mining

\$40,000 - \$ 50,000	0 + .03 • (Net Income)
\$50,001 - \$100,000	\$1,500 + .05 • ([Net Income] - [\$50,000])
Over \$100,000	\$4,000 + .07 • ([Net Income] - [\$100,000])

- C. Calculations: This information is identical to Michael Grillot's 12/3/78 memo. He constructed two cases of typical Alaskan mines which showed that the mining license tax had the effect of a 1 percent tax on sales. Since the tax schedule has not changed, 1 percent is still valid.
- D. Conclusion: The Alaskan severance tax is 1 percent of sales. This is the current RAMC input for Alaska, so no change is necessary.

3. Arkansas

- A. Contact: Ms. Calder (501) 371-1486
- B. Information: State Coal Severance Tax = \$0.02/ton
- C. Conclusion: Arkansas severance tax is \$0.02/ton which is the current RAMC input. No change is necessary.

4. Colorado

- A. Contact: Statistics Branch (303) 839-3809
- B. Information: The state severance tax for Surface Mines = \$0.60/ton. This rate is adjusted by comparing the Producer Price Index of January 1978 with the current PPI. The per ton rate is increased 1 percent for every 3 point increase in the PPI. The current state severance tax is \$0.672/ton.
- Deep mines get a 50 percent credit on the severance tax, so the effective rate is \$0.341/ton.
- C. Calculations: According to Michael Grillot's memo, the RAMC input convention is to assign the deep mine tax rate (\$0.672 or \$0.67) to Colorado South and the surface tax rate (\$0.341 or \$0.34) to Colorado North. Mr. Grillot also had transposed the surface mine tax rate with that for deep mines.
- D. Conclusion: Colorado Severance Tax (\$/ton)

	<u>New Rate</u>	<u>Old Rate</u>
Colorado North	.67	.31
Colorado South	.34	.62

5. Kentucky

- A. Contact: Sales Tax Division (502) 564-4920
- B. Information: State Coal Severance Tax is 4.5 percent of taxable value.
- C. Calculation: Grillot's Assumption: Taxable value $\approx$ sales. Latest information from Kentucky shows taxable value to be 91 percent of sales. Accordingly, the tax rate on sales is 4.1 percent.
- D. Conclusion: Kentucky's coal severance tax is 4.1 percent of sales. This is a change from the current RAMC input of 4.5 percent of sales.

6. Louisiana

- A. Contact: Ms. Sartin (504) 342-6224
- B. Information: The state severance tax on coal is \$0.10/ton.
- C. Conclusion: The RAMC input for Louisiana's severance tax should be \$0.10/ton. There was no previous value.

7. Maryland

- A. Contact: Mr. Abar (301) 359-3057
- B. Information: Maryland's surcharge on coal is \$0.15/ton.
- C. Conclusion: The RAMC input for Maryland's severance tax should be \$0.15/ton. There was no previous value.

8. Montana

- A. Contact: Al Davis (406) 449-2981
- B. Information: Montana has three coal taxes.

(1) Coal Mines Severance Tax

Heating Quality (BTU/Lb)	Surface Mines		Deep Mines	
	(\$/ton)	(% of C.S.P.*)	(\$/ton)	(% of C.S.P.)
Under 7000	.12	or 20	.05	3
7001-8000	.22	or 30	.08	4
8001-9000	.34	or 30	.10	4
Over 9000	.40	or 30	.12	4

*Montana allows a 20,000 ton exemption each year.

- (2) Resource Indemnity Trust Tax: \$25/year + 0.5 percent of gross value before any processing or loading.

- (3) Gross Proceeds Tax:

Tax Base

Surface Mines = 45 percent of C.S.P.
Deep Mines = 33 1/3 percent of C.S.P.
Tax Rate: Local Mil Levy

C. Calculations: All the additional information used in these calculations can be found on pages 89, 113, and 122 of the Montana Report of the State Department of Revenue for the Period July 1, 1976 (sic.) to June 30, 1978.

I. LOCAL PROPERTY TAXES

CALENDAR YEAR 1977					
1 Coal Producing Counties in Montana	2 Gross Proceeds from Coal	3 County Adj. Tax Rate All Sources	4 Property Taxes Collected	5 Total Gross Value of Coal Prod'n	6 Contract Sales of Coal
(A) Big Horn	\$33,515,569	.110 39	\$ 3,699,784	\$101,803,350	\$ 74,479,042
(B) Musselshell	71,746	.139 58	10,014	297,696	318,869
(C) Powder River	28,160	.080 27	2,260	125,878	125,154
(D) Richland	758,382	.138 68	105,172	2,154,607	1,685,294
(E) Rosebud	18,824,430	.122 88	2,313,146	54,251,724	41,832,067
(F) Montana	\$53,198,287		\$ 6,130,376	\$158,633,255	\$118,440,426
(G)	<u>Taxes Collected</u> <u>Gross Value</u>	=	\$ 6,130,376 = \$158,663,255	0.0386	3.86% of sales

II. RESOURCE INDEMNITY TAX

(H) Rate = 0.5% of sales

III. SEVERANCE TAX

The severance tax is levied against a Contract Sales Price, or CSP, which is the gross value on sales minus taxes paid to local, state, and federal agencies. The curious part of this calculation is that the severance tax itself is deducted "to avoid taxing the tax."

$$CSP = X - S \cdot CSP - R \cdot CSP - L \cdot CSP - F \cdot CSP$$

Where

CSP = Contract Sales Price

X = Actual Selling Price

S = Effective State Severance Tax Rate (Taxes ÷ Contract Sales)

R = Effective Resource Indemnity Tax Rate

L = Local Property Tax Effect

and F = Federal Taxes Effect (\$0.40/ton) • (Tons) ÷ Contract Sales)

(A) S: Effective State Severance Tax Rate:

$$\frac{\text{Calendar 77 Tons}}{\text{FY 77-78 Tons}} \cdot \frac{\text{Severance Collected}}{\text{Contract Sales}} = \frac{27,229,052}{26,446,444} \cdot \frac{33,623,864}{118,440,426} = 1.03 \cdot .2839 = S = .2923 \text{ of CSP}$$

(B) R: Effective Resource Indemnity Tax Rate:

$$\frac{\text{Gross Value}}{\text{Contract Sales}} \cdot 0.005 = 1.3396 \cdot 0.005 = R = 0.0067 \text{ of CSP}$$

(C) L: Local Property Tax Effect

$$\frac{\text{Property Tax Collected}}{\text{Contract Sales}} = \frac{\$6,130,376}{\$118,440,426} = L = 0.0518 \text{ of CSP}$$

(D) F: Federal Taxes Effect

$$\left(\frac{\text{Calendar 77 Contract Sales}}{\text{Calendar 77 Tons}} \right)^{-1} \cdot \$0.40/\text{Ton} = \left(\frac{\$118,440,426}{27,229,052} \right)^{-1} \cdot \$0.40 =$$

$$= (4.350)^{-1} \cdot 0.40 = .2299 \cdot 0.40 = F = 0.0920 \text{ of CSP}$$

(E) CSP

$$\text{CSP} = X - 0.2923 \text{ CSP} - 0.0067 \text{ CSP} - 0.0518 \text{ CSP} - 0.0920 \text{ CSP}$$

$$\text{CSP} = X - 0.4428 \text{ CSP}; 1.4428 \text{ CSP} = X$$

$$\text{CSP} = 0.6931 X; \text{multiply this rate times the effective severance tax rate: } 0.6931 \cdot 0.2923 = .2026 = 20.26\% \text{ of sales}$$

IV. SUM OF MONTANA TAXES

Local Property Taxes	3.86% of sales
Resource Indemnity Tax	.50% of sales
State Severance Tax	20.26% of sales
Montana Coal Prod'n Taxes:	24.62% of sales

Note: For future updates of the Montana Severance Tax a less strenuous estimate is the following:

$$\frac{\text{FY 77-78 Severance Taxes Paid}}{\text{Calendar 1977 Gross Value}} \cdot \frac{\text{Calendar 77 Tons Produced}}{\text{FY 77-78 Tons Produced}} =$$

*\$0.35 for federal reclamation and \$0.05 for black lung disease.

$$\frac{\$ 33,623,684}{\$158,663,255} \cdot \frac{27,229,052 \text{ Tons}}{26,446,444 \text{ Tons}} = .2119 \times 1.0296 = 21.82\% \text{ of sales}$$

D. Conclusion: The New RAMC Model Input for Montana's Production Tax on Coal is 24.62 percent of sales, replacing the previous value of 30 percent.

9. New Mexico

A. Contact: John Romero, Tax Research (505) 827-3221 ext. 211

B. Information:

(1) State Coal Severance Tax:

Steam Coal = \$0.435/ton
Met Coal = \$0.206/ton

Tons produced = 13,134,457; Revenues collected = \$5,117,005

(2) Resource Excise Tax

.0075 • Taxable Value
Revenues Collected = \$1,135,261

(3) Conservation Tax

.0019 • Taxable Value
Revenues Collected = \$288,638

(1) Severance

$$\frac{\text{Revenues}}{\text{Tons}} = \frac{\$5,117,005}{13,134,457 \text{ tons}} = \$0.3896/\text{ton}$$

(2) Resource

$$\frac{\text{Revenues}}{\text{Tons}} = \frac{\$1,135,261}{13,134,457 \text{ tons}} = \$0.0864/\text{ton}$$

(3) Conservation

$$\frac{\text{Revenues}}{\text{Tons}} = \frac{\$288,638}{13,134,457 \text{ tons}} = \$0.0220/\text{ton}$$

(4) Summary of New Mexico Coal Production Taxes

\$/Ton

Severance . 0.3896
Resource 0.0864
Conservation 0.0220

New Mexico \$0.4980/ton or \$0.50/ton

- D. Conclusion: The New RAMC Input for New Mexico's Severance Tax is \$0.50/ton, replacing the previous value of \$0.45/ton.

10. North Dakota

- A. Contact: Barry Hast (701) 224-2770
- B. Information: North Dakota's current state severance tax is \$0.85/ton. This rate is adjusted semi-annually by comparing the June Producer Price Index with the previous December and December with the previous June. The per ton rate is raised \$0.01 for each 1- point increase in the PPI. The next adjustment will occur with the release of December's PPI.
- C. Conclusion: The RAMC severance tax input for North Dakota is \$0.85/ton, replacing the previous value of \$0.83/ton.

11. Ohio

- A. Contact: Mr. Dern (614) 466-7026
- B. Information: The State Severance Tax for Ohio is \$0.04/ton.
- C. Conclusion: The RAMC severance Tax input for Ohio is \$0.04/ton. The current value is \$0.04; no change is necessary.

12. South Dakota

- A. Contact: Department of Revenue (605) 773-3311
- B. Information: The State Severance Tax is 4.5 percent of gross profits.
- C. Calculations: Michael Grillot in his memo constructed two cases representative of South Dakota coal mines and found that at 4.5 percent the Gross Profits Tax had an effect similar to a 1 percent tax on sales.
- D. Conclusion: The RAMC South Dakota Severance Tax input is 1 percent. This is the current RAMC input. No change is necessary.

13. Tennessee

- A. Contact: Miscellaneous Tax Division (615) 741-2011
- B. Information: State Coal Severance Tax = \$0.20/ton.
- C. Conclusion: The RAMC Tennessee Severance Tax input = \$0.20/ton. This value is the current input, so no change is necessary.

14. West Virginia

- A. Contact: Mr. Snyder (304) 348-4030
- B. Information: The State Business and Occupation Tax is 3.85 percent. No change is necessary.

15. Wyoming

- A. Contact: Mr. Baver (307) 777-7215
- B. Information:

Severance Tax	=	10.5%
Ad Valorem	=	<u>6.5%</u>
		.17
Tax Base/Ton of Coal = \$7.24		
Avg. Price/Ton = \$9.07		
- C. Calculations:

.17 • 7.24	=	1.2308
1.2308 ÷ 9.07	=	13.57% of sales
- D. Conclusion: The new RAMC input for Wyoming's coal production tax is 13.57, replacing the previous value of 14.6 percent.