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An Executive Summary of Coal Slurry Pipelines in Virginia A Preliminary Feasibility Study

by

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EXECUTIVE SUMMARY

INTRODUCTION

The following information is designed to help the lay reader understand the results of this study through a brief explanation of its pertinent points.

During the preliminary feasibility study, eight different coal slurry pipeline alternative routes -- leading from southwest Virginia to Portsmouth -- were examined using topographical maps and a computer optimization model. Each of the alternative routes and pipeline sizes were model-tested using state-of-the-art preparation, pumping, and dewatering components. All were found to be technically feasible.

Uneven topographical features, occasioned by mountainous terrain, were not found to be a barrier to technical feasibility.

Water supply, analyzed through annual stream-flow records, appears to be ample for the transportation range of between 2.5 and 25 million tons per year.

The environmental impact of the slurry pipeline on its medium for transportation, water, appears to be benign at this study's level of investigation. To be certain, further study is required.

Construction costs, annual operating costs, and unit costs were determined by the optimization program for annual throughput, which varied from 2.5 to 25 million tons annually, and for interest rates ranging from 10 to 30 percent. Over this range the unit costs varied from a low of 1 cent per ton-mile to a high of almost 5 cents per ton-mile. Unit costs did exhibit an expected dependence-on-scale with the larger pipelines yielding the smaller unit cost. The cost of borrowing money is one of the most important determiners of economic feasibility.

While technical feasibility is assured and economic feasibility seems possible, several legal issues, right of eminent domain and interbasin transfer of water, remain as barriers to actual construction of slurry pipelines in Virginia.

A brief summary of the several aspects listed above along with the cost estimates are contained in the following pages of this executive summary.

SCOPE

A preliminary feasibility study for a possible slurry pipeline was accomplished to determine the technical and economic aspects of transporting coal from southwestern Virginia to southeastern Virginia to serve various power plants, and the domestic and export markets. Eight different pipeline route alternatives, varying between 380 and 470 miles in total length, were investigated and involved one terminal (Portsmouth) and three points of origin (Grundy, Big Stone Gap and Pound) as shown in Figure 1.1. Alternative routes are labeled with a number (either 1, 2 or 3), referring to the source location, and are followed by two letters (NN, NS, SN, or SS) which identify the north or south route-branches that lead to Bedford and beyond.

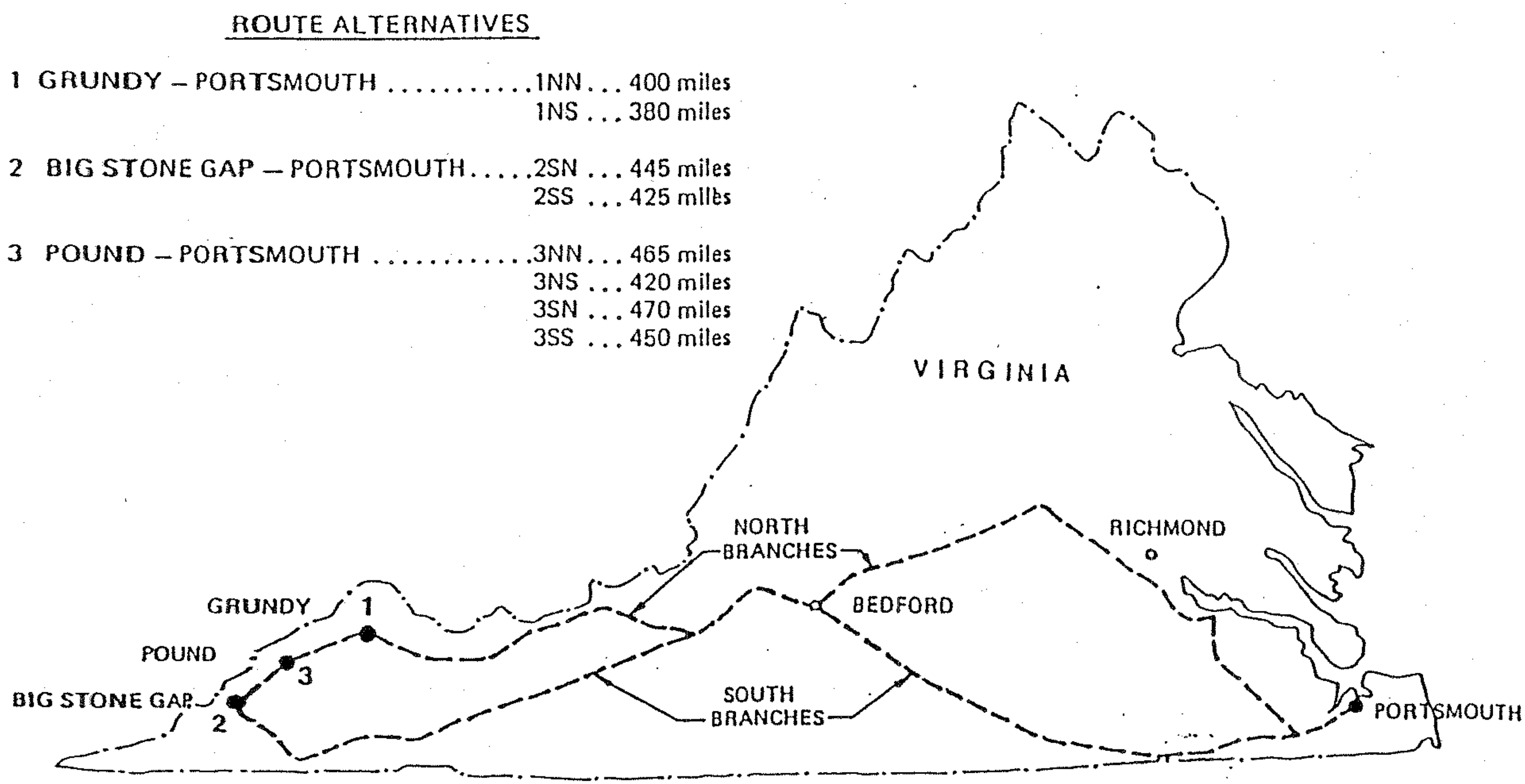

Figure 1.1. Route Alternatives Considered for Virginia Coal Slurry Pipelines

Alternative route #1 originates at an approximate elevation of 1100 feet above the mean sea level (MSL), while routes #2 and #3 originate at elevations of 1500 feet and 1550 feet (MSL), respectively. The topographic features of the north branch are only slightly rougher, with maximum terrain elevations of up to about 2700 feet (MSL), than those of the south branch which reaches a maximum elevation of about 2500 feet (MSL). However, nearly all of the rough terrain is confined to within the first 150 to 250 miles, depending on the route used.

The pipeline location characteristics, along these alternative routes, were determined at five-mile intervals with the use of 1:500,000, 1:250,000, and 1:62,500-scale U.S. Geological Survey topographic maps. Based on this topographic survey, the majority of pipeline slopes were found to remain within a ±2 percent grade, averaged over each five-mile interval, reaching a maximum of ±4 percent in the vicinity of Richlands. The actual pipeline would probably encounter larger slopes at some locations. However, in view of the generally accepted limiting-design slopes of ±16 percent, for avoiding slurry plugs in the line, curved portions of the pipeline, and river, highway and railroad crossings, the topographic conditions are not expected to present any extraordinary or unmanageable engineering design, construction or operation-related difficulties.

METHODOLOGY

The coal slurry pipelines in this study have the three conventional main-system components, namely a slurry preparation and feeding facility at the pipeline origin, the pipeline and the pumping stations, and a slurry dewatering facility at the pipeline terminal. A collection system with access to nearby mines, preparation plants, and a communication and supervisory control system are also incorporated. Technical characteristics of these system components are also assumed to be conventional, because they are based on the technology of existing coal slurry pipelines. These are the Consolidation Coal Pipeline in Ohio and the Black Mesa Pipeline in Arizona, as well as those planned, such as the ETSI, Coalstream, Alton, NICES, San Marco, and Alberta pipelines. Considerable technical information from nonslurry pipelines was also utilized.

After the route alternatives were determined, all the technical design and unit cost characteristics were entered as the input data for the computer optimization model employed in this study. The outputs of the computer model consisted of the optimum system characteristics for each specific application, results being given in tabular as well as graphical formats.

WATER RESOURCES

The water requirements for the pipeline are summarized in Table 1.1. Based on the general rule that 1 ton of water would be required for 1 ton of solids transported, the total amount of water required would be about 1,300 gallons per minute (gpm) or 2.0 million gallons per day (mgd), or 2,000 acre-feet/year for 2.5 million tons per year (mty). The corresponding values for 25.0 mty are 13,300 gpm, 19.2 mgd or 20,300 acre-feet/year.

The annual streamflow records from the U.S. Geological Survey were employed for an examination of the hydrologic situation in five streams and two reservoirs in the vicinity of Grundy, Pound and Big Stone Gap, as sketched in Figure 1.2.

Annual Throughput (million tons/yr)	2.5	5.0	10.0	15.0	20.0	25.0
Q (cfs) cubic ft/sec	2.96	5.92	11.85	17.77	23.69	29.62
Q (gpm) gal/min	1,329.83	2,659.65	5,319.30	7,978.95	10,638.61	13,298.26
Q (mgd) million gal/day	1.91	3.83	7.66	11.49	15.32	19.15
Q (acre-ft/yr)	2,017.34	4,053.57	8.107.13	12,160.70	16,214.26	20,267.83

Table 1.1 Approximate Water Requirements

Levisa Fork, at Big Rock (BR in Figure 1.2) near Grundy (GY), has an average precipitation of 18 inches per year corresponding to a mean discharge of about 400 cubic feet per second (cfs). While floods as high as 19,000 cfs were recorded, a week-long minimum flow of 5.0 cfs is also known to have occurred. Thus, a rather small reservoir with a seasonal storage of three to six-month's storage, would provide the water required by the pipeline. Another stream-gauging station near alternative route #1 is on the Clinch River at Richlands (RLS), where the recorded values are about 190 cfs for the mean discharge, about 9,500 cfs for the maximum flood, and about 9 cfs for the minimum recorded discharge. These are roughly similar characteristics to those of the Levisa Fork, and thus, similar arguments may be presented.

Russell Fork at Haysi (HYS) is not far from Grundy (GY) nor from Pound (PD). The mean discharge is about 330 cfs, the maximum flood is about 26,000 cfs, while the very low value of 0.2 cfs is on record as the minimum discharge. Again, it seems quite probable that this stream can provide an adequate supply of water to either Grundy (GY) or Pound (PD) with the help of a seasonal-storage reservoir.

The Powell River near Jonesville (JVL), or the Clinch River at Cleveland (CLD) seem to provide an adequate water supply for Big Stone Gap (BSG) with little or no impoundment required. The mean discharges are 540 cfs and 710 cfs, respectively, for the two stream-gauging stations. The recorded minimum flow rates are associated with short durations during the summer and are 17 cfs and 35 cfs, respectively. It appears a small reservoir may be quite adequate to provide flow regulation for a short period in summer.

In addition, two flood protection reservoirs exist in the area, the Flanagan Reservoir (FLN) and the Pound River Lake (PDL). The active volume of the Flanagan Reservoir associated with summer operations is about 78,000 acre-feet. This is four times greater than the water required for a throughput of 25.0 mty, and forty times more than the water required for 2.5 mty. The Pound River Lake is a smaller reservoir with a volume of 8,000 acre-feet/year reserved for summer operations.

The above discussion reveals that the region seems to have adequate water resources to provide water for a coal slurry pipeline. It is also clear that a detailed study would be required not only to fully investigate the hydrologic characteristics of the region but also to assess the economics of various water-supply alternative systems, such as run-of-river diversions, and nearby reservoirs with short supply lines. Such an investigation would also reveal the benefits and costs of additional flood-control measures enacted with consideration for residential areas, mines, railroad tracks, and other properties.

COST CHARACTERISTICS

The costs of various system components are based on an extensive survey and evaluation of the available data and information compiled. This concerns not only the existing and planned coal slurry pipelines, but also pipelines transporting other kinds of slurries as well as liquids and gases. The costs presented are in line with year-end 1982 prices, and estimates of the prices of the previous years -- the fourth quarter of 1980, in particular -- when adjusted for inflation. Use was made of national and regional values and variations of the relevant cost indices which are published periodically.

SYMBOLS FOR TOWNS & CITIES

- *BSG* : *Big Stone Gap*
- *GY* : *Grundy*
- *PD* : *Pound*

SYMBOLS FOR EXISTING RESERVOIRS

- *FLN* : *Flanagan Reservoir near Haysi*
- *PDL* : *Pound River Lake near Pound*

SYMBOLS FOR STREAM GAGING STATIONS

- *BR* : *Levisa Fork at Big Rock*
- *CLD* : *Clinch River at Cleveland*
- *HYS* : *Russell Fork at Haysi*
- *JVL* : *Powell River near Jonesville*
- *RLS* : *Clinch River at Richlands*

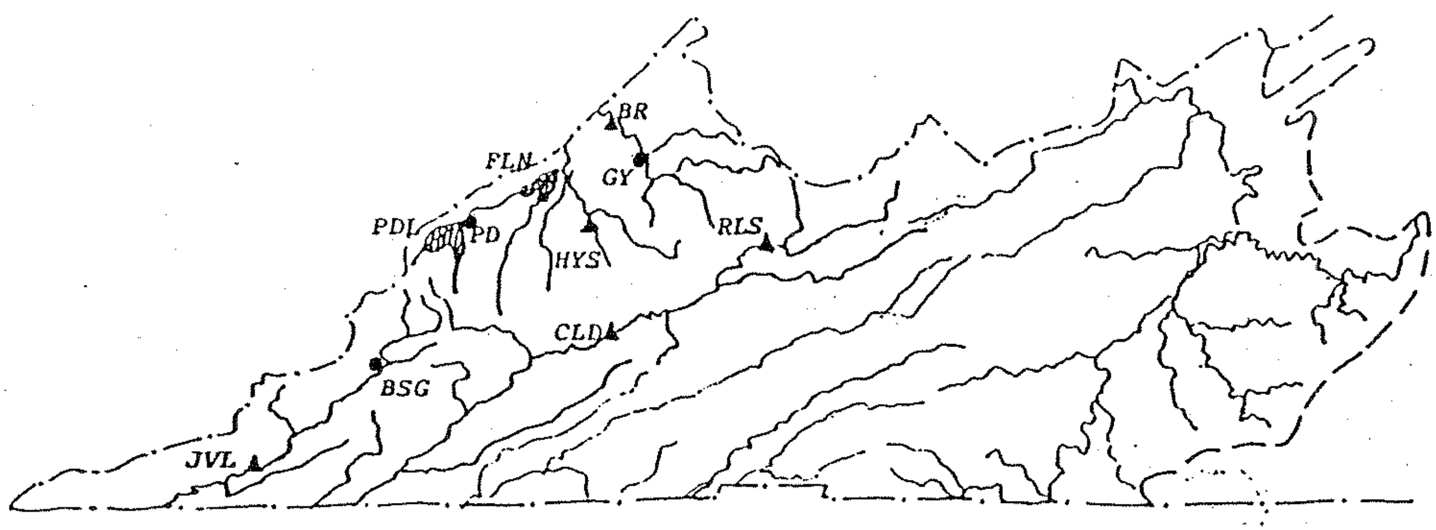

Figure 1.2 Streams and Reservoirs in Region

The cost functions employed in this study are associated mainly with the following pipeline system components: line pipe, pumping stations, slurry preparation plant, slurry dewatering plant, automated operation, control and communication system, and contingencies. All include costs of material, equipment, land, installation capital costs, and operational and personnel costs relating to annual expenses. The calculated transportation costs are based on an economic evaluation of these capital and annual operating and maintenance costs as well as an assumed depreciation schedule and capital charges based on a project life of 30 years, to exclude taxes.

OVERALL EVALUATION OF RESULTS

Table 1.2 gives a summary of the results obtained for all alternative routes and for throughputs of 5.0, 10.0, and 20.0 million tons per year. The total annual expenses (annuity) vary with the annual interest rate applied, as well as from route to route, and for different annual throughputs. However, the minimum values are obtained for the lowest interest rate (10 percent), and lowest throughput (2.5 mty) for any given route, while the maximum values, on the other hand, are obtained for the highest rate (30 percent), and the largest throughput (25 mty). Transportation costs ($/ton) as well as unit transportation costs (cents/ton/mile) also vary a great deal, depending on the route, annual throughput and annual interest rates applied.

As for typical values, for the shortest route #1NS (380 miles) and for an annual throughput of 5.0 million tons per year the capital investment required is estimated to be $282.3 million, and annual operation and maintenance expenses amount to $18.2 million per year. The transporation costs vary from $7.4/ton for an interest rate of 10 percent to $18.7/ton for a 30 percent interest rate, and for the unit transporation costs, the variation is from 1.9 cents/ton/mile for a 10 percent interest rate to 4.9 cents/ton/mile for a 30 percent interest rate.

For the longest route #3SN (470 miles), and again for an annual throughput of 5.0 million tons per year, the capital investment required is $334.3 million, and the annual operation and maintenance costs amount to about $20.0 million per year. The transportation costs and the unit transportation costs vary from $8.5/ton and 1.8 cents/ton/mile for the 10 percent interest rate to $21.8/ton and 4.6 cents/ton/mile for the 30 percent interest rate.

Of the various alternative designs investigated, no single one should be selected at this stage of the investigations as the best overall alternative for a coal slurry pipeline between southwestern and southeastern Virginia. Before such a step can be taken, further analyses and decisions would be required concerning (a) projected supplies from the affected mines, (b) projected demands at the terminals, namely at the power plants as well as at the ports for domestic and overseas export, (c) economic and institutional aspects of the water supply systems at the pipeline origins, (d) financial and institutional characteristics of the pipeline owner/operator, and (e) more detailed case studies and a comparison of the selected pipeline with alternative modes of transportation such as railroads, considering both the economics and other points of view.

The results contained here provide a spectrum of technical and cost characteristics which can be used as a reliable data base for evaluating any particular alternative system associated with any scenario that may be applicable in the future.

Table 1.2

COST SUMMARY FOR 5.0-MTY ANNUAL THROUGHPUT

ROUTE NO.	PIPE LENGTH (MI)	CAPITAL COST ($-MILL.)	ANNUAL O & M ($-MILL./YR)	TRANSPORTATION COST ($/TON) 10%	20%	30%	UNIT TRANSP. COST (C/TON/MI) 10%	20%	30%
1NN	400	289.3	18.5	7.56	13.34	19.13	1.89	3.33	4.78
1NS	380	282.3	18.2	7.41	13.05	18.70	1.95	3.43	4.92
2SN	445	324.3	19.7	8.26	14.74	21.23	1.85	3.31	4.77
2SS	425	308.4	18.8	7.87	14.04	20.21	1.85	3.30	4.75
3NN	440	327.1	19.6	8.28	14.82	21.37	1.88	3.37	4.85
3NS	420	317.2	19.3	8.09	14.43	20.78	1.92	3.43	4.94
3SN	470	334.4	20.0	8.46	15.15	21.83	1.80	3.22	4.64
3SS	450	323.6	19.7	8.26	14.73	21.20	1.83	3.27	4.71

COST SUMMARY FOR 10.0-MTY ANNUAL THROUGHPUT

ROUTE NO.	PIPE LENGTH (MI)	CAPITAL COST ($-MILL.)	ANNUAL O & M ($-MILL./YR)	TRANSPORTATION COST ($/TON) 10%	20%	30%	UNIT TRANSP. COST (C/TON/MI) 10%	20%	30%
1NN	400	443.2	25.0	5.45	9.89	14.32	1.36	2.47	3.58
1NS	380	432.7	25.3	5.42	9.75	14.07	1.43	2.56	3.70
2SN	445	487.6	26.2	5.87	10.75	15.63	1.32	2.41	3.51
2SS	425	479.5	25.2	5.71	10.51	15.30	1.34	2.47	3.60
3NN	440	491.0	26.1	5.88	10.79	15.70	1.34	2.45	3.57
3NS	420	484.8	25.0	5.74	10.58	15.43	1.36	2.52	3.67
3SN	470	527.8	25.9	6.11	11.39	16.67	1.30	2.42	3.54
3SS	450	504.6	25.6	5.92	10.97	16.01	1.32	2.44	3.56

COST SUMMARY FOR 20.0-MTY ANNUAL THROUGHPUT

ROUTE NO.	PIPE LENGTH (MI)	CAPITAL COST ($-MILL.)	ANNUAL O & M ($-MILL./YR)	TRANSPORTATION COST ($/TON) 10%	20%	30%	UNIT TRANSP. COST (C/TON/MI) 10%	20%	30%
1NN	400	731.0	38.2	4.35	8.00	11.66	1.09	2.00	2.91
1NS	380	700.5	37.8	4.22	7.73	11.23	1.10	2.03	2.95
2SN	445	771.1	38.7	4.51	8.37	12.22	1.01	1.88	2.74
2SS	425	741.1	38.3	4.38	8.09	11.79	1.03	1.90	2.77
3NN	440	782.9	38.5	4.54	8.45	12.37	1.03	1.92	2.81
3NS	420	752.2	38.1	4.41	8.17	11.93	1.05	1.94	2.84
3SN	470	811.7	39.2	4.57	8.73	12.79	0.99	1.86	2.72
3SS	450	759.2	38.8	4.47	8.27	12.06	0.99	1.84	2.68

(In the above tables there are three columns under transportation cost ($/ton) and unit transportation costs (cent/ton-mile). These columns are headed by the interest rate for borrowing money which was assumed in the derivation of the unit costs.)

WATER ENVIRONMENTAL IMPACT

With regard to the various constitutents in coal and their impact on water, simulation studies and laboratory tests reported by Manahan et al. (1980) of Missouri Water Resources Center indicate the following: ". . . In many cases, the percentage of total metal extracted from coal in a fifty percent slurry is very small. . . . Specifically, environmentally important heavy metals are not leached appreciably into the water, despite their significant levels in the coal. This is evidenced by the essential absence from the water of lead, cobalt, nickel, and chromium, . . . only about 0.01 percent of iron, aluminum and copper are removed . . ." It was added, that ". . . Because of the rather good sorption qualities of coal for organic compounds and heavy metals, serious consideration should be given to the use of coal slurries for water purification. Thus, impaired water could be used as a source of water for a coal slurry line and could be largely purified by a long-term contract with coal in the slurry. . . ."

OVERVIEW OF LEGAL ISSUES

Before a pipeline is built, it is necessary to obtain approval from federal and state agencies to cross public lands, and get easements from landowners to cross their property. In the Office of Technology Assessment (1978) report, the provisions concerning pipelines are referred to under the following headings and definitions:

(a) "State Eminent Domain: . . . Pipelines (often) require rights-of-way through numerous states for long-distance construction (or within a given state, rights-of-way through railroad tracks in particular, which have been consistently denied in the past) . . ."
(b) "Water Rights: . . . Acquisition of water rights (for coal slurry pipelines) is dependent on the laws and administrative regulations of the particular jurisdiction. . . ."
(c) "Commodities Clause: . . . Pipeline operators would be forbiden from any ownership interest in the end line activity (e.g., utility power plant) or any source activity (e.g., coal mining or coal land ownership rights). Under this provision, utilities and mining companies or their contractors would have more difficulty in building and operating a pipeline. . . ."
(d) "EIS Requirements: If federal eminent domain legislation is enacted . . . NEPA (National Environmental Policy Act) requires that the federal agency file an environmental impact statement (EIS) if the action will have a significant effect on the environment . . ."

CONCLUSIONS

This preliminary technical and economic feasibility study, carried out for a prospective coal slurry pipeline between southwestern and southeastern Virginia, revealed the following general conclusions:

(a) The technology of "conventional" coal slurry pipelines is established and readily available from the viewpoints of design, construction, equipment, transportation capacity, continuous and efficient operation, line plugging, control of start-up and shut-down processes, and preparation and dewatering of slurry to any practical degree.

(b) There appear to be no extraordinary technological problems relative to a coal slurry pipeline in Virginia as concerns topographical features, and water supply or environmental aspects, at least at this preliminary level of investigation.

(c) A detailed and realistic comparison of pipeline transportation costs with various other modes of transportation is beyond the scope of this study. Nevertheless, it can be stated, based on this preliminary investigation, that coal slurry pipelines appear to provide a competitive alternative to current coal transportation systems in Virginia for certain capacities and with current interest rates.

TRANSPORTATION COST, $/TON
16% ANNUAL INTEREST RATE

LOCATION AND MILES	Pipeline Capacity, m.t.y. 2.5	5.0	7.5	10.0	12.5	15.0	20.0	25.0
1NS (380)	15.64	10.79	8.79	8.02	7.47	7.01	6.33	5.95
1NN (400)	16.42	11.02	9.14	8.11	7.72	7.27	6.54	6.17
3NS (420)	17.00	11.90	9.69	8.64	7.82	7.44	6.67	6.31
2SS (425)	17.09	11.57	9.55	8.59	7.78	7.38	6.61	6.36
3NN (440)	17.38	12.21	9.83	8.83	8.09	7.60	6.89	6.50
2SN (445)	17.53	12.15	9.87	8.80	8.06	7.56	6.82	6.41
3SS (450)	17.49	12.14	10.04	8.95	8.15	7.58	6.75	6.68
3SN (470)	18.10	12.47	10.36	9.28	8.43	7.93	7.10	6.63

1 - GRUNDY (MILES IN PARENTHESIS)
2 - BIG STONE GAP
3 - POUND