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**Final Environmental Impact Statement
Volume 2**



**Solvent Refined Coal—II
Demonstration Project**

**Fort Martin
Monongalia County
West Virginia**

U.S. Department of Energy

January 1981

Cover Sheet
Final Environmental Impact Statement
Solvent Refined Coal-II Demonstration Project
Fort Martin, West Virginia
DOE/EIS-0069

(a) Lead Agency: U.S. Department of Energy (DOE)

(b) Proposed Action: The cost sharing by DOE (45%), the Federal Republic of Germany (25%), Japan (25%), and SRC International, Inc. [composed of The Pittsburg & Midway Coal Mining Co., a wholly owned subsidiary of Gulf Oil Corporation (50%), and the West German (25%) and Japanese (25%) industrial participants] in the construction and operation of a 6000 tons per stream day (tpsd) solvent refined coal (SRC-II) demonstration plant with the potential for ultimate development of a 30,000-tpsd commercial facility at Fort Martin, Monongalia County, West Virginia.

(c) For further information, contact (1) Mr. James A. Reafsnyder, Research and Development Manager, SRC Projects Office, U.S. Department of Energy, P.O. Box E, Oak Ridge, TN 37830 [phone (615) 576-1055]; (2) Dr. Robert J. Stern, Acting Director, NEPA Affairs Division, Office of the Assistant Secretary for the Environment, Room 4G-064, Forrestal Building, 1000 Independence Avenue SW, Washington, DC 20585 [phone (202) 252-4600]; or (3) Mr. Stephen H. Greenleigh, Esq., Assistant General Counsel for Environment, Room 6D-033, Forrestal Building, 1000 Independence Avenue SW, Washington, DC 20585 [phone (202) 252-6947].

For copies of the EIS, contact James A. Reafsnyder at the address noted above.

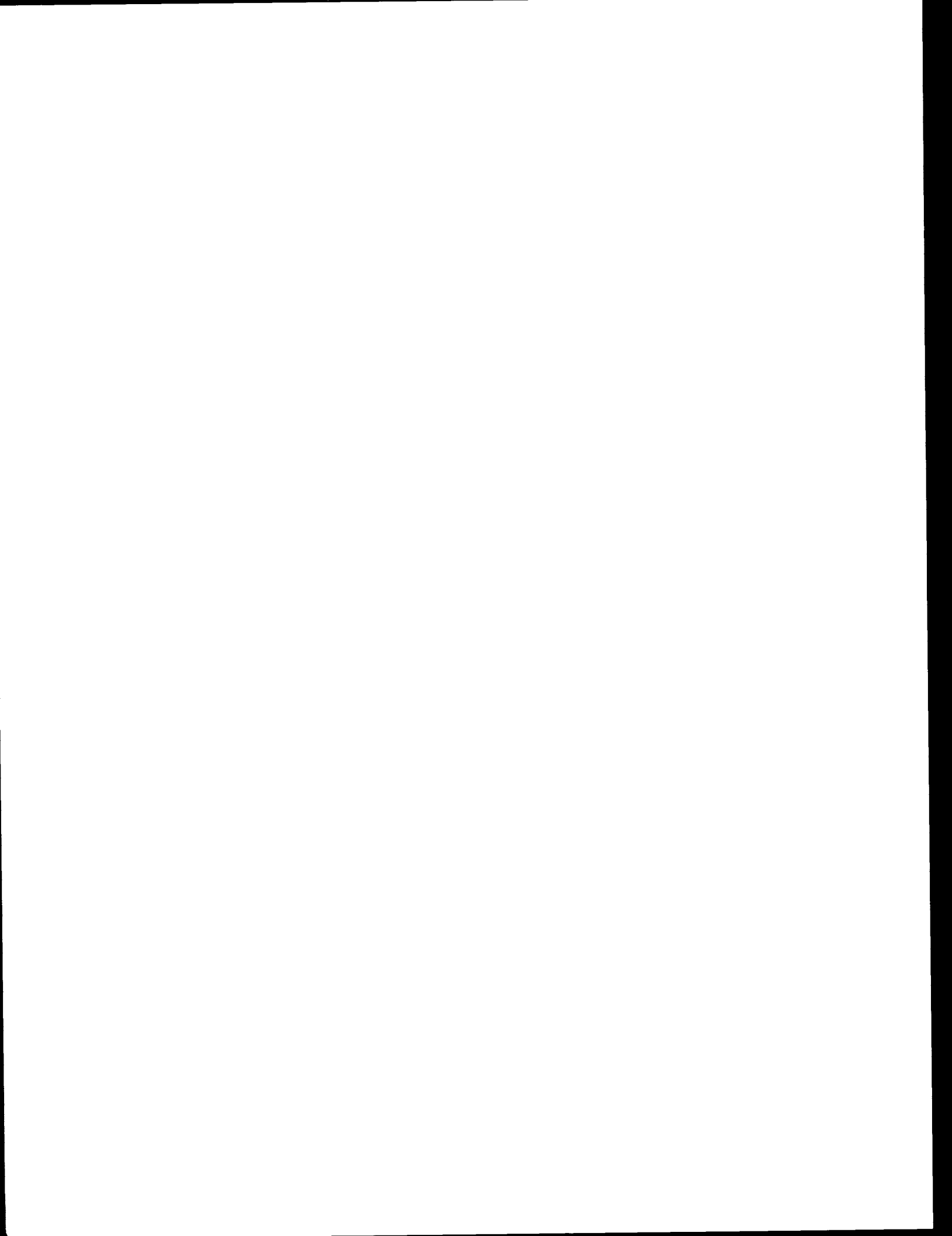
(d) Designation: Final EIS (FEIS).

(e) Abstract: The statement assesses the potential environmental impacts associated with the construction and short-term operation of a 6000-tpsd-capacity facility that will demonstrate the technical operability, economic viability, and environmental acceptability of the solvent refined coal (SRC-II) process at Fort Martin, West Virginia. Impacts assessed include effects of the project on occupational and public health resulting from the production and use of SRC products; potential impacts on terrestrial and aquatic ecology; potential and expected impacts on land use; projected effects on floodplains and wetland areas; potential contamination of surface and groundwater quality; water use and effects on water availability; potential effects on State and Federal ambient air quality standards; potential change of the cultural landscape, including structures eligible for or listed on the National Register of Historic Places; effects on sites of archaeological significance; and changes to existing economic and social characteristics of the site area. Additionally, the statement presents an assessment of potential long-range and cumulative impacts of a future commercial expansion of the proposed facility to achieve an approximate 30,000-tpsd capacity. The effects of continued operation of the demonstration plant, mothballing, conversion to another government use, and decommissioning are also considered as alternative fates of the facility after the demonstration. A mitigation plan and the construction and operational monitoring plans for assessing the effectiveness of mitigation measures for the duration of the demonstration phase are also presented.

(f) In assessing the potential environmental impacts of the proposed action, several programmatic and design alternatives are considered and evaluated. The range of alternatives assessed includes proceeding with the action as proposed, modification of the action and subsequent continuation of the project, and no further action. The modification section includes evaluation of alternative plant designs and alternative plant sites.

(g) The proposed action is intended to demonstrate the feasibility of a solvent refined coal process. As a result, it is possible that design changes or other similar actions may occur. If such changes or actions are determined to produce significant adverse environmental impacts beyond those described in this FEIS, appropriate NEPA (National Environmental Policy Act) documentation will be provided.

(h) A Record of Decision will be prepared and published in the *Federal Register* in connection with this proposed action. In considering the comments received on the DEIS in preparation of this FEIS, the Department has been particularly cognizant of the complexity of issues raised in connection with this project. Accordingly, the Department will consider any written comments on the FEIS received on or before March 15, 1981, in preparation of the Record of Decision. Any comments should be sent to Martin L. Rogowsky, Chairman, Fossil Energy Environmental Task Force, Room 5A-061, Forrestal Building, 1000 Independence Avenue, Washington, DC 20585.



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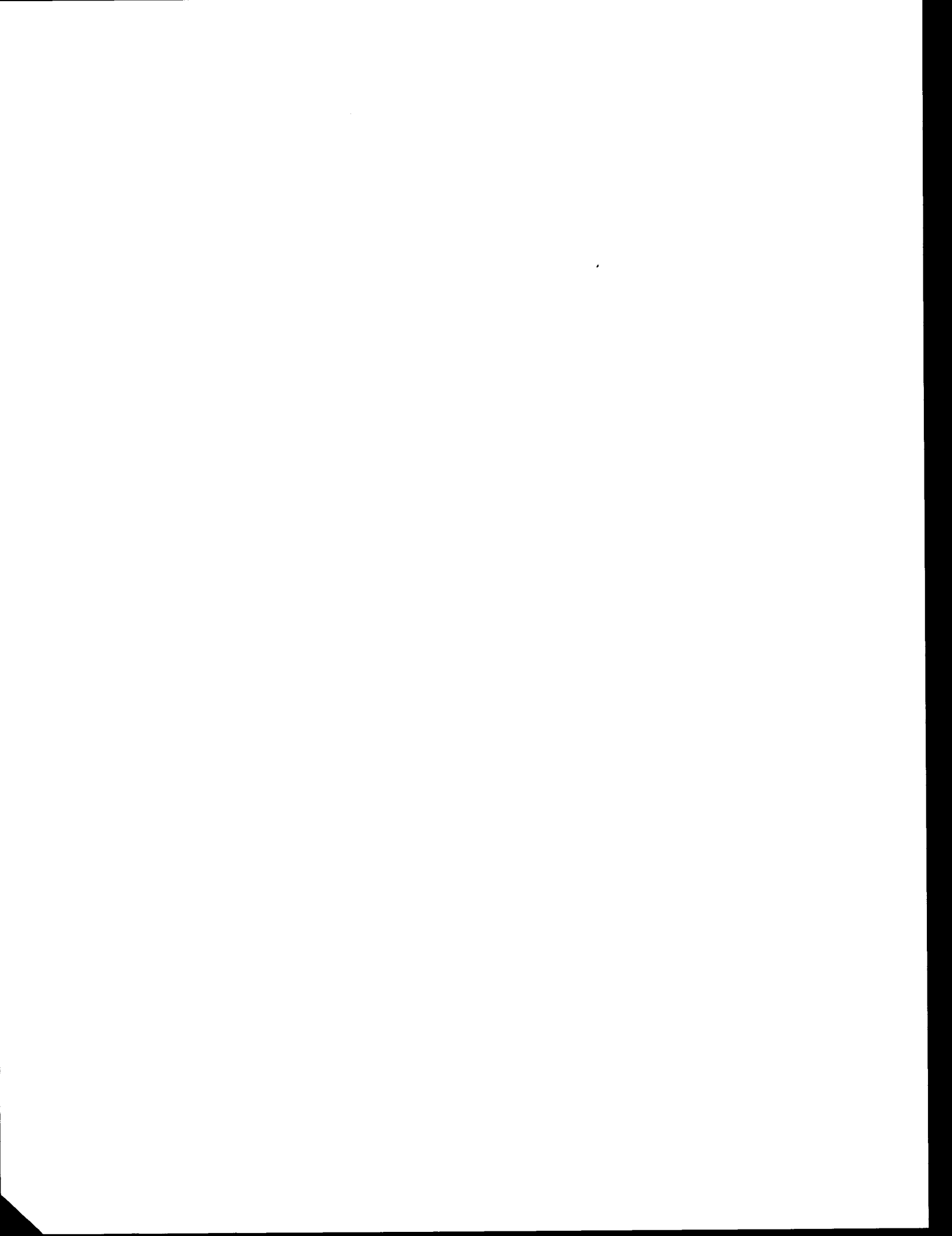


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Appendix B
SITE-SELECTION ANALYSES

Appendix B

SITE-SELECTION ANALYSES

B.1 INTRODUCTION

In 1975, Gulf Oil Corporation undertook a site-selection analysis for accommodating a 6000 tons/d SRC-II plant, capable of supporting an expansion of plant capacity to 30,000 tons/d. The siting criteria used in the Gulf study were primarily physical, engineering, and economic factors that were judged to be important for construction and operation of the SRC-II plant. Morgantown, West Virginia (specifically Ft. Martin) was chosen as the proposed site. At that time, the U.S. Department of Energy (DOE) was not a participant in the project.

After Gulf completed its site-selection analysis for the SRC-II project, several important events transpired: (1) the DOE became a participant in the project and (2) Executive Orders 11988 and 11990 pertaining to floodplain/wetland encroachment were issued (May 24, 1977). The Request for Proposal (RFP) from DOE to solicit an industrial partner for the SRC-II Demonstration Project required the industrial respondents to submit a site-specific proposal. Morgantown, West Virginia, having been chosen in the 1975 Gulf site-selection study, was proposed as the site for the SRC-II project. The DOE, taking NEPA responsibility for the issuance of the SRC-II Environmental Impact Statement (EIS), enlisted ORNL to prepare the EIS for their review. Although a proposed site had already been chosen for the project (as specified in the RFP from DOE and the contract with its industrial partner), it was recognized that an evaluation of the reasonable alternatives to the proposed action, including alternative sites, was necessary. Oak Ridge National Laboratory evaluated a large number of potential sites. The evaluation included sites identified for other synfuel demonstration projects to give regional diversity to the study. The proposed Morgantown site had been evaluated previously, and primary baseline data had been collected from an extensive monitoring program conducted at the site by Stearns-Roger.

A major difference between the site-selection analyses performed by Gulf Oil and ORNL is that the ORNL analysis placed primary emphasis on environmental criteria and identified the two environmentally least sensitive alternative sites. The Gulf site-selection study placed primary emphasis on engineering criteria. Section B.2 of this appendix describes the actual site-selection process conducted by Gulf in 1975, which includes the Morgantown site. Section B.3 describes the ORNL analysis, which evaluates a number of sites, from which two alternative sites were selected (Sects. 2.3.2, 4.3, and 4.4).

B.2 THE GULF OIL CORPORATION SITE-SELECTION ANALYSIS

This section of Appendix B discusses the actual site-selection process that resulted in the choice of the Morgantown site as the proposed site for the SRC-II facility.

Beginning in 1973, Gulf Oil Corporation accelerated activity toward commercial development of the SRC process including involvement in several potential projects that led to the initiation, in 1974, of a joint development activity with foreign companies, Mitsui of Japan and Ruhrkohle and STEAG of the Federal Republic of Germany. Part of this effort was to design an SRC-II Demonstration Plant with a coal feed rate of about 6000 tons/d.

Site evaluation for the proposed plant began in the fall of 1975 when letters were written to the governors of the states of Illinois, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, and West Virginia, describing the prospective project, defining site requirements, and requesting assistance in finding a site for the SRC-II Demonstration Plant. A total of 20 sites were initially nominated by the states for consideration. Two sites were later added, and two sites were withdrawn. Most of these sites previously had been offered to Coalcon for the ERDA-sponsored Clean Boiler Fuel Demonstration Plant, and, for those sites, the Coalcon project was given first choice. Table B.1 is a complete list of the sites.

Table B.1. List of proposed sites

State	Site	County
Illinois	New Athens ^a	St. Clair
Indiana	Mt. Vernon	Posey
Kentucky	Baskett	Henderson
	Cooper Landing ^b	Livingston
	Holt Bottom ^b	Breckinridge
Ohio	Belmont	Belmont
	Brilliant	Jefferson
	Dilles Bottom	Belmont
	Haverhill	Scioto
	Witten	Monroe
Pennsylvania	Clinton	Armstrong
	Crucible	Greene
	Georgetown ^{b,c}	Beaver
	St. Joe Lead	Beaver
	Tarrtown ^{b,c}	Armstrong
Tennessee	Lillard ^b	Polk
	Loudon ^b	Loudon
	Shellmound ^b	Marion
West Virginia	Ben's Run ^d	Tyler
	Morgantown	Monongalia
	North Point Pleasant	Mason
	Ravenswood	Jackson

^aSelected by Coalcon.^bNot presented to Coalcon for evaluation.^cNot originally presented to GMRC.^dSite withdrawn by Union Carbide.

A specific requirement for the SRC-II Demonstration Plant site was that it be able to support a commercial plant because a major project objective was to expand the demonstration plant once the technology had been proven and the economic uncertainties resolved. The site requirements were:

1. land — at least 526.5 ha (1300 acres),
2. location — rail, highway, and barge access,
3. labor — requirement for about 400 operators and maintenance personnel and a construction work force of about 2000 for the demonstration plant and about twice that number for the expanded plant,
4. water — water requirements for the demonstration plant were specified as 567 l/s (9000 gpm) consumed and 5040 l/s (80,000 gpm) of once-through cooling water. If a closed cooling water system was to be used, the water consumption would be 945 l/s (15,000 gpm),
5. electric power — approximately 40 MW, and
6. coal — the demonstration plant's annual consumption would be about 1.8×10^7 t (2×10^6 tons) of high-sulfur coal. Upon expansion to commercial size, annual consumption would increase to about (10×10^6 tons). Large reserves of coal should be located close to the site to minimize the transportation costs.

Information received from the various states was evaluated, first to eliminate from consideration those sites that did not meet the stated requirements, and then to eliminate less desirable sites in each state. Of the original 20 nominations, eleven were eliminated rapidly. In addition, Coalcon announced selection of New Athens, Illinois, for its proposed plant and Union Carbide withdrew the Ben's Run site in West Virginia. The remaining seven sites in five states were selected for further study by an inspection team.

As a result of these inspections, the number of candidate sites was narrowed to four — Baskett, Kentucky; Cooper Landing, Kentucky; Ravenswood, West Virginia; and Morgantown, West Virginia.

Stearns-Roger, Inc., an engineering firm, and Woodward-Clyde, geotechnical consultants, were selected to assist Gulf in a more thorough evaluation of each of the four sites. Tours of each site and discussions with local and state officials took place in February 1976, after which a detailed evaluation of each site was made. Twelve items were point evaluated on using the following criteria:

1. Available land and cost was assigned a point range of 20 to 50 because of the fairly wide range in costs from \$3087 to \$7410 per ha (\$1250 to \$3000 per acre).
2. Railroads was assigned a point range of 10 to 30 because of the range of difficulties in running a spur and total costs.
3. Highways was assigned a point range of 10 to 30 because of the range of quality of the roads.
4. The availability of slag disposal areas was assigned a point range of 25 to 50 because of its potentially large impact on the environment and operating costs.
5. Access to navigable waterways to accommodate barge facilities was assigned a point range of 5 to 20 because of the wide range of shipment potential, routing, and size of barges that could be accommodated on the various rivers.
6. Site geology was assigned a point range of 20 to 50 because of the anticipated variations in site-preparation problems and foundation conditions at the various sites and because of possible variation in seismic classifications.
7. Environment was assigned a point range of 20 to 75 because of its great influence on plant capital expenditures to maintain the various standards and restrictions imposed on operating plants.
8. Available Power Source was assigned a point range of 5 to 10 because the survey indicated little difference in available power sources at the various sites.
9. Water source was assigned a point range of 20 to 75 because of its importance in plant operations.
10. Tax considerations was assigned a point range of 5 to 10 based on construction taxes only; accordingly, point values are low.
11. Construction manpower was assigned a point range of 10 to 15.
12. Work force availability, because of its importance, a point range of 30 to 40 was selected.

As a result of these evaluations and additional discussions with local and state officials, the Cooper Landing site was eliminated for geological reasons; the other three sites adequately fulfilled site requirements. However, as events developed, the Baskett site was committed to another DOE-industry joint project and difficulties in acquiring the Ravenswood site made the site undesirable. As a result, the Morgantown site was selected in early 1977. Arrangements were made with the local Monongalia County Development Authority to begin acquiring options of the various land parcels that made up the site.

Among the factors that influenced the final selection of the Morgantown site were:

1. Apparent availability at reasonable cost of land adequate to support a commercial coal liquefaction facility,
2. Location in a major high-sulfur bituminous coal producing region,
3. Rural site location with no large concentration of housing nearby,
4. Site area had already been proposed for industrial use by the Monongalia County Planning Commission,
5. Favorable existing environmental quality and small possibility that construction of the SRC-II Demonstration Plant would significantly degrade the environment,
6. Availability of water adequate for the demonstration plant and for a future commercial plant,
7. Proximity to an existing 1150 MW electrical generation station,
8. Proximity to a navigable river and an existing railroad system that services the regional coal fields and projected market area,

9. Proximity to large eastern market for liquid product,
10. Proximity to pipeline for delivery of product pipeline gas,
11. Availability of adequate manpower for construction and operation of the plant,
12. Favorable local business climate and state government support, and
13. Steady growth of area and availability of good schools, good medical facilities, and many cultural activities. The Morgantown area is regarded as a desirable community for living and working.

B.3 ORNL SITE SELECTION ANALYSIS

This appendix describes the method used to select two alternative sites in addition to the proposed Fort Martin, West Virginia site. Additional sites were identified for the purpose of comparing the environmental impacts anticipated at the Fort Martin site to impacts at other sites. This method identified two alternative sites for analysis: (1) Equality, in Ohio County, Kentucky, and (2) Ravenswood, in Jackson County, West Virginia. The selection of these sites was based on a survey of sensitive environmental issues. The results of the analysis of environmental impacts at the two alternative sites are discussed in Sects. 4.3 and 4.4 and are summarized and compared to the proposed site in Sect. 2.3.2 of this Final Environmental Impact Statement (FES).

The two sites were selected for detailed environmental analysis by comparative evaluation of 27 candidate sites (Table B.2). Although the candidate sites have been identified as possible alternative sites for coal-conversion demonstration facilities,¹⁻⁵ all the sites were not considered. The 27 candidate sites were selected from a larger set of sites on the basis of two requirements:

Table B.2. Initial site screening — sites not satisfying physical constraints

Alternative sites	Constraint not satisfied			
	Area ^a	Water source ^b	Railroad access ^c	Barge access
1. Pigeon, Shelby County, Tenn.				
2. Rivergate, Shelby County, Tenn.	X			
3. Mud Island, Shelby County, Tenn.	X			
4. North, Shelby County, Tenn.	X			
5. Lewisport, Hancock County, Ky.				
6. Equality, Ohio County, Ky.				
7. Moro Island, Randolph County, Ill.	X			
8. Banner, Fulton County, Ill.				
9. Dykersburg, Williamson County, Ill.		X		
10. New Athens, St. Clair County, Ill.		X		
11. Mt. Vernon, Posey County, Ill.	X			
12. Carrs, Lewis County, Ky.	X			
13. Belmont, Belmont County, Ohio	X			
14. Dilles Bottom, Belmont County, Ohio	X			
15. Brilliant, Jefferson County, Ohio				
16. Witten, Monroe County, Ohio		X		
17. Haverhill, Scioto County, Ohio	X			
18. Clinton, Armstrong County, Pa.	X			
19. Crucible, Greene County, Pa.		X		
20. Ravenswood, Jackson County, W. Va.				
21. North Point Pleasant, Mason County, W. Va.	X			
22. Ben's Run, Monongalia County, W. Va.				
23. Site A, Noble County, Ohio				X
24. Site D, Noble County, Ohio		X	X	X
25. Site E, Noble County, Ohio	X		X	X
26. Site F, Noble County, Ohio	X		X	X
27. Site G, Noble County, Ohio			X	X

^aAt least 526 ha (1300 acres).

^bYield of 910–1140 m³/h (4000–5000 gpm).

^cClose or contiguous.

1. A candidate site must be identified and considered (at least in part) from an environmental perspective in a site-selection document, and
2. A site must be well defined rather than identified as a larger area (such as a county) in which a proposed facility could be located.

Although any of these 27 sites may be considered suitable for a synfuel demonstration facility, additional constraints must be imposed based on plant size, design, and resource considerations. Thus, 20 sites were eliminated from further consideration because of failure to satisfy four constraints identified by SRC-II (see page B-5): (1) at least 1300 acres of available land, (2) a water supply yielding 9000 to 15,000 gpm, (3) a railroad close or contiguous to the site, and (4) barge access. Table B.2 lists the 27 sites and indicates the sites that were eliminated because of failure to satisfy these four constraints.

The remaining seven sites were evaluated on the basis of seven important environmental issues (Table B.3). For each issue, each site was rated +, -, or 0 to indicate a potential for beneficial, adverse, or little or no impact, respectively. Ratings were determined by contacting state and local agencies and knowledgeable persons and by consulting maps, siting reports, and other publications.

The ratings on the seven environmental issues were used to compare each potential site with every other site. For each pair of sites, the site with the more positive rating for most of the variables was selected as the preferable alternative. Table B.4 shows an example of this procedure.

Table B.5 is the matrix that results from comparing all the sites by pairs. Each entry in the matrix is the identifying number of the preferable site resulting from comparing the row-numbered site with the column-numbered site. A total of seven sites results in six comparisons of any one site with other sites. The more frequently that a site is rated equivalent or superior to another site, the more preferable the site. Table B.6 summarizes the results of the matrix comparison.

For the issues considered, ratings of four sites were almost equivalent as far as having fewer sensitive environmental issues: Lewisport, Kentucky; Equality, Kentucky; Ravenswood, West Virginia; and Ben's Run, West Virginia. These sites were evaluated further on 15 additional environmental issues, which included physical, biological, and socioeconomic effects of the demonstration plant (Table B.7). Each set of sites was evaluated by the method used to produce the matrix in Table B.5. This evaluation (Tables B.8 and B.9) indicated that Ravenswood was the most preferable alternative site. Lewisport was rated lower, but the ratings for Equality and Ben's Run sites were equivalent on the first and second comparison matrices. The matrix method could not distinguish between these two sites.

The proposed site and the first alternative site are West Virginia sites. Of the remaining alternatives, only the Equality site is not located in West Virginia. To provide a range of potential locations in the analysis, the Equality site in Kentucky was chosen as the second alternative site. Impacts on the proposed Fort Martin site and the alternative Ravenswood and Equality sites are evaluated in Sect. 4 and compared in Sect. 2.3.2.

Table B.3. Ratings of the seven alternative sites on seven environmental variables

	Site number ^b	Variable ^a						
		1	2	3	4	5	6	7
Pigeon, Shelby County	1	0	0			0	0	
Lewisport, Hancock County	5	0	0	0	0	0	0	0
Equality, Ohio County	6		0	0	0	0		0
Banner, Fulton County	8		0		0	0	0	0
Brilliant, Jefferson County	15	0	0	0		0	0	
Ravenswood, Jackson County	20	0	0	0	0	0	0	0
Ben's Run, Monongalia County	22	0	0	0	0	0	0	0

^aEnvironmental variables listed in Table B.4.

^bSite numbers listed in Table B.2.

Table B.4. Example Comparison of two sites on seven important environmental variables^{a,b}

Environmental variable	Site 1 — Pigeon	Site 15 — Brilliant
1. Surface water quality Significant impact potential exists at the site	0	0
2. Endangered species Breeding area or significant habitat, known or suspected	0	0
3. Wetlands Significant wetlands at or near the site		0
4. Geological hazard Potential for slope failure and/or seismic risk		
5. Prime agricultural soils Large portions of site having soils classified as prime agricultural soils	0	0
6. Groundwater use Potential impacts to use of groundwater, quality or quantity	0	0
7. Air quality Nonattainment area for ozone, sulfur dioxide, or suspended particulates		

^aSite 15, Brilliant, is selected over site 1, Pigeon, because it is rated more positively (lower impact potential) for one issue, wetlands, and equivalent for the remainder.

^bKey to potential impacts:
+ Beneficial impact
0 Little or no impact
- Adverse impact

Table B.5. SRC-II — first comparison matrix^a

Site No. ^b	22	20	15	8	6	5
2	22	20	15	8	6	5
5			5	5		
6			6	6		
8	22	20				
15	22	20				
20						
22						

^aEach entry indicates the more preferable site from the comparison of the row-numbered site with the column-numbered site on the basis of ratings on seven sensitive environmental variables in Table B.4.

^bSite numbers listed in Table B.2.

Table B.6. Results of first comparison matrix (see Table B.5)

Site No. ^a	No. of times superior	No. of ties
2	0	0
5 ^b	3	3
6 ^b	3	3
8	1	1
15	1	1
20 ^b	3	3
22 ^b	3	3

^aSite numbers listed in Table B.2.

^bHighest score.

Table B.7. Environmental issues that are evaluated to determine final selection of alternative sites

Socioeconomic issues	Community infrastructure Historical or archaeological resources Transportation Employment Local finances
Biological and ecological issues	Surface water quality Vegetation Aquatic habitats Terrestrial habitats Land use
Physical issues	Lithology Soils Groundwater quality Structural geology Topography

Table B.8. SRC-II second comparison matrix^a

Site	No.	22	20	6
Lewisport	5	22	20	6
Equality	6		20	
Ravenswood	20	20		
Ben's Run	22			

^aEach entry indicates the more preferable site from the comparison of the row-numbered site on the basis of ratings on fifteen sensitive environmental issues shown in Table B.7.

Table B.9. Results of second comparison matrix (see Table B.7)

Site	No. of times superior	No. of ties
Lewisport	0	0
Equality	1	1
Ravenswood ^a	3	0
Ben's Run	1	1

^aHighest score.

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Appendix C

PLANT DESIGN AND CHARACTERIZATION OF EFFLUENTS

Appendix C

PLANT DESIGN AND CHARACTERIZATION OF EFFLUENTS

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Appendix C

PLANT DESIGN AND CHARACTERIZATION OF EFFLUENTS

C.1 INTRODUCTION

C.1.1 Process history

Development of the solvent-refined coal (SRC) process began in 1962 at the Merriam, Kansas, research laboratories of The Pittsburg & Midway Coal Mining Co. (P&M), a wholly-owned subsidiary of Gulf Oil Corporation. Bench-scale work has continued at that location since that time. This work led to the construction and operation of a 0.5-ton/d coal-feed-rate pilot unit in 1964, which provided design data for a 50-tons/d pilot plant. Construction of the 50-tons/d Government-owned facility was completed in 1974 in Fort Lewis, Washington, and the unit has been in operation since then. This extended research and development program at Merriam and Fort Lewis has been conducted by P&M under contract to the U.S. Department of Energy (DOE) and its predecessors.

All work until 1973 was aimed at the development of a process to produce a low-ash, low-sulfur solid product known as SRC-I. In the SRC-I process, coal is slurried in a distilled, coal-derived, recycle solvent, mixed with hydrogen, and reacted at high temperature and pressure. The reaction product is filtered to remove ash and unreacted coal (critical-solvent deashing and antisolvent deashing are also being tested for removal of ash and unreacted coal) which is further processed, such as by gasification, to convert it to a form that may be disposed of in an environmentally acceptable manner. The filtrate is vacuum-distilled to separate distillate from the "heavy" residual organic material that is removed and solidified as the solid SRC-I product. The distillate is further fractionated to separate it into (1) a recycle process solvent used in the reaction area and (2) limited quantities of fuel oil and naphtha products.

By 1973, Merriam data had indicated the potential problems of insufficient production of the process solvent to satisfy the need in the reaction area and extreme difficulty in separation of the residual ash by filtration. It was theorized that additional solvent production could be attained by recycling a portion of the reactor-effluent slurry and using it to replace some of the distilled solvent used to slurry the feed coal. This mode of operation increases the concentration of ash and its catalytic components and allows the "heavy" (high molecular weight) organic material contained in the slurry to be subjected to further liquefaction reactions. The initial slurry-recycle experiments were successful in achieving the objective of increased solvent production. More importantly, though, results indicated that replacing the distilled solvent completely with recycle slurry increased the degree of conversion of the "heavy" organics to distillate liquids to such an extent that a modification of the overall SRC process appeared feasible, which would allow the elimination of the troublesome and costly filtration method of solids separation. Instead, solids separation from the reaction product would be accomplished in a much simpler and common commercial processing step — vacuum flashing — with the high-solids "heavy" organic stream from the bottom of the vacuum-flash drum being used as feed to a high-pressure gasifier for production of the hydrogen required in the coal-reaction area. Subsequent testing has demonstrated the viability of this SRC process modification, which is now known as SRC-II. The SRC-II process results in the production of a liquid, rather than a solid, as the main product.

In 1976, Gulf initiated operation of a one-half ton of coal per day process development unit, identified as P-99, at its Corporate Research Center at Harnarville, Pennsylvania, to develop process-design information for the SRC-II process. Privately funded research was conducted until 1978, at which time a contract was signed by P&M to continue the research work under contract to DOE. Since that time, the Merriam, Fort Lewis, and P-99 units have all continued operation in further development of the SRC process; the P-99 efforts have been dedicated to SRC-II and much of the Merriam and Fort Lewis efforts have also been devoted to SRC-II.

P&M began privately funded conceptual-design studies for a demonstration-sized SRC-II plant in 1975. As a result of these studies, P&M contracted with DOE in 1978 to design, construct, and operate an SRC-II demonstration plant with a feed rate of 6000 tons per stream day (tpsd) of coal. The goals were to demonstrate the technical, economic, and environmental viability of the SRC-II process, which could lead to expansion of the demonstration plant to a commercial plant of up to 30,000-tons/d capacity and potential construction of commercial plants at other locations. Design

work has continued since that time. The following design and environmental information has been prepared from the Phase Zero Conceptual Design, preliminary results from the Phase I Design, and information developed in support of environmental permit applications. (See Appendix R for a schedule for procuring environmental permits.)

C.1.2 Organization of this Appendix

Section C.2 describes the various sections or process areas of the demonstration plant. Environmental control equipment is described in Sect. C.3. Emissions and residuals from plant operation are described in Sect. C.4. Section C.5 describes the construction phase activity and environmental controls. Section C.6 gives the resource consumptions associated with the plant. Section C.7 describes end-use emissions when the plant products are utilized. Section C.8 describes the potential expanded commercial plant and its environmental characteristics.

C.2 PLANT DESCRIPTION

The currently proposed design of the SRC-II demonstration plant is an update of the one described in the Draft EIS. The design is being evaluated by both DOE and the industrial participant (SRC International) and may be further modified. Any changes resulting in a significantly more adverse impact than predicted in this FES will trigger preparation of a supplement to the FES. This aspect of DOE's NEPA strategy is described in Appendix X.

The demonstration plant is being designed to produce a primary product of low-sulfur distillate fuel oil from Pittsburgh seam coal. By-products will include substitute natural gas, propane, butane, naphtha, ammonia, elemental sulfur, and tar acids. Production rates from the demonstration plant are shown in Table C.1. Figure C.1 is a site layout map showing the plant on the proposed Fort Martin site. Figure C.2 shows a plot plan of the process area.

Table C.1. Products from the demonstration plant^a

Quantity		Higher heating value		
		Btu/lb	Btu/bbl ($\times 10^6$)	Btu/scf
Products				
Substitute natural gas	10.6 $\times 10^6$ scfd			950
Liquid propane product	2,924 bbl/d	21,630	3.85	
Naphtha (nominal boiling range 150-385°F, 31°API) ^b	3,368 bbl/d	17,500	5.02	
Light fuel oil (nominal boiling range 385-600°F, 14.4°API) ^b	6,278 bbl/d	17,110	5.87	
Heavy fuel oil (nominal boiling range 600-950°F, 7.2°API) ^b	2,871 bbl/d	16,930	6.40	
By-products				
Anhydrous ammonia	30 short tons/d	9,600		
Elemental sulfur	202 short tons/d	4,050		
Tar acids	43 bbl/d	20,000	7.50	
Plant fuel products				
Synthesis fuel gas	30.8 $\times 10^6$ ft ³ /d			
Mixed liquid butane product	1,590 bbl/d			
Methane-rich gas	34.6 $\times 10^6$ ft ³ /d			

^aExpected products if the decision is made not to burn naphtha as fuel. If naphtha is burned, rather than being a product, the substitute natural gas production would increase to about 40 $\times 10^6$ ft³/d.

^bLiquid fuel specific gravity and API gravity. A 10°API oil has a specific gravity at 70°F of 1.0 in relation to water at 60°F. The general formula for API is

$$^{\circ}\text{API} = \frac{141.5}{\text{specific gravity } 70^{\circ}\text{F}/60^{\circ}\text{F}} - 131.5$$



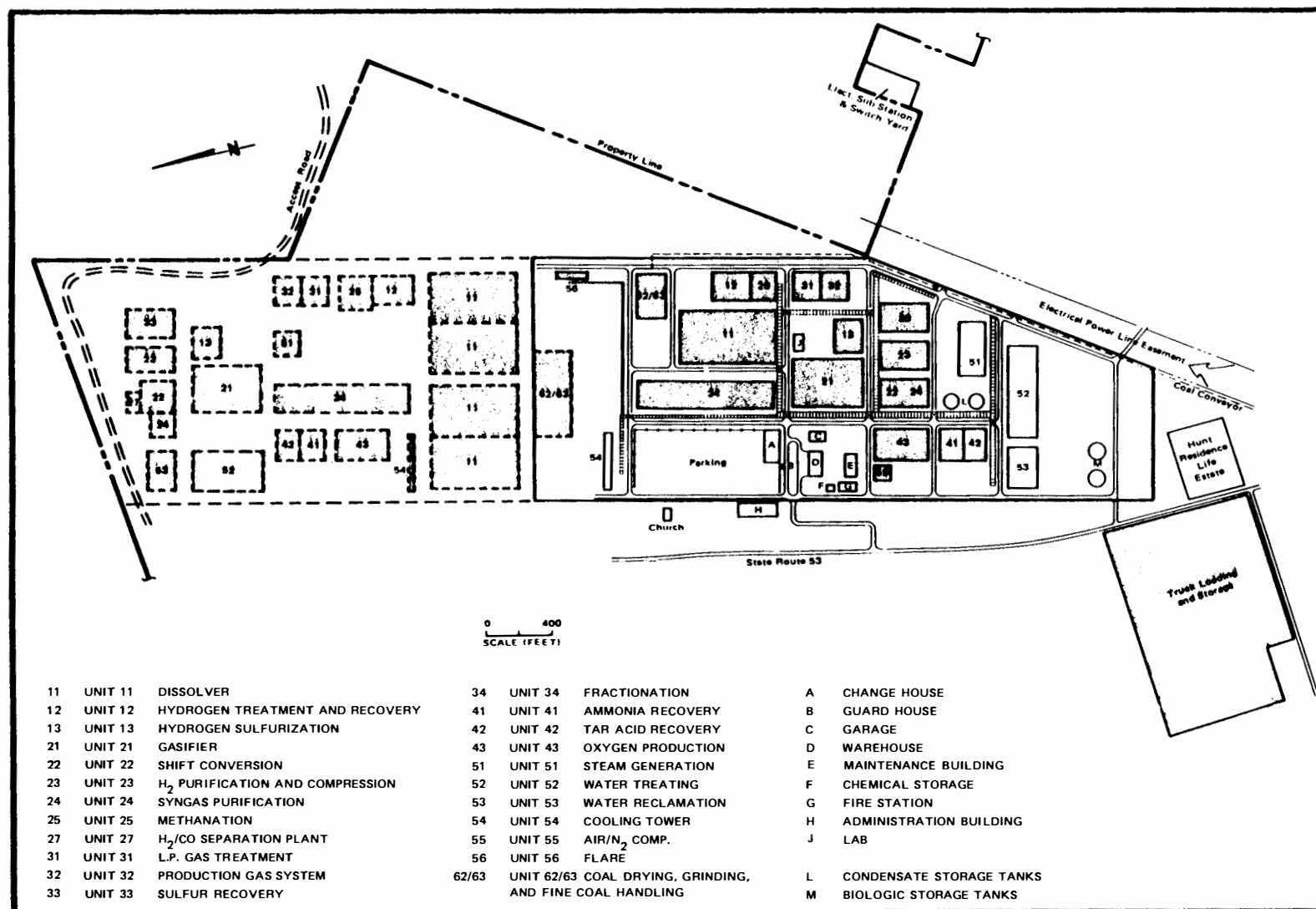


Fig. C.2. Plot plan of the process area. (Dashed lines show proposed future commercial expansion.)

The on-stream factor for the initial period of demonstration plant operation is expected to be low. On an overall basis, transient emission generation that occurs during startup/shutdown activity will be offset by low emissions during shutdown. SRC International has estimated that for the first year, one dissolver (50% of the plant) will operate 50% of the time, but at 70% of rated throughput, leading to a capacity utilization of 18%. Values are higher in the second, third, and later years of operation (see Table C.2 for details). These factors affect rate of coal transport and delivery, rate of brine generation, yearly rate of emissions, etc. Because the impact analyses in this EIS are based on the plant operating continuously at 100% of capacity, these analyses are believed to be conservative. Emissions which will continue during shutdown include fugitive dust from the coal pile, flue gas from the power boilers, and water discharge from treated storm runoff.

Table C.2. Estimate of demonstration plant capacity for first five years of operation

Year	Time onstream (%)	Total dissolver capacity operating ^a (%)	Average design capacity of the dissolver(s) onstream (%)	Annual average calendar day capacity. (% of stream day design capacity)
1	50	50	70	18
2	60	80	75	36
3	70	90	80	50
4	75	100	85	64
5	80 ^b	100	90 ^c	72

^aPercent of total dissolver capacity equals average number of dissolvers in operation times 50%; for example, one dissolver 40% of the time and two dissolvers 60% of the time = 80%.

^bBecause 30 single-train ammonia plants, now a mature industry with numerous spare parts pools, have plateaued at 85% onstream, anything above 80% for the one-of-a-kind, first-of-a-kind SRC demonstration plant would be unrealistic.

^cBased on two dissolvers operating 70% of the time at 100%, 20% at 75%, and 10% at 50%.

The various processing steps are briefly described below. Environmental and control equipment are discussed in Sect. C.4. A block flow diagram for the preliminary design is presented in Fig. C.3.

C.2.1 Coal feedstock handling and preparation

When operating at design capacity, the plant will process 6000 tpsd of Pittsburgh seam coal from the northern West Virginia panhandle and adjacent Belmont County of Ohio. The characteristics of the coal used as the design basis are shown in Table C.3. Coal from several mines in the Morgantown area (Blacksville Nos. 1 and 2, Loveridge, and Robinson Run) has been tested in the SRC-II process. These coals have been found to be substantially less reactive (25 to 30% less oil yield) than coal obtained from mines in the northern West Virginia panhandle and adjacent Belmont County of Ohio (Valley Camp No. 3, Ireland, Powhatan Nos. 5 and 6). As a result, the use of coal from the Morgantown area would not be economically attractive. Research work is continuing to determine what processing steps can be taken to improve the applicability of coal from the Morgantown area. This work could result in the ultimate use of Morgantown-area coal for at least part of the plant supply.

Coal sized 2 x 0 in. and washed to about 12% ash level will be delivered to the plant by barge. The coal will be unloaded from the barges with a continuous bucket unloader and transported by conveyor to the coal storage area where it will be stored in layered or chevron type piles with an automatic luffing stacker.

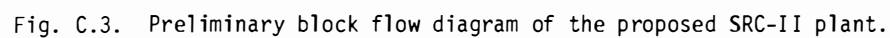
Table C.3. Feed coal composition for the demonstration plant (moisture-free basis)^a

	Wt %
Carbon	70.49
Hydrogen	4.88
Nitrogen	1.12
Oxygen	7.87
Sulfur ^b	3.59
Chlorine	0.05
Ash ^c	12.00
Total	100.00

^aBtu/lb = 12,400.

^bComposed of pyrite (2.00), organic (1.54), and sulfate (0.05).

^cIron contained in the ash amounts to 1.75 wt %.



The coal storage area will consist of two piles having a 30-d total capacity (about 180,000 tons) and will occupy an area of about 7 acres. Both piles will be active — one being filled while plant feed is reclaimed from the other. To ensure homogeneity in the pile, about 200 longitudinal passes of the stacker will be used to form each pile. The rapid turnover of coal from the storage piles (maximum of 30 d in storage at design rate) will keep coal stocks on hand at less than the period needed for spontaneous combustion and will alleviate the potential for coal-pile fires and the resultant emission of particulates and sulfur compounds. The proposed location of the coal storage area is shown in Fig. C.1.

Coal will be reclaimed from the storage area by an automatic reclaimer and transported by conveyors to the coal pulverizing-drying system. The pulverized coal will be transferred pneumatically through piping to silos in the process area. From the silos, it is slurried and fed into the process.

C.2.2 Coal liquefaction

The demonstration facility will use the noncatalytic, direct hydrogenation SRC-II process to liquefy 6000 tpsd of bituminous coal. The properties of the plant's products are not expected to vary significantly due to variations in the properties of the coal anticipated for use. The pulverized feed coal will be mixed with a hot recycled heavy liquid/mineral residue slurry stream from the process, pumped to reaction pressure, and then mixed with hydrogen. This coal slurry-hydrogen mixture will flow through a fired preheater, where it will be heated to reaction temperature. In the preheater, the coal will partially dissolve in the recycle slurry. Hydrogenation and hydrocracking reactions will begin in the preheater and continue in the dissolver; this necessitates the addition of cold hydrogen to the dissolver to control the reaction temperature at the desired level.

The major reactions occurring in the preheater and dissolver will be:

- solution of the coal in the solvent, accompanied by formation of a gel as the coal begins to dissolve,
- hydrogenation and depolymerization of the gel and of the coal in solution,
- hydrocracking of the dissolved coal to lower molecular weight hydrocarbons ranging from liquid middle distillates to methane,
- conversion of organic sulfur by hydrogenation to hydrogen sulfide,
- conversion of iron pyrites to ferrous sulfide, and
- hydrogenation of oxygen in the coal to water, chlorine to HCl, and nitrogen to ammonia.

The dissolver effluent will flow to a hot high-pressure separator where the hot slurry will be separated from the gas stream.

C.2.3 Dissolver off-gas processing

The hot overhead vapor and gas stream from the hot high-pressure separator will be cooled in a series of heat exchangers and additional vapor-liquid separation steps. Water injection will be required to solubilize ammonium compounds to prevent their deposition as solids resulting in plugging and possible corrosion. The condensed hydrocarbon liquid from these separators will go to the fractionation system. The non-condensed gas will consist of unreacted hydrogen, methane, and other light hydrocarbons, plus hydrogen sulfide (H_2S) and carbon dioxide (CO_2). The gas will first be sent to a butane wash tower to remove heavy hydrocarbons and then to a diethanolamine (DEA) acid gas treating unit for removal of H_2S and CO_2 . The treated gas will then flow through a guard vessel to remove impurities that could solidify in the cryogenic unit; then, it will be processed in the cryogenic unit for removal of argon, nitrogen, methane, and other light hydrocarbons. The recovered hydrogen will be mixed with fresh make-up hydrogen from the gasifier train. This mixture will comprise the hydrogen fed to the process.

An ethane-rich stream from the cryogenic unit will be fractionated to recover propane and butane as by-products and an ethane stream, which will be mixed with the methane-rich stream from the cryogenic unit and fed to the methanator, along with the required amount of hydrogen, to convert the ethane to methane. Following dehydration, the methanator product, substitute natural gas, will be introduced into a natural gas pipeline as a plant product. Some of the methanator feed may be used as plant fuel.

C.2.4 Dissolver effluent slurry processing

The slurry leaving the hot high-pressure separator will flow through a series of pressure reduction stages, combined with phase separation and condensers. The gas streams will be combined with gas streams from the fractionation area and routed to a low-pressure DEA acid-gas removal system. The clean gas will then be used as plant fuel. The flashed liquid will be condensed and sent to fractionation. The slurry stream will be split into two streams — one will flow back to the liquefaction step for use in slurrying fresh coal feed, while the other will flow to the vacuum-flash system.

C.2.5 Vacuum flashing

In the vacuum-flash system, distillate will be separated as an overhead stream and sent to the fractionation system. The bottoms from the vacuum drum will consist of a slurry containing about 30% ash, 15% unconverted coal, and 55% heavy oil with a normal boiling point of above 900°F. It will be used as feed to the gasifiers.

C.2.6 Distillation, fractionation, and hydrotreating

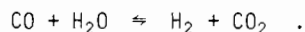
The overhead stream from the vacuum-flash system and the condensed liquid streams from the various flash vessels downstream of the high-pressure, high-temperature separator will be combined and fed to a fractionation system for separation into light and heavy fuel-oil products and crude naphtha, which will be upgraded by hydrotreating for use as plant fuel or a reformer feedstock grade product.

C.2.7 Air separation

Approximately 12,000 tons/d of air will be separated into nitrogen and oxygen in a cryogenic air-separation plant. Part of the nitrogen will be used throughout the plant as an inerting gas, and the remainder will be vented. The oxygen will be compressed and used in the gasifiers.

C.2.8 Gasification

Texaco gasifiers will react vacuum-tower bottoms with a limited quantity of oxygen in the presence of steam at elevated pressure to produce a synthesis gas, primarily carbon monoxide and hydrogen. Oxygen (rather than air) is supplied to the gasifiers to facilitate separation of high-purity hydrogen for process use. Gasification of this material will offer the dual advantage of recovering the carbon content of the mineral-residue slurry and converting the mineral residue into a slag suitable for disposal. The carbon monoxide produced will be reacted with steam in a catalytic shift converter to produce additional hydrogen and carbon dioxide in accordance with the following reaction:



A variety of carbon sources, including coal, oil, and natural gas can also be used as gasifier feed. Consideration is being given to providing for the use of one or more such alternate fuels for periods, such as plant startups, when mineral-residue slurry feed is not available.

During normal operation, no direct emissions to the atmosphere from the gasification process will occur. However, a gas purge stream from the slag dewatering system will be directed to the controlled combustor (see Sect. C.3.8). The gasification and shift-conversion processes will consume water. A wastewater stream (slag and gas quench water) will result, which will be directed to the wastewater treatment and reclamation system.

The slag produced by the gasifier will be the major solid waste produced by the process; it will be conveyed to the slag-disposal area. Disposal is discussed in Sect. C.3.7.1.

C.2.9 Acid-gas removal, sulfur recovery, and tail-gas treating

In the dissolver, hydrogen will react with both organic and inorganic sulfur to produce hydrogen sulfide and other reduced sulfur compounds (COS, CS₂). Most of the sulfur will be contained as hydrogen sulfide in the gas and vapor stream; however, a significant amount of sulfur will remain with the liquid streams and the mineral residue, and most of it will be liberated as hydrogen sulfide during subsequent processing steps, especially in the gasifier. A sulfur balance for the plant is presented in Sect. C.4.1.2, Table C.13. The presence of hydrogen sulfide is considered undesirable from a process standpoint, and gaseous streams containing excessive quantities will be directed to acid-gas removal systems at various locations within the plant (after gasification, dissolver effluent separation, and fractionation).

These systems could use several commercial processes (but currently envisioned to be DEA and Selexol) in which the hydrogen sulfide is absorbed into a scrubbing solution and then removed from the solution by further processing, which produces a concentrated hydrogen-sulfide stream and a clean gas stream for further processing or use. The concentrated hydrogen-sulfide streams will be collected from the various acid-gas treating facilities and routed to the Claus sulfur-recovery unit.

In the Claus unit, a portion of the hydrogen sulfide will be burned to produce sulfur dioxide, which will then be combined with the unburned hydrogen sulfide and passed over a catalyst. The catalyst will promote an oxidation/reduction reaction between the hydrogen sulfide and the sulfur dioxide to produce elemental sulfur, which will be recovered and stored in molten form for sale as a by-product. The tail gas from the Claus unit will be processed in the SCOT tail-gas unit, first to convert residual SO_2 to H_2S and then to recover all the hydrogen sulfide for recycle back through the Claus unit. The tail gas from the SCOT unit will then be incinerated to convert trace quantities of hydrogen sulfide and other reduced sulfur compounds to sulfur dioxide. This will mitigate odor problems and reduce the acute toxicity of the tail gas. As described in Sect. C.4.1.2, the flue gas from the tail-gas incinerator will constitute the major sulfur-dioxide emission from the demonstration plant. (Refer to Sect. C.4.1.2 for emissions and controls discussion.)

C.2.10 Waste heat rejection

Control of process operations will require the removal of significant quantities of heat from process streams. Wherever economically feasible, heat will be recovered through transfer to other process streams or by steam generation to increase overall thermal efficiency of the plant (expected to be about 60%). Decreased water use will also result from heat recovery rather than heat rejection through wet evaporative systems. However, substantial amounts of heat must still be rejected to the environment. Aerial coolers will be used where environmentally acceptable and technically and economically justified to decrease water use. The major heat rejection, however, will be through wet evaporative water cooling towers. (Refer to Sect. C.3.5.5 for emissions and controls discussion.)

C.2.11 Water supply, use and treatment

Several water-related factors and features individually and collectively will affect the design, operability, and environmental effects of the SRC-II demonstration plant including: quantity of water withdrawn and released to the river and the net water consumption; types of wastewater treatment; degrees of application of evaporative, dry, and indirect cooling; size and number of wastewater reservoirs; and methods for disposing of soluble salts.

Based on data that is still being collected and developed, it now appears feasible and environmentally desirable to design the plant with the flexibility for:

- discharge to the river of suitably treated cooling-tower blowdown, process wastewater, and rainwater runoff from the process area, product-storage area, coal pile, and slag pile during those periods when river conditions allow it to be done in conformity with applicable permitting requirements and regulations and
- substantial reduction or possible elimination of the discharge of treated cooling-tower blowdown and treated process wastewater, with its associated salts, during periods of high soluble-salts loading in the river, with particular attention to sulfate concentration in the river.

Modes of operation required to decrease water discharge to the river will result in decreased plant thermal efficiency and an increase in the quantity of soluble salts removed from the process which require disposal by special means.

Significant reductions in consumptive water use can be achieved only by favoring dry cooling over wet-cooling methods for process-heat rejection. Dry-cooling methods are most effective when used on high-temperature streams; however, it is difficult to detect fugitive emissions from leaking air-fin heat exchangers. Thus, the proposed cooling strategy for the demonstration plant involves using dry cooling on the hottest and least hazardous streams, with a barrier fluid (indirect) wet-cooling system used on the more hazardous high-pressure streams as discussed in Sect. C.3.5.5. A high-pressure direct wet-cooling circuit (i.e. without the barrier fluid) is being considered, instead of the indirect system, for the low-pressure more hazardous streams. This would ensure that, in the event of a leak, the process fluid would not contaminate the cooling fluid because the cooling fluid would be forced into the process fluid by its higher pressure. Conventional (i.e., atmospheric) direct wet cooling will be used on all non-hazardous process streams where dry cooling is not economically advantageous.

Reduction in water-withdrawal rate and treated wastewater effluent rate can be achieved by increasing the quantity of water recycled within the process to users such as steam boilers and cooling towers. The chloride concentration of a water stream is an important criterion in assessing whether the stream is acceptable for recycle, because high chloride concentrations can cause severe corrosion and plugging problems. Thus, water streams will be recycled wherever possible until chloride levels become prohibitive. Purge streams carrying chlorides, other salts, and organic contaminants will be directed to the wastewater treatment system. Section C.3.6 details waste stream characteristics. Equipment will be included in the wastewater treatment system to remove virtually all of the organic contaminants and heavy metals, with only dissolved salts (chlorides and sulfates, etc.) remaining in the treated wastewater. Evaporator or other desalination equipment will be included to enable (1) removal of the dissolved solids and (2) recycle within the plant (zero wastewater discharge) when river conditions dictate. However, it is doubtful that overall environmental advantages are achieved by its continuous use because the evaporator (desalination) equipment produces a concentrated brine solution for which few disposal options are available; each disposal option has associated environmental risks. Thus, the treated-wastewater disposal strategy currently believed to present the least impact on the environment would be to discharge treated wastewater to the Monongahela River during periods of high river flow and conditions of low ambient total dissolved solids (TDS). As described in Sects. 4.5.3.3 and 4.5.4, an extensive water monitoring program will be conducted on both the discharge itself and the river to ensure the environmental acceptability of the treated wastewater discharge. Standby desalination equipment will be operated during those periods when the river cannot accommodate the increased TDS loading.

Due to the relatively low initial production rate of brine, especially during reduced plant capacity, a long-term plan for brine disposal will not be a pressing need for several years (see Table C.11). This will provide time to adequately determine the chemical characteristics of the brine and to develop an acceptable alternative disposal plan for the soluble salts. Brine disposal options currently under consideration include chemical fixation, chemical landfill, deep well injection, and barging to the ocean. Factors that will affect the need for brine disposal are discussed in Sect. C.3.7.2.

C.2.11.1 Water supply and use

The water supply for the plant will be provided by withdrawing, under normal operation, an average of 4826 gpm of water from the Monongahela River, supplemented by an average of 400 gpm of rain-water runoff accumulated from contaminated areas (process areas, coal piles, and slag pile) where collection will be provided. Therefore, the average total water input to the plant will be 5226 gpm. Total consumptive use averages 3988 gpm, whereas net consumptive use from the river is 3588 gpm (8.0 cfs), compared with 3900 gpm (8.7 cfs), which was a worst-case estimate used by the Water Resources Council in their evaluation of water-use impact on the Monongahela River.¹ The rate of discharge of treated wastewater to the Monongahela River during periods of discharge is estimated to average 1238 gpm.

Figure C.4 shows an estimated water balance for the plant operating at design rate and with normal flow of treated wastewater effluent to the river. A drawing of the intake structure is included in Appendix D.

C.2.11.2 Wastewater treatment under normal conditions

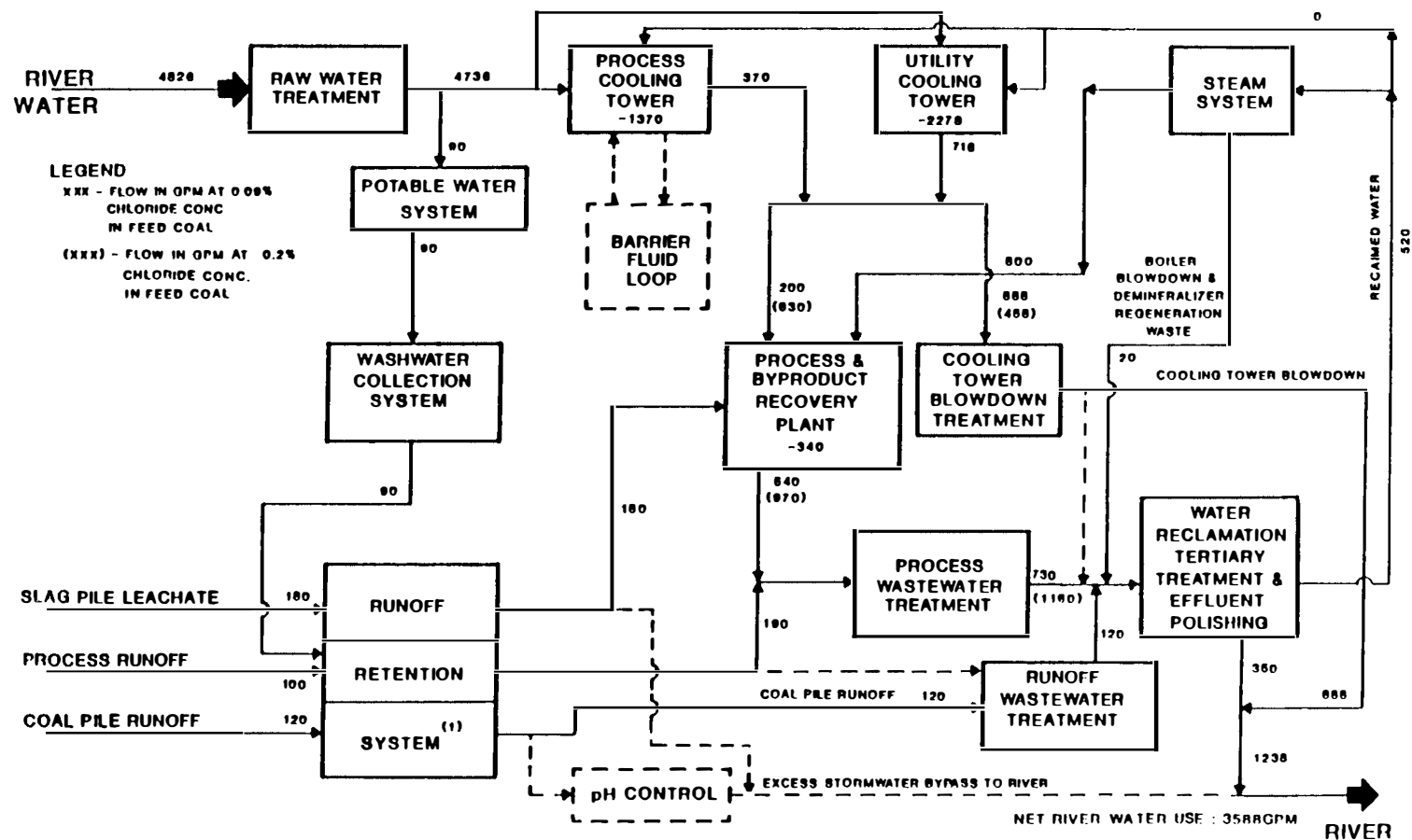
Flow and treatment processes, equipment, and alternatives for the various plant wastewater streams are discussed in Sect. C.3.6.2. It is important to recognize that treatment system performance on plant wastewater will not be known with certainty until completion of treatability studies that are under way.

C.2.11.3 Wastewater treatment under abnormal conditions

A number of circumstances will cause a substantial deviation from the normal operating mode described above. The design features included in the wastewater treatment system to prevent an adverse impact under abnormal conditions are described below. The occurrences that are expected to tax the wastewater treatment system include:

- shutdown and startup,
- extended shutdown,
- abnormally low river flow, and
- abnormally high rainfall.

NORMAL WATER BALANCE SRC-II DEMONSTRATION PLANT



(1) Reservoir sized to retain a 10-year, 24-h storm. Rainwater from nonprocess areas will flow directly to the river.

Fig. C.4. Water balance.

Shutdown and startup

Because this facility will be a demonstration plant, shutdown and startup of the principal process units are expected to occur frequently, producing variations in quantities and concentrations characterizing the feed to the wastewater treatment system and producing a significant effect on the operation of the wastewater treatment systems.

During a major shutdown of the plant, wastewater treatment facilities will continue to operate. Wastewater flow from the gasifier and dissolver will stop, while those from the slag pile, coal pile, and process area runoff will continue to be generated at their normal rate. Emptying and flushing of process equipment in preparation for maintenance activities will increase the flow of process wastewaters for a time.

Facilities will be provided to permit handling and treatment of flushing wastewater with minimum disruption of wastewater treatment operations. These facilities will include a flushing sewer and storage system equipped with vapor recovery, flow and concentration equalization, and, where appropriate, treatment capacity allowances to accommodate these non-continuous flushing wastewater flows.

As inventories of dissolver and gasifier wastewaters are depleted to preselected levels, the Tar-Acid Recovery and Ammonia Recovery facilities will be shut down. If the shutdown is to extend over a long time period, dissolver-wastewater inventory will be retained to serve as a sustaining feed for the biological-treatment system, which will be operated throughout the shutdown.

Sufficient boiler and cooling-tower capacity will remain onstream to provide for the steam requirements of the wastewater-treatment systems and to provide evaporation of treated wastewater when required. It is therefore expected that zero wastewater discharge can be achieved during shutdown.

During the shutdown, untreated wastewater inventories will be depleted to preselected levels so that, when normal operations are resumed, flows to the wastewater treatment units may be gradually increased to normal levels.

Flow rates and contaminant loads of effluent to the river will decline substantially during a shutdown. During the subsequent startup, flows or contaminant loading are not expected to exceed normal levels.

Extended shutdown

During a shutdown of the principal process units for an extended period of time, rainwater runoff from the process area, coal pile, slag pile, and product storage areas can accumulate in holding ponds to the extent that it needs to be either treated for discharge or evaporated. Treating and discharging to the Monongahela River is the preferable approach as long as the river conditions allow this to be done. However, during periods of high TDS concentrations in the river, discharge may not be acceptable, and evaporation may be required. This eventuality will be handled by operating a utility boiler and the cooling tower at reduced loads. The boiler and throttling system will produce low-pressure steam to drive the evaporators, which will, in turn, produce cooling-tower makeup.

Curves showing the Monongahela River's assimilative capacity for dissolved solids are presented in Sect. C.4.2. These curves are examples of a family of curves that could be constructed for each regulated compound and discharge species. Monitoring composition of the wastewater discharge and the ambient river will be used to determine when to discharge treated wastewater. If monitoring indicates that the available assimilative capacity of the Monongahela River for a particular discharge species will be exceeded, evaporators will be brought on line, and the wastewater treatment plant will convert to the zero wastewater discharge mode. Retention basins are used to equalize and minimize swings in the concentration of constituents in the discharge.

Abnormally low river flow

Under conditions of abnormally low river flow, the mass-discharge rate of dissolved solids (TDS) or toxic metals to the river may result in unacceptably high levels of TDS or toxic metals. Under these circumstances, facilities will be provided to allow salt-bearing streams to be withheld from discharge to the river and stored. Various alternates for handling these accumulated wastes are being explored, including: (1) subsequent discharge to the river when flow and assimilative capacity increases and (2) concentration, followed by deepwell disposal to a compatible brine-bearing aquifer, secured chemical landfill, barging to sea, chemical fixation, or encapsulation and landfill. Estimates of the assimilative capacity of the Monongahela River for TDS are discussed in Sect. C.4.2.

Abnormally high rainfall

During periods of abnormally high rainfall, the capacity of runoff storage ponds associated with the coal pile and slag pile will occasionally be exceeded. Under these conditions of extended heavy rainfall, river flow will be high, so that bypass of the dilute runoff water from contaminated plant areas should not present a serious environmental problem. Possible exceptions to this statement would include: (1) process-fluid spillage from process equipment during an extended rainy period and (2) residual acid drainage from the coal pile.

During such an extended rainy period, process area runoff will be designated the priority stream, and slag-pile runoff will be diverted to the river. Coal-pile runoff will be diverted to the river through a pH correction system that will neutralize acidity. As a result, the full capacity of the runoff wastewater treatment system would be made available for treatment of excessive process area runoff flow, which may be contaminated with hydrocarbons. This method of operation (using boilers, cooling towers, and evaporators as water consumers) is expected to reduce significant adverse impact on the river.

C.2.12 Controlled combustion and flare system

During abnormal operating conditions (upsets), it will often be necessary to relieve pressure in process units, either by automatic pressure-relief valves or by manually operated valves, to prevent damage to equipment or hazards to personnel. A flare system will be provided in the SRC-II demonstration plant for this purpose. Liquid knockout vessels will be provided upstream of combustion devices to separate liquid for return to the process. The vapors and gases will then flow to a controlled combustor, a special combustion device that will provide very efficient combustion with no external flame to cause illumination and noise problems. Very high flows that exceed the capacity of the controlled combustor will result in sufficient flare-header pressure to "blow" a water seal and direct the flow to an elevated flare. More information on the controlled combustor flare system is provided in Sect. C.3.5.4.

C.2.13 Tar-acid and ammonia recovery

The process water from the liquefaction area will contain significant quantities of tar acids (phenols) and ammonia. The quench water purged from the gasification equipment will also contain ammonia. This water effluent from the liquefaction area will be processed in licensed equipment to recover about 98% of the tar-acid content as a by-product. The water effluent stream from tar-acid recovery will be combined with the quench water purge stream from gasification and processed in licensed equipment to recover about 98% of the ammonia content as a by-product. The effluent-water stream from the ammonia-recovery unit will flow to the wastewater treatment area of the plant for further purification.

C.2.14 Steam and electrical generation

A substantial amount of steam will be generated at several pressure levels by recovering heat from process streams. In addition, fired boilers totalling 600,000 lb/h design capacity will provide additional 1500 psig steam. The currently planned steam-pressure levels and primary uses will be:

- 1500 psig — to power steam turbines for large compressors and the plant electrical generator and to provide reaction steam for the gasifiers,
- 600 psig — to power steam turbines on large pumps and medium-sized compressors,
- 250 psig — to power steam turbines for medium and small pumps and steam ejectors, and
- 50 psig — for heating and tracing.

As described in Sect. C.3.2.2, the boilers are planned to be fired with plant fuel — naphtha and/or gas during normal operation; if available, natural gas will be used for plant startups and upsets. It may become necessary to purchase some liquids for use as supplemental fuel during upsets and startups, especially during the initial plant startup. No plans for using coal have been made, and none are expected. If, in the future, coal is considered, the coal-burning installation would of necessity include suitable stack-gas scrubbing to control emissions in accordance with environmental regulations.

To improve reliability, it is proposed to generate the plant's electricity needs of about 45 MW by using conventional steam turbogenerators. The estimated water use and air emissions are based on this design feature.

C.2.15 Fuel system

Current plans are for a mixed-fuel system using hydrotreated plant-produced naphtha, excess gas from the gasification system, and hydrocarbon gases produced in the process. The gases will be treated to remove sulfur compounds.

C.2.16 Product storage and shipping

Two separate product storage and shipping areas are planned. The truck shipping area adjacent to the main process area (see Fig. C.1) will store and handle tar acid, propane, butane, anhydrous ammonia; it will also provide facilities for truck loading. The shipping area at the south end of the plant site adjacent to the railroad and the Monongahela River will provide storage for naphtha, light and heavy oil, and liquid elemental sulfur products and will have facilities for loading rail cars (Fig. C.1). This riverside storage is part of the floodplain/wetlands review presented in Appendix D.

All liquid-product and sulfur storage areas will be diked and lined with an impervious material to contain the release of liquid-product materials in the event of tank failure or spillage due to operator error. The diked area will have capacity adequate to contain the contents of the tank plus precipitation from the 10-year, 24-h storm and water used in the event of a fire. Drainage from within the diked area and runoff from the product loading areas will be pumped to the wastewater treatment system. The drainage collection system will incorporate measures to prevent inadvertent releases of material to the environment as a result of equipment failure or operator error.

The closest residence will be about 500 ft from the truck loadout storage area and 2500 ft from rail storage.

The bases of the tanks located in the storage area along the Monongahela River will be above the 500-year flood, and the tanks are protected by diking. Product storage on the floodplain of the Monongahela River is the subject of a floodplain/wetlands assessment presented in Sect. 4.8 and Appendix D.

Propane will be stored in pressure spheroids, whereas butane and ammonia will be stored in pressure bullets.

See Sect. C.3.5.3 for more information on spill prevention and containment.

C.2.17 Solid wastes

When operating at the design rate (6000 tpd of coal), the SRC-II demonstration plant will generate the following approximate quantity of solid wastes per year:

- gasifier slag, 240,000 tons,
- process sludges, 14,000 tons,
- spent catalysts and adsorbents, 250 tons, and
- when the plant is operating in the zero wastewater discharge mode, a brine of soluble salts will be produced and will require disposal. At a coal feed rate of 6000 tpd with an average chloride concentration of 0.09 wt %, the plant will produce 102,000 gal of brine per day. If the coal has a chloride concentration of 0.2 wt %, the brine production rate would be 227,000 gpd. The solids content of the brine would be 0.43 lb/gal. The zero wastewater discharge mode is not the principle mode of operation. Table C.11 gives the percentage of the year that zero discharge operation is expected.

Methods for disposal of these wastes are discussed in Sect. C.3.7.

C.2.18 Turndown capability

Although the SRC-II demonstration plant is being designed to process 6000 tpsd of coal, it is acknowledged that having the capability to operate at greatly reduced rates is very important, especially for the initial months of operation and during plant startups. Consequently, the plant is being designed for the capability to operate at greatly reduced rates. At this time, minimum throughput of around 1500 tons/d appears feasible. All environmental control equipment and systems, as well as the main process systems, will be designed for compatibility with the minimum reduced rate that is determined to be technically and economically feasible.

C.3 ENVIRONMENTAL-CONTROL EQUIPMENT AND ALTERNATES

The use of adequate engineering controls during the design of the SRC-II demonstration plant is of utmost importance to ensure the safety and health of the workers and the public. Engineering controls that will be followed in the design of the SRC-II demonstration plant include:

- the development of appropriate specifications, taking into consideration special severe conditions (i.e., temperature, pressure, erosion, and corrosion) that affect mechanical integrity,
- the evaluation of special requirements for adequate plant operability during off-normal operation (such as startup, shutdown, upsets, and emergencies) and the effect on equipment and systems,
- the independent review of the design as it develops by multi-discipline personnel such as those with special training and experience in engineering, operations, safety, health, maintenance, environmental effects, and quality assurance, and
- the use of data and specialized know-how that has been developed in the SRC research and development programs and other related programs over many years.

C.3.1 Total suspended particulates (TSP)

The primary sources of suspended particulates released by the SRC-II demonstration plant will be incomplete combustion in heaters and burners and fugitive dust from (1) coal handling, storage, and preparation, (2) slag handling and storage, and (3) travel over haul roads. Currently planned environmental controls and alternatives for these various sources are discussed in this section.

C.3.1.1 Coal handling and preparation

The use of a continuous bucket-type barge unloader is currently planned. This type of unloader generates less dust than clamshell-type units. A large number are currently in operation. Before making the final selection of equipment, alternative types will be investigated. In addition, experience with similar unloaders in the general area, and therefore climate, of the proposed plant will be used to determine if additional dust-suppression equipment, such as special enclosures and/or water sprays with special additives, will be required at the inlet and outlet of the unloader. At this time, it is believed that such equipment will not be needed because, in most cases, the coal in the uncovered barge being unloaded will be wet or damp (except perhaps the top surface) due to rainfall in transit. The dampness of the coal should suppress fugitive emissions.

Belt conveyors used to transport the coal to and from storage will be covered to prevent wind dusting. The trade-off between the cost of totally enclosing the conveyors and decreased dusting that would result will be evaluated as an alternative. Totally enclosed units require ventilation, washwater, and fire prevention systems. Transfer points will be enclosed to decrease airborne dusting. One alternative, using vacuum hoods and venturi scrubbers for transfer points, was ruled out because of (1) increased complexity and cost, (2) the increased attention required by operating and maintenance personnel in the remote locations of the transfer points, (3) the disposal problem of the sludge generated, and (4) doubt about any overall environmental advantage over enclosed transfer points.

The coal will be stored in two windrow-type layered piles — one being filled while plant feed is reclaimed from the other. A 30-d supply to the plant at design rate will be provided. As explained in Sect. C.2.1, this relatively short time in storage will decrease the potential for coal pile fires. Another alternative, covered or enclosed storage of the coal, was ruled out for safety reasons. Even very small smoldering coal fires emit toxic sulfur compounds and carbon monoxide. Covering or enclosing the pile would greatly increase the safety hazard to workers. In addition, firefighting would be hampered and more hazardous. Another alternative for coal storage is in silos. However, several very large, costly silos would be required. In addition, the high degree of coal blending and uniformity which is needed for the stable operation of the SRC-II process could not be achieved with the use of silos.

A luffing-type stacker is planned. The entire device will move on rails, longitudinally to the pile being formed. The discharge conveyor will be adjustable vertically so that the distance the coal falls as it forms the pile will be minimal. As a result, dust generation will be reduced. Many similar stackers are currently in service handling dusty solids. A water-and-additive spray system is planned for the coal-discharge area. Alternative types of stackers are still being studied, but it is expected that plans for the use of a luffing type will not change.

Water spray will be used to mitigate dusting from the storage piles. The use of a polymer-crusting agent for the pile being formed is impractical for the proposed stacker. However, the use of such an agent on the static portion of the pile being reclaimed is probably feasible and will be investigated. Before its use, however, studies must be made to ensure that such polymer material will not cause processing problems (such as foaming in the dissolver letdown, acid-gas removal, or fractionation systems) when fed into the plant with the coal.

An automatic reclaimer, designed for low dust formation, will be used to reclaim coal from storage. It is currently believed this equipment will be a patented drum reclaimer that is essentially dustless and provides maximum coal-blending capabilities. More than 40 of this particular type are in use throughout the world on coal, ores, and various solid materials. Original plans were for coal to be reclaimed with large front-end loaders. However, the drum reclaimer was chosen as the preferred alternative due primarily to the great reduction in dust generation and secondarily to its coal-blending capabilities.

Coal drying and pulverizing will be accomplished in a conventional pulverizer-classifier where it is simultaneously pulverized and dried by the combustion of flue gases. The temperature in the mill will be well below the oxidation temperature of the coal and metallic sulfides. The pulverized coal will be recovered primarily by a cyclone system. The exhaust air will contain the combustion products of the heating furnace, water (perhaps sulfurous) removed from the coal, entrained particulates, and potentially some volatiles from the coal. The gases will flow from the cyclone to a conventional baghouse designed to remove 99% of the particulates. Grinding and drying tests will be performed on the design coal to determine the concentration of acid gases (H_2S , HCN), hydrocarbons, and particulates in the exhaust air. The exhaust-air system will be designed to capture pollutants as required by EPA and state air quality standards. The design of the system has not progressed to the point where design specifications such as air/cloth ratio, bag material, and cleaning mechanisms have been developed. However, they will be developed as the design continues, based on best industrial practices and experience. The equipment selected will perform to meet regulatory requirements.

One alternative is flash drying, with wet coal being crushed and then dried separately. In a flash-dryer system, crushed coal is injected into warm solvent. The coal-solvent mixture flows to the slurry-mixing vessel, where a hot process-recycle solvent and a recycle slurry are added and slurried. The water flashes off as steam and is later condensed, leaving a hydrocarbon gas that would then be injected into the vapor-recovery system. The flash-drying system would not produce a particulate emission. However, the larger-sized particles, especially rock, very likely would settle in various parts of the process, resulting in plugging and coking. This type of system has potential economic and environmental advantages but has not been tested sufficiently for inclusion in the construction of the SRC-II demonstration plant. A modification of this alternative would be the addition of a ball or rod mill to grind the coal-solvent stream before or after mixing it with the hot slurry. The conventional drying-pulverization system is the selected method for the initial operation of the SRC-II demonstration plant because flash drying is still developmental. To demonstrate flash-drying technology, such equipment could be installed at a later time, should a decision be made to do so.

The fine dry coal will be transferred pneumatically through piping from the dryer-pulverizer bins to silos in the dissolver area. The pneumatic system will use inert gas as the transfer medium. This gas will be recycled, with part of it being purged to prevent the buildup of very fine particles. This purge stream will pass through a conventional bag-filter system for removal and recovery of the very fine dust.

C.3.1.2 Slag handling

Slag from the gasification system will be wet and will remain wet during transport to and deposition in the slag-landfill facilities. Consequently, little, if any, dust is expected to result from this operation. Plans call for the wet slag to be transported to the landfill area by belt conveyor where it will be deposited by truck or front-end loader. The Draft EIS indicated that the entire movement would be by truck. This alternative has now been ruled out because of the safety hazard of the heavy truck traffic within the plant area and across Highway 53 and because of the potential dust problem due to blowing or spilling of the wet slag in transit and its subsequent drying. Another alternative for slag handling that would minimize dusting is its transport as a water slurry; this is done conventionally in coal-fired electric generating plants. Several potential advantages and disadvantages are apparent with this alternative and, as a result, a great deal more study is needed before a decision can be made relative to its use.

Successful use of a slurry movement depends on slag characteristics. An advantage of slurry compared with conventional conveyance is the simplified operation at the pond (i.e., the slag pile formed at the end of the transporter is self-leveling, and use of earthmoving equipment is minimized). However, energy consumption and maintenance of equipment (especially pumps) is more costly with slurries. Slurries increase the plant's consumptive water use and also increase

the load on the wastewater treatment plant. Scaling in slurry lines from leached slag constituents can result in downtime. Truck movement might be feasible as a backup mode.

C.3.1.3 Roads

Essentially all roads and streets in the process area of the plant and heavily traveled access roads will be paved. There may be a limited number of lightly traveled roads that will only be graveled. These roads will be oiled or water sprayed, as required, to decrease dusting. As noted in Sect. C.3.1.2, the previously considered heavily traveled haul road for slag between the gasification area and the slag-disposal area has been eliminated by the substitution of belt conveyors for truck transport.

C.3.1.4 Fired heaters

Operation of the SRC-II demonstration plant will require significant quantities of heat, which will be supplied by combustion of fuel in indirect heaters. It is currently planned to provide this fuel from plant-derived streams — desulfurized plant gas and hydrotreated (hydrodesulfurized) naphtha. These fuels will allow compliance with applicable environmental standards, without requiring additional emission control equipment. Fired heaters can readily be obtained to burn this type of fuel with very little generation of suspended particulates.

Consideration is being given to using naphtha as a plant product and using only gaseous fuel in the plant. This would further reduce the quantity of particulates formed and emitted to the air from combustion sources.

C.3.2 Sulfur dioxide (SO₂)

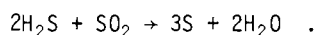
C.3.2.1 Sulfur removal and recovery

The simplified block-flow diagram for the SRC-II demonstration plant shown in Sect. C.2, as Fig. C.3, includes the steps used to remove and recover sulfur to maximize process performance and reduce sulfur emission to the environment.

Because the design coal for the plant is expected to contain about 3.6 wt % sulfur, about 200 tons/d of sulfur will be introduced into the plant with the coal (when the plant is operating at full capacity). About 95% of the sulfur will be converted to hydrogen sulfide in chemical reactions in the dissolvers and gasifiers and will be contained in the gas streams leaving those facilities. The gas streams from the dissolver will consist of: a high-pressure stream at essentially the same pressure as the operating pressure of the dissolver and a low-pressure stream consisting of gas flashed during the various pressure-letdown steps plus the soluble gas which is released during fractionation of the process liquids. These gas streams will contain a high ratio of hydrogen sulfide (H₂S) to carbon dioxide (CO₂). As a result, the two acid gases will not have to be selectively separated in order to provide suitable feedstock to a Claus sulfur-recovery plant. Consequently, a nonselective acid-gas removal process, diethanolamine (DEA), has been chosen to remove the H₂S and CO₂ from these hydrocarbon streams. Reduction of H₂S content of the hydrocarbon stream to less than 100 ppmv is readily achievable. DEA has been proven to be a reliable process over many years in similar applications throughout the gas processing, refining, and chemical industries.

The synthesis-gas stream made by the gasifier will have a low ratio of H₂S to CO₂. Consequently, the use of a nonselective acid-gas removal system would provide an acid gas with an H₂S concentration too low for acceptable feedstock to a Claus unit. Therefore, a selective acid-gas removal process, Selexol, has tentatively been selected for this application. It will produce a syn-gas stream that contains well below 100 ppmv H₂S plus two acid-gas streams, one that will have a moderately high ratio of H₂S to CO₂ and another that will be mostly CO₂ with only a very small H₂S content. The H₂S-rich stream will flow to the Claus sulfur-recovery unit. The CO₂-rich stream, with its very small amount of H₂S, will bypass the Claus unit and flow directly to the H₂S incinerator, for conversion to SO₂.

The concentrated acid-gas streams from the high-pressure DEA, low-pressure DEA, and Selexol systems will be combined and processed in a Claus system where the H₂S is converted to elemental sulfur, which will be condensed and recovered as a liquid by-product. Process steam will be raised in the sulfur condenser. About one-third of the H₂S first will be burned in a deficiency of air to produce a mixture of essentially two moles of H₂S and one mole of SO₂. This mixture will then be reacted over a catalyst to produce elemental sulfur and water as shown by the following reaction:



The oxidizer will be controlled so that slightly less than one-half as much SO_2 as H_2S will flow to the catalyst, which will minimize the amount of SO_2 that passes through the converter and is subsequently released to the air. The Claus-unit tail gas will flow to a SCOT tail-gas-treatment unit where residual SO_2 will first be converted to H_2S , followed by absorption and recovery of the H_2S for recycle back through the Claus system. The tail gas, which will have a low sulfur content, will be combined with the CO_2 -rich stream from the Selexol unit, which will have a small H_2S concentration, and fed to the H_2S incinerator where the H_2S will be converted to SO_2 and released to the atmosphere through a stack.

As can be seen from the previous discussion, a high-pressure DEA, low-pressure DEA, Selexol-Claus-SCOT system now appears to be the preferred combined sulfur-removal and recovery system for the SRC-II demonstration plant whereas, when the Draft EIS was issued, it appeared that an alternative high-pressure DEA, low-pressure DEA, Benfield-Claus-SUPERSCOT system was preferred. In the Benfield unit, two acid-gas streams would be produced, both with very low H_2S -to- CO_2 ratios — 0.01 and 0.02. The stream with the lower ratio, 0.01, would be routed to the low-pressure DEA unit. The stream with the higher ratio, 0.02, would still be far too dilute in H_2S to serve as suitable feedstock to a Claus plant. Therefore, it would be combined with the acid-gas streams from the low-pressure DEA and high-pressure DEA units and fed to a SUPERSCOT unit to yield a carbon dioxide-rich stream with a low H_2S content, which would flow directly to the H_2S incinerator, and an H_2S -rich stream. The H_2S -rich stream would serve as feed to the Claus unit. The tail gas from the Claus unit would be combined with the feed to the SUPERSCOT unit. Simplified block-flow diagrams of these two alternatives are shown in Fig. C.5. Either system would produce a treated tail-gas effluent containing 230 ppmv or less of SO_2 , which conforms to EPA's New Source Performance Standards (see Appendix O).

The primary reasons for selecting the new preferred alternative were lower operating costs and a probable reduction in SO_2 emissions due to an expected very low H_2S concentration in the CO_2 -rich stream that bypasses the Claus unit and goes directly to the H_2S incinerator.

The overriding reason for selection of the preferred alternative is the demonstrated reliability and flexibility over other alternative processes, such as Rectisol H_2S removal or Stretford tail-gas treating. This factor outweighs all others when evaluations are based on the consequences of upsets and varying rates that are expected during the demonstration period, especially during the first year or two.

Other alternatives that have been considered to a lesser extent and rejected are discussed in the following paragraphs.

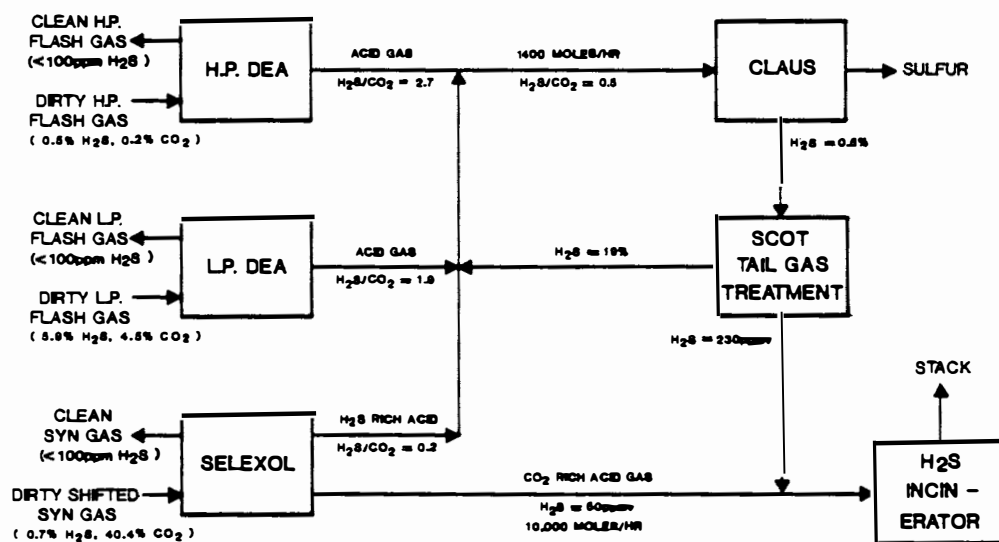
With the use of a Beavon-Stretford tail-gas treatment system, the resulting off-gas concentration would theoretically be reduced to about 40 to 80 ppmv SO_2 , and SO_2 emissions would be reduced to 125 to 250 tons per year. However, the liquid effluents (sour water and Stretford-solution blowdown) leaving the Beavon unit would contain vanadium salts, which would pose serious problems for environmentally safe disposal. A Giammarco-Vetrocoke alternative could replace the Stretford unit in the Beavon-Stretford system, reducing the SO_2 concentration to less than 40 ppmv in the tail gas, and reducing SO_2 emissions to less than 125 tons per year. A major drawback would be the use of arsenic compounds, which would appear in trace quantities in all effluents, including the sulfur product.

Two commercially available alternative technologies exist which could potentially replace the Claus sulfur-recovery system: Stretford and Giammarco-Vetrocoke. Both of these systems have demonstrated lower sulfur emissions than Claus systems in some applications, but their performance is sensitive to feed-stream composition, and the feed stream in the proposed plant may be variable and may contain process contaminants that would preclude the effective use of these alternative systems. The same disposal problems listed in the previous paragraph would also apply to these technologies.

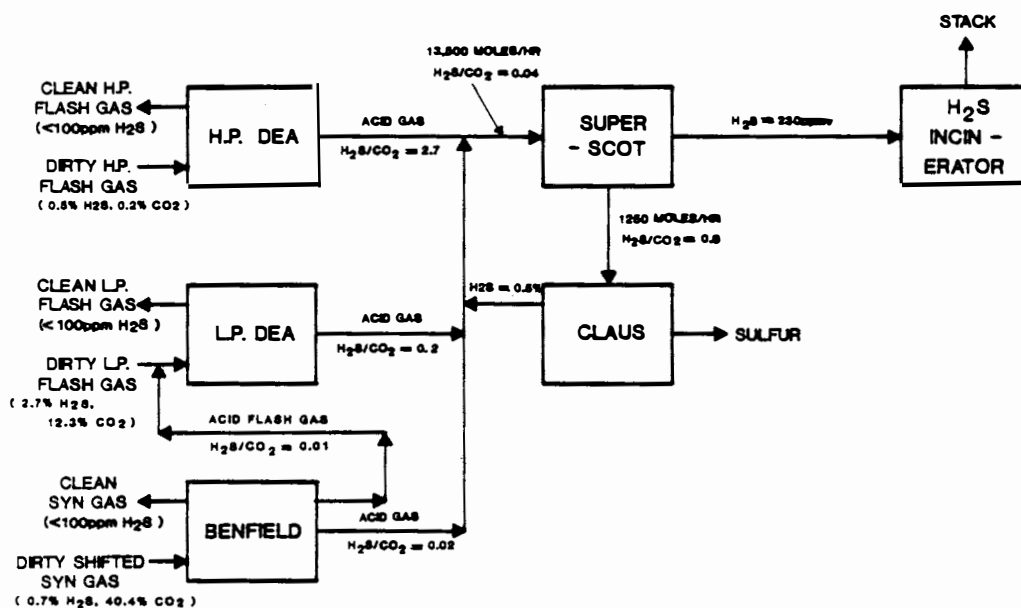
An acid-gas oxidizer plus the Chiyoda Thoroughbred 101 process is a potential alternative which would provide a gypsum product from the remaining sulfur in the tail-gas instead of elemental sulfur. Sulfur dioxide in the off-gas might be slightly less than with the proposed system. Other potential alternatives, which may or may not be applicable to high- CO_2 streams, include the Dual-Alkali process, the Cleanair process, the Wellman-Lord (W-L) system, the IFP-2 system, and a lime-limestone slurry system. The use of some of these systems would have the distinct disadvantage of requiring the disposal of large quantities of sludge. Wellman-Lord feeding SO_2 to Claus would increase the production rate of sulfur by-product.

C.3.2.2 Fired heaters

The only viable control for the level of SO_2 emissions from the fired heaters in this plant is to control the quantity of sulfur in the fuel. The SO_2 -emission rates projected for the plant have been based on: 29% of the heating value of the fuel being provided by plant naphtha that has



(a)



(b)

Fig. C.5. Block flow diagrams of two alternative sulfur-removal and recovery systems: (a) selected system; (b) Benfield alternative.

been hydrotreated to a level of 0.1 wt % sulfur and 71% of the heating value of the fuel provided by hydrocarbon flash gas and synthesis gas, each with a sulfur content of 100 ppmv. The combustion of this mixed plant fuel produces 0.047 pounds of SO_2 per million Btu of energy input.

Pilot tests by Gulf Science and Technology Company have shown that raw naphtha produced in the SRC-II process with the P-99 process-development unit can be readily desulfurized to a level below 0.1% sulfur with moderate-severity hydrotreating. Several commercial processes have demonstrated the capability of reducing H_2S in gas streams to less than 100 ppmv: Selexol, Benfield Hi-Pure, DEA, and two-stage activated hot carbonate. As noted previously, it is believed that the Selexol process will be used in the SRC-II demonstration plant to remove H_2S from the gasifier synthesis gas, and DEA will be used to remove H_2S from the hydrocarbon flash gases.

Alternatives considered earlier and rejected were: purchased gaseous fuels (natural gas or LPG), purchased petroleum-distillate fuels, coal, and process-generated heavy liquids. Purchased gaseous and distillate fuels would consume resources that are already in short supply; their use during normal operation was rejected for that reason. Use of process-generated heavy distillate fuels or coal would require extensive facilities for control of sulfur dioxide and particulate emissions to meet emission limitations and Prevention of Significant Deterioration requirements. Use of process-generated desulfurized gases and hydrotreated naphtha will allow compliance with applicable environmental standards without requiring additional control equipment; so it was selected as the preferred alternative.

An alternative still being considered and likely to become the preferred alternative is the use of desulfurized plant gas for the entire plant fuel requirement, except during startup, shutdown, and emergency periods. Because the gas will be lower in sulfur content than the naphtha that is planned for use as plant fuel, a 46% reduction in SO_2 emissions from the plant would result.* The naphtha that would be diverted from plant fuel to a plant product would be upgraded to a high-octane unleaded-gasoline blending stock, which could supplement gasoline supplies derived from petroleum.

Due to the possible short period of demonstration plant operation and the high capital cost of coal-fired boilers, it is very unlikely that any consideration will be given to the use of coal as boiler fuel for the SRC-II demonstration plant. However, certain potential international developments could result in its consideration at some future date. In the event it is decided to do so in the future, commercially available stack-gas scrubbing will be installed to control particulate and SO_2 emissions within acceptable emission limitations. In such a case, it would be necessary to meet environmental regulations and to obtain the necessary permits to operate the boilers with that type of fuel. An additional alternative on coal is fluidized-bed combustion, which combines desulfurization with combustion and avoids the capital and operations and maintenance costs of scrubbers.

C.3.3 Nitrogen oxides (NO_x)

The commonly accepted theory for the occurrence of NO_x in flue gases is that they originate from two sources: (1) thermal fixation of nitrogen from air and (2) conversion of fuel-bound nitrogen. Thermal NO_x increases with flame temperature and decreases with reduced availability of free oxygen. Fuel-bound nitrogen conversion is not believed to be directly temperature dependent, but it too decreases with reduced availability of free oxygen.

Various approaches that have been employed by burner-boiler manufacturers to reduce NO_x production include:

- low excess air,
- low air preheat,
- flue-gas recirculation, and
- staged burning: burner type and overfire air.

These techniques are employed in various combinations by the boiler vendors to meet NSPS. Published literature by these vendors indicate they can meet these limits for liquid and gaseous fuels. Examples of the literature are:

*The reduction is estimated as follows: the 29% of naphtha provides 62% of the sulfur total. The 71% gas provides 38% of the sulfur total; at 100% gas, sulfur would be 54% of the base case, a reduction of 46%. The mixed-fuel base case is thus considered a worst case for impact modeling purposes. See Sect. C.4.1.1.²

1. Combustion Engineering: Paper entitled "NO_x Control in Oil and Gas-Fired Boilers" by R. D. Winship and P. W. Brodeur, Figs. 6 through 9, presented at the Power Engineering Conference and Exhibition, Hamilton, Canada, Oct. 25, 1973.
2. Babcock & Wilcox: Paper entitled "Nitric Oxide Control - A Program of Significant Accomplishments" by W. H. Barr and D. E. James, Figs. 12 and 13, ASME Paper No. 72 WA/PWR 13, Nov. 26, 1972.
3. Riley Stoker: Paper entitled "Application of NO_x Control Technology to Power Boilers" by A. H. Rawdon and S. A. Johnson, Proceedings of the American Power Conference, vol. 33, Chicago, May 10, 1973.

The large heaters in the plant (the slurry-charge heaters and the auxiliary boiler), which combined will use about 75% of the total plant fuel, will be specified to have low-NO_x burners and perhaps automatic air control. Automatic air control is not cost-effective for the numerous smaller process heaters; therefore, operators of these units will adjust air intake manually.

The full expertise of the heater designers and manufacturers will be used to provide workable heaters for all applications which conform to regulatory standards.

Noncatalytic ammonia injection is capable of achieving a higher level of NO_x control, but it has not been commercially tested. Small-scale tests have shown that temperatures outside a narrow temperature range result in emissions of NH₃ or NO_x higher than if no ammonia injection were used; this implies possible control problems. Ammonia also poses toxicity hazards within the plant.

Catalytic ammonia injection has been demonstrated in Japan. However, these systems cannot be justified for the level of emissions characteristic of the proposed demonstration plant.

C.3.4 Carbon monoxide (CO)

No satisfactory control measures exist that will reduce CO emissions beyond efficient boiler and process-heater operation and, at the same time, minimize fuel consumption. Furthermore, most control techniques for reducing CO emissions result in increased NO_x emissions. EPA's policy has been to stress control of NO_x, even when this might result in increased CO emissions. However, with proper monitoring of excess air to the boiler and heaters, little CO will be formed.

C.3.5 Non-methane hydrocarbons (NMHC)

The four major potential sources of NMHC emissions to the air will be: leaks from valves, flanges, seals, drains, etc.; vapors released from storage and loading operations; spills; and venting operations that are required to prevent overpressuring of process equipment.

C.3.5.1 Fugitive emissions (leaks)

The contract between DOE and the industrial participant for the design, construction, and operation of the SRC-II demonstration plant requires that the industrial participant prepare, during the design stage, a Plant Facility Maintenance Plan. A part of this Plan will be a "directed" maintenance program. This program will include monitoring to determine when maintenance is required, procedures for performing such maintenance, and monitoring during the maintenance work to determine when sufficient corrective action has been performed. The program will emphasize procedures, such as more frequent monitoring, for those equipment items that have the potential for the largest leak rate of materials considered to have the greatest adverse health impacts.

The EPA is currently conducting studies in refineries to define (1) methods and procedures for directed maintenance programs and (2) criteria for determining when maintenance is needed. Preliminary results from these studies, as well as the current Draft Generic Standards,³ were used to formulate the initial directed maintenance program outlined in the following paragraphs.

The program for the SRC-II demonstration plant will apply to all pump and compressor seals, valves, and drains in 1-in. and larger process lines and equipment carrying 10% or more of materials considered to have the greatest adverse health impacts (+600°F boiling point). All process valves, drains, pumps, and compressors to be included in the program can be identified prior to operation of the demonstration plant. Those items that have not previously been assigned an equipment number, mostly valves and drains, will be permanently tagged for identification for the program. Beginning with initial operation of the demonstration plant, compressor seals, pressure relief valves, and pipeline valves in gaseous service will be leak tested quarterly; pump seals, drain valves, and pipeline valves in liquid service will be leak tested semi-annually. Any emission sources in the program will be subject to leak testing if routine visual inspection indicates a dripping liquid or visible vapor leak.

Leak testing will be conducted with a portable, volatile organic chemical detection instrument. Specifications for the instruments will include selectable scales, as well as specific values for drift, response time, calibration drift and error. The specifications will be established to allow competitive bidding without instrument development costs. The program will include

- (1) periodic calibration of the test instruments according to the manufacturer's instructions and
- (2) documentation of the results.

The EPA is developing detailed procedures for conducting a leak test. The procedures, when available, will be incorporated in the program. Pump and compressor seals will be leak tested at several points around the shaft at the junction of the shaft and the pump or compressor case. All valves will be leak tested around the bonnet and/or stem and drain; relief valves will be leak tested at the outlet, where feasible.

Results of the leak testing will be documented regardless of the leakage rate. Leaks that result in a concentration exceeding 10,000 ppmv will be reported to the plant's maintenance department, and the leak generally will be repaired within 15 days. When attempts to repair could clearly result in an increase in emissions, repairs may be delayed until a regularly scheduled shutdown.

Maintenance procedures for repairing the leaks in this program will be developed before, and used during, the operation of the plant. Leak testing will be conducted immediately after repair to determine if the repair was successful.

Records will be maintained for each source; as a minimum, the records will show equipment items, leakage rates, maintenance performed, and dates of monitoring and repair. The program will undergo periodic reviews, the objective of which will be to determine answers to the following types of questions:

- Should additional items of equipment be included in the program?
- Should certain items of equipment be deleted from the program?
- Should monitoring frequencies be revised?
- Should leakage rates requiring immediate repair be revised?
- Can maintenance procedures be improved?
- What are the estimated benefits of the program?
- What are the costs of the program?

"Directed" maintenance programs have not been prevalent in the past in the oil-refining, gas-processing, and chemical industries. As a result, the maintenance program for the demonstration plant will be considered to be part of the major overall demonstration project objective of determining the commercial viability of the SRC-II process. In other words, the "directed" maintenance program for the demonstration plant will attempt to determine what practices are necessary for future commercial plants and, also, what practices are less critical.

C.3.5.2 Vapors from storage and loading

Hydrocarbon storage tanks will have vapor-recovery systems in conformity with 40CFR60, Subpart K(a).⁴ Vapors will be collected, compressed, and returned to the main process. Pressure-relief devices on LPG and ammonia tanks will be directed to the controlled combustor. Ammonia will be injected into the molten sulfur product on its way to storage to react with any free H₂S.

Neither EPA nor West Virginia have regulations concerning vapor recovery at hydrocarbon loading and transfer facilities. As a result, vapor-recovery systems will be designed according to good engineering practice, guided by Colorado regulations. Typical requirements will be:

- dry-break loading couplings to prevent spills during uncoupling,
- vapor collection and recovery from vehicles being loaded,
- provisions for prevention of over-filling vehicles,
- suitable back-pressure devices, set at a lower pressure than pressure-relief valve settings on transport vehicles, and
- closed-line drainage systems.

Propane and ammonia loading systems will be designed in accordance with API Standard 2510, Manufacturing Chemists Association Data Sheets SD-8, and Colorado Rules and Regulations pertaining to storage and handling of anhydrous ammonia. Special care will be given in the piping design to the expansion characteristics of these materials so that trapping of liquid in piping sections between valves can be avoided. Hydraulic pressure-relief valves will be located where required.

C.3.5.3 Storage and spills

A spill is a fugitive emission and can result in high concentrations of NMHC's in the air, as well as fire and explosion hazards, until the spilled liquids are properly recovered. The greatest potential adverse environmental impact, however, may be the possibility of contamination of surface and ground waters unless storage and process areas are designed to properly contain and recover such spills.

All storage tanks for products and by-products will be diked with walls and floors of an impervious material with the specific material selected during detailed design. The industrial partner is now studying alternative impervious materials. Secondary containment will be of similar design. They will meet EPA's regulations (40 CFR 112) governing spill prevention, control, and countermeasures. Primary containment will provide for segregating and recovering large oil spills to prevent their flow into the secondary-containment facilities.

Secondary containment will collect contaminated rainwater (as well as oils escaping primary containment) and send it to the wastewater treatment plant.

The design of the containment system (discussed in Appendix C, Sect. C.3.5.3) is in distinct contrast to the tank farm at the Fort Lewis pilot plant, where an SRC liquid spill quickly soaked into the soil and contaminated local groundwater. (Reference 2 in Appendix Z gives a detailed discussion of the Fort Lewis spill.)

The tank spacing and fire-protection system will meet regulatory requirements and/or standards.

A preliminary study has shown that the bulk-product storage tanks can be located near the railroad and river above the 500-year floodplain, although some fill in the 500-year floodplain will be required (see Appendix D). Contaminated rainwater at this location will be collected and pumped to the wastewater treatment plant.

Process areas that have a potential for significant spills will be paved and curbed so that spills can be collected and recycled to the process and so that rainwater runoff can be collected and treated. Rainwater runoff will be routed to wastewater treatment reservoirs and equipment. The design of such reservoirs will also meet applicable standards for protection of surface and groundwater as part of the West Virginia permitting process. Also see Sect. C.2.16.

C.3.5.4 Vent and flare system

The main processing units normally will not emit hydrocarbons, and there will be no continuous emissions to the flare system, which will have a continuous natural-gas-fired pilot. However, venting to the flare system will be required while commissioning and decommissioning equipment during normal plant startups and shutdowns. In addition, process upsets and emergencies will occur that will require the immediate venting of gases and vapors to relieve internal pressures to prevent safety hazards to personnel and damage to equipment.

In conventional chemical and petrochemical-processing facilities, pressure relief is normally accomplished by venting to an elevated flare stack, where the material is ignited and burns in the atmosphere without additional controls. Many of the SRC-II process streams contain complex organic materials, some of which are known to have toxic or carcinogenic characteristics (see Sect. 4.1). Even though most of these materials would be separated and retained as liquids in the flare system, small quantities may be contained in the gases and vapors going to the flare. Conventional flares are not considered to provide adequate assurance that combustion of these materials will be complete. Therefore, in addition to an elevated flame, the flare system for these portions of the plant will include a continuously gas-pilot-controlled combustor. The uncontrolled combustor's principal advantage over the elevated flare is the reduction of unburned hydrocarbons due to controlled, more efficient combustion. This system also will include a vent purge combustor, which utilizes a continuously gas-fired burner, including a gas pilot. The purpose of the vent purge combustor is to effectively combust very small streams that are vented or leak into the flare system. Emergency situations may require extremely rapid venting of process vessels which will activate the elevated flare. The entire flare system for the liquefaction-distillation is shown in Fig. C.6.

A second elevated flare is planned to handle vent streams from the remainder of the plant, including the gasification system. Because these streams will not contain heavy hydrocarbons (potential

carcinogens), they can be effectively combusted in an elevated flare. However, consideration is being given to installing a controlled combustor as part of this system to decrease problems associated with excess illumination and noise. As design progresses, the desirability of additional flare systems may be indicated.

The design of a safe flare system is a complex engineering task. The one for the SRC-II process is even more complex because the vented material could contain, under some conditions, heavy liquids, which solidify even at relatively high temperatures and contain high concentrations of ash. Therefore, special design features will be required to prevent accumulation of these materials and their freezing (solidification) or coking. Also, vented streams will contain ammonia and carbon dioxide which, under certain conditions, combine to form solid compounds that could restrict flow to the flare. Similar concerns were faced during the design of the Fort Lewis SRC Pilot Plant. Although some problems have been encountered during its operation, it has operated safely since plant startup six years ago. The Fort Lewis experience will be considered when designing the demonstration plant flare system.

The overall design of the SRC-II demonstration plant flare system is expected to be based, to a large extent, on information contained in the Hydrocarbon Processing Equipment Design Handbook for Refining and Chemical Plants.⁵ Figure C.6 is a simplified sketch of the controlled-combustor/elevated-flare system for the SRC-II process as it is currently envisioned: using a two-stage burner system in the combustor. As material is released into the various laterals leading to the flare system through the safety and pressure-control devices, an increased pressure in the flare header will result. When the pressure increases to that equivalent to the hydraulic seal leg in the low-rate seal drum, the seal will blow, and gases will flow to the low-rate burners in the controlled combustor. A liquid knockout drum or drums upstream of the low-pressure seal drum will allow for disengagement of entrained liquid which will be returned to the process. If flow through the flare header increases further, increased backpressure will result, which in turn blows the water seal in the high-rate seal drum; then, the high-rate burners in the controlled combustor will be activated. The flare reference discussed above indicates each set of burners, low and high, can be designed for a turndown ratio of 10:1. Therefore, the two-stage combustor can provide efficient combustion over a range of 1% to 100% of its maximum design capacity. The seal-leg heights, the flare-header system's pressure drop, and the combustor burners must all be designed as a system. When the capacity of the controlled combustor is exceeded, the elevated-flare water seal will blow and allow gases to flow to the elevated flare. Flares are more efficient at these high vent-gas rates than at low rates, because more air is educted into the flame, and the increased turbulence provides better mixing of the air and vent gas. For smokeless operation, steam injection into the flame will also be provided. Its addition provides additional mixing and air injection and thus more efficient combustion. The addition of steam also reduces soot formation because of the resulting water-gas reaction, $C + H_2O \rightarrow CO + H_2$.

The system also includes a vent purge combustor, located after the liquid knockout drum, to destroy fugitive leaks into the flare header system. No flow normally passes to the controlled combustors and flares. The vent purge combustor takes care of dilute gases (purge nitrogen and fugitive hydrocarbons), which are incapable of sustaining combustion. The combustor operates on plant fuel gas at an 8×10^6 Btu/h firing rate. The design basis is 2600°F peak with 0.5-s residence at or above 1600°F. [See PSD permit application supplement number four (Oct. 24, 1980) for further details.]

A hydrocarbon or inert purge gas will be introduced at the bottom of the flare during "no-flaring" conditions to decrease the diffusion of oxygen into the stack to a safe level to prevent stack explosions.

Based on the flare design reference mentioned in Sect. C.4.1.6, calculations have been made for what is expected to be the maximum rate of flaring in the plant, Case A of Tables C.14 and C.15. At these conditions, a flame 600 ft long, with a maximum width of 100 ft, is estimated to occur for a short time — perhaps several minutes. As a result, a flare stack height of about 235 ft would be required so that personnel on the ground could safely escape. Special protective clothing would be required within about a 500-ft radius of the flare.

C.3.5.5 Waste-heat rejection

During normal operations, the SRC-II demonstration plant will generate about 1.63×10^9 Btu/h of nonrecoverable process heat. The heat rejection rate is comparable to that of a coal-fired steam plant of about 250 MW electrical output.

A major environmental concern affecting the selection of cooling systems for the SRC-II demonstration plant is the potential for contamination of the cooling water by polynuclear aromatic compounds (PNA) and other hydrocarbons. These contaminants may enter the cooling system through leaks and failed tubes in heat exchangers operating in high-pressure process conditions. The coal dissolver, liquid refining and fractionation, hydrogen recovery, and naphtha hydrogenation

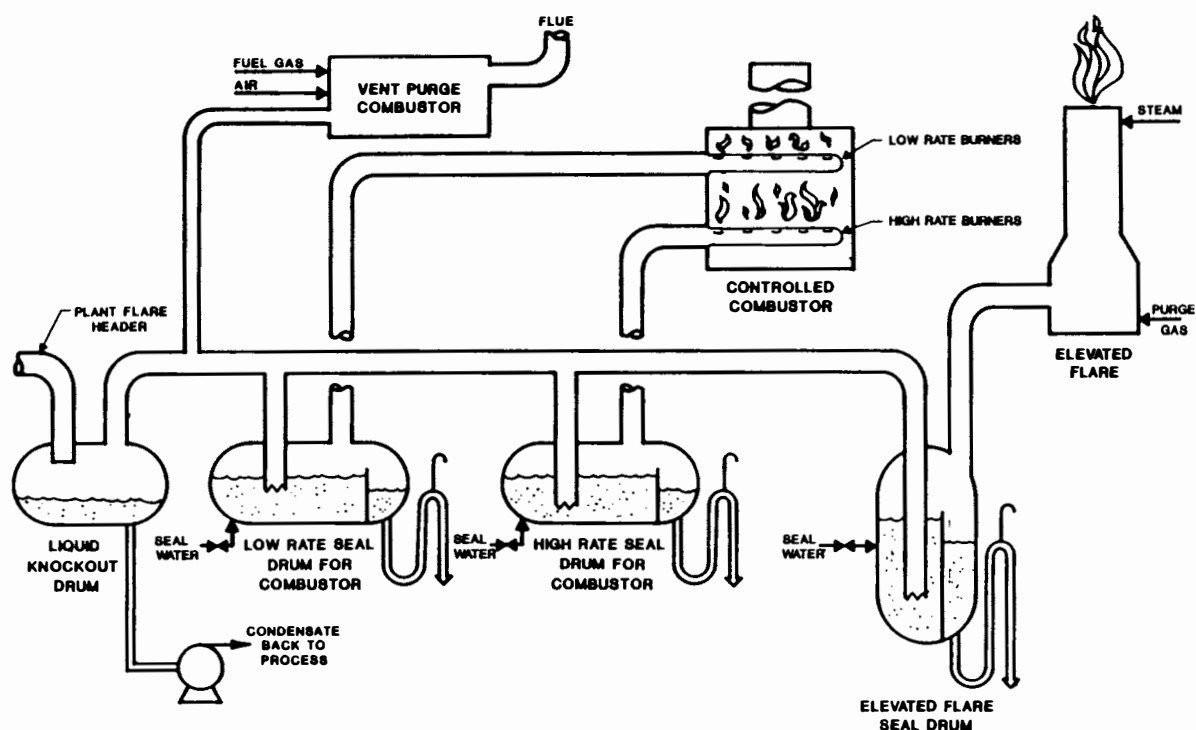


Fig. C.6. Sketch of controlled combustor/elevated flare system.

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units are areas where high temperature and pressure hydrocarbon streams require cooling; therefore, heat exchanger failure and contamination of cooling water by hydrocarbons and PNAs could occur in these areas. The cooling system ultimately used in the demonstration plant will minimize or eliminate the release of toxic and carcinogenic compounds to the environment.

There are five types of cooling systems available for waste heat rejection: aerial coolers, conventional or wet (evaporative) cooling towers, dry indirect cooling towers, wet indirect cooling towers, and wet/dry cooling towers. The following paragraphs present a discussion of these alternatives; Figs. C.7 and C.8 are flow diagrams of these cooling systems. Another alternative being studied during the detailed design phase is the use of cooling tower biocides other than the proposed chromate-based inhibitor. Phosphate inhibitors are also being studied.

Aerial coolers

Aerial coolers are suitable for cooling process streams down to about 140 or 150°F. Process fluids flow inside finned tubes, and atmospheric air is circulated over them with motor-driven fans. By using welded connections, the possible leak points at flanges are minimized. Leaks can be detected with monitoring equipment and visual inspection. Unless process materials are at high temperature, large heat transfer areas are required, and capital costs are high. Significant ground area is also required.

Wet evaporative cooling towers

Wet evaporative cooling towers are the most widely used type. Cooling water is circulated through exchangers to remove heat from the process fluids and is cooled by contacting air in a cooling tower open to the atmosphere. The possibility exists that the circulating water may become contaminated with process materials introduced through cooling system leaks from higher-pressure process environments. These contaminants could escape to the atmosphere through cooling tower evaporation and drift. Drift losses may be minimized by high-efficiency drift eliminators. This conventional type of system is the lowest in overall cost and is suitable for cooling down to 85 or 95°F, depending on atmospheric wet-bulb temperatures.

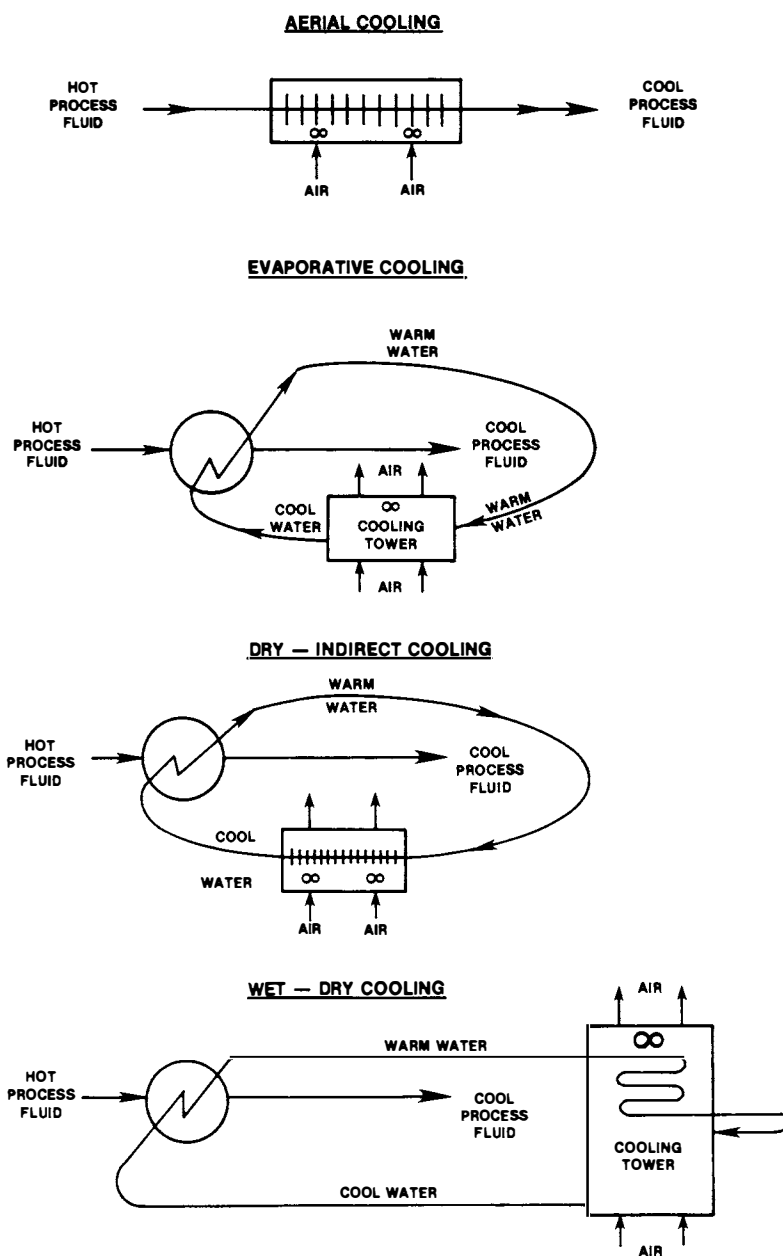


Fig. C.7. Alternative cooling systems.

Dry indirect cooling

For this type, process fluids would be cooled by a heat exchanger circulating a heat transfer fluid that is ultimately cooled through an aerial cooler. The heat transfer fluid may be low-pressure, moderate-temperature, corrosion-inhibited water, so that leakage into this water would not be a problem. If a leak occurs, the process material would be separated from the heat transfer fluid in a disengaging drum. Vapors would be flared and liquids recovered until the system could be shut down for repairs. Any contaminated heat transfer fluid (water) would be sent to the waste-water treatment system.

Thus, the dry-indirect-type system prevents risk of contaminating the atmosphere by leaks of certain process hydrocarbons into the circulating cooling water. Because the circulating water would be cooled inside tubes by, for example, air in an aerial cooler, this type also eliminates evaporation and drift losses of water to the air, thus reducing the plant makeup water requirements and their impact on the river supply.

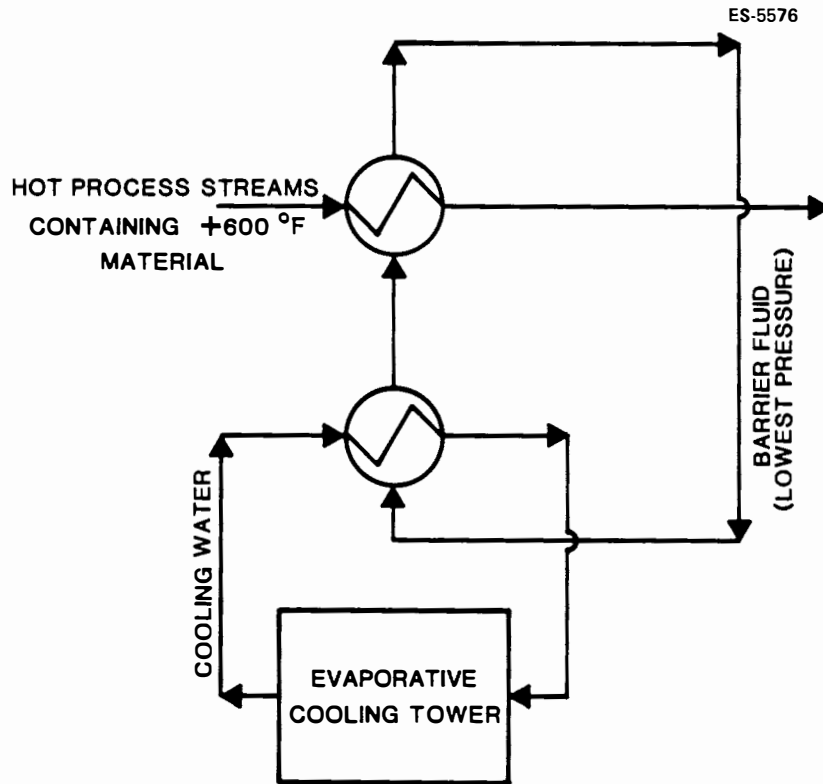


Fig. C.8. Wet indirect cooling system.

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Three major disadvantages of the dry indirect system are (1) increased complexity of the system; (2) the cost involved, considerably more than that of the conventional wet (evaporative) water cooling tower system, and (3) that extensive use could decrease the plant's evaporative water rate to such an extent that zero wastewater discharge could not be achieved.

Wet indirect cooling

Wet indirect cooling is similar to the dry indirect method described earlier, except that heat is rejected indirectly to a second circulating evaporative cooling water system rather than to the air. Its use would result in the same net evaporative rate as would conventional wet evaporative cooling. Thus, the risk of contamination would be eliminated, and the drift and the effect on plant water balance would be the same as for wet evaporative cooling (Fig. C.8).

Wet/dry cooling

This type of cooling tower has a dry upper section (cooling water in tubes, cooled by upward air flow), and a lower wet evaporative cooling section, with the water in open contact with air, to cool by evaporation. The principal advantages of this type are that it:

- diminishes visible water-vapor plume and reduces fog,
- obtains a colder fluid temperature that approaches ambient wet-bulb temperature, and
- conserves makeup water as compared with the 100% wet evaporative cooling tower.

Alternative design arrangements are being considered to decrease further the low potential for carcinogens to escape to the atmosphere and to reduce the possible water cooling tower fog problem.

Proposed and alternative designs

Aerial coolers will be used to decrease water consumption whenever technically acceptable and economically justified. To prevent their potential leakage into the environment, streams containing significant quantities (more than 2%) of +600°F material — believed to be associated with carcinogenic hazards — will not be cooled in aerial coolers.

Mutagenicity and carcinogenic potential are currently being measured on narrow-boiling cuts of SRC-II middle (350 to 550°F) and heavy (>550°F) distillates. Final design of the heat-exchanger system as to selection of aerial, indirect evaporative, or other types on specific streams will account for the results of this study with a safe-side allowance of about 50°F. Laboratory data are not currently available. Preliminary indications are that Ames test effects are minimal with cuts boiling below 600°F and begin to be noticeable above 760°F.

The major heat rejection will be through evaporative water-cooling towers. Preliminary mutagenicity tests indicate little effect for those streams boiling below 600°F. Therefore, an indirect cooling system is planned for cooling streams containing more than 2% of >600°F material (Fig. C.7) to prevent leakage into the cooling tower system. Additional data are being developed that could result in a change in this preliminary composition criteria for indirect cooling. The indirect or barrier-fluid system will be maintained at a pressure less than the process streams from which it is extracting heat and the cooling water to which it rejects heat. In this way, any exchanger leakage will result in flow into the barrier system where leaks can be monitored by inventory change and analyses. It may be desirable to provide a high-pressure cooling-water system to cool the low-pressure streams of this type. In such a system, the water pressure would be maintained higher than that of the hydrocarbon stream. The result during a leak is that cooling water cannot be contaminated with organics. However, additional study is required to establish the desirability of such a system, because leaks of water into high-temperature hydrocarbon streams can cause safety problems.

The ability of the proposed wastewater treatment system to achieve zero process liquid discharge when called on to do so relies on the evaporation of water in cooling towers to partially offset the accumulation of contaminated rainwater runoff. The final decision on the design of the plant cooling system will require a thorough evaluation of the rate at which the water retention basins can be emptied by process evaporative cooling. During the detail design stage, it will be necessary to thoroughly evaluate rainfall patterns and plant operating modes and their effect on water evaporation to ensure that, under all combinations of weather and process operating conditions, all contaminated water can be adequately processed within the plant and that none will be discharged to the river.

C.3.6 Raw water and wastewater treatment systems

C.3.6.1 Raw-water treatment

Raw water from the Monongahela River and some runoff waters from uncontaminated plant areas will be stored in open basins. Before its use, this water will be gravity-settled to remove suspended solids. Facilities will be provided for the addition of coagulant and flocculating chemicals to assist in the gravity separation. About 20 gpm intended for potable use will be further treated by filtration and chlorination. The remaining raw water will be used for utility wash water and for cooling-tower makeup. The river-water intake will be designed so that the intake velocity will not exceed 4 cm/s for the demonstration plant and 10 cm/s for the expanded commercial plant. Fish screens will be included.

Other water-supply requirements, including normal process waters and boiler feed water, will be met by using various treated wastewaters as shown in Fig. C.4.

C.3.6.2 Wastewater sources and treatment alternatives

C.3.6.2.1 Wastewater sources

The principal wastewaters generated by the SRC-II demonstration plant include:

- dissolver-system purge water,
- gasifier-quench purge water,
- coal pile runoff,
- slag pile leachate,
- gas-treating condensates,
- cooling tower blowdown,
- process area runoff,
- coal-handling area runoff, and
- tank-storage-area runoff.

The expected characteristics of these streams are discussed below.

Dissolver-system purge water

Some water will be produced in the SRC-II dissolver through the reaction of hydrogen feed with oxygen contained in the feed-coal slurry. This water will be vaporized along with other volatile components in the dissolver pressure letdown system. Other volatile components will include ammonia, phenols, and hydrochloric, hydrosulfuric, and hydrocyanic acids. Additional water will be added, as a purge, to this overhead stream to prevent the deposition of ammonium chloride in the piping. To prevent excessive buildup of dissolved ammonium chloride in the recirculating quench water, a purge stream of contaminated water will be withdrawn from the system.

Analyses of purge water generated in the P-99 pilot plant have yielded the results shown in Table C.4. Limited data are available on some wastewater parameters of interest, and no data have been available for other parameters.

Table C.4. P-99 recycle water analyses Powhatan coal feed, mg/liter

	Av	Std. Deviation	Max	Min	No. of samples
Total carbon	11,475	3,168	19,800	5,800	32
TOC	8,304	1,542	10,600	4,700	30
TIC	3,449	2,176	11,200	1,000	30
Alkalinity	38,195	24,249	112,939	11,200	28
Oil and grease	1,068	1,121	2,803	56	5
pH	9.05	0.168	9.4	8.6	32
Total N	23,960	11,136	55,800	6,100	33
NO ₃ , as N	<0.1				2
NH ₃	24,106	12,785	34,000	10,400	8
Chloride	1,418	1,568	8,972	328	33
H ₂ S	41,949	14,824	70,300	18,383	32
Sulfate	457	856	4,250	0	32
Total phenols	6,598	6,502	11,196	2,000	2

An effort is under way by Gulf Science & Technology Company (GS&TC) at Harmarville to produce sufficient data to permit a material balance on components of greatest importance to the design of the wastewater treatment systems. An effort has also been initiated at Harmarville to demonstrate the biodegradability of materials in the P-99 purge water, but results of these programs are not yet available. In addition, a wastewater treatability test program will be conducted to yield the necessary baseline data for the detailed design of the wastewater treatment plant.

Gasifier-quench purge water

A large amount of steam will be added to the gasifier, some of which will be consumed in the gasification reaction. Additional water will be added to the slag lockhopper where it will serve as sluicing water by being used to transport slag to the dewatering system. The slag water system will be a recirculating loop with a purge stream to the gas scrubber. Product gas from the gasifier will be scrubbed in a venturi scrubber to remove fine particulates. A purge from the recirculating scrubber loop will be directed to wastewater treatment. This purge will be necessary to control the buildup of chlorides and/or total dissolved solids (TDS) from the system to prevent excessive corrosion rates.

Samples of purge water from the Texaco Pilot Gasifier at Montebello have been analyzed as a result of the January 1979 and January 1980 test runs on Fort Lewis mineral-residue slurry (vacuum column bottoms). Samples of purge water from the January 1979 run were submitted to Resource Conservation Company where the analyses were performed. Samples of the purge water from the January 1980 run were submitted to HydroQual where the analyses were performed.

As in the case of the dissolver purge, only limited data are available on some of the wastewater parameters of interest; therefore, the following must be recognized:

1. The vacuum bottoms used as feed to the pilot gasifier were not produced from the coals expected to serve as feed to the demonstration plant. However, they are expected to suffice as a reasonable representation for design purposes.
2. Operation of and equipment in the pilot unit does not fully represent operation and equipment of the demonstration plant.
3. The range of contaminant concentration that may be produced in the demonstration plant can only be predicted from the results of pilot tests on two feeds within a certain range of accuracy.
4. The most extensive body of wastewater parameters — that produced by Texaco — may not be completely reliable because problems with recirculating water system equilibrium and electroneutrality were experienced.

Additional test work in this area is anticipated.

Coal pile runoff

Rain falling on the feed-coal storage piles will produce a highly contaminated runoff stream important to the design of the wastewater treatment system. Although the results of ORNL leaching tests are available (see Appendix K), planned test work to produce design data on this waste stream has not yet been conducted. A review of the technical literature now under way is expected to conclude that a test program is required to obtain data adequate for the design of wastewater treatment facilities.

It is evident that this waste from pyritic coals will be high in iron, acidity, and sulfate content and will have significant levels of many minor and trace components. To establish a coal pile runoff composition to serve as a basis for design, preliminary values will be used for the first effort at a material balance for the wastewater treatment plant. These preliminary values are drawn from a literature survey based on data collected by coal-fired generating stations, coal mines, and other such facilities.

Slag pile leachate

It is expected that slag will be dewatered and transported in a moist condition to a disposal area equipped with an impervious clay liner. Rainwater falling on the slag pile will produce a leachate water. Test work performed by HydroQual on slag produced during the January 1980 gasifier run on Fort Lewis pilot-plant vacuum-column bottoms showed that the leachate water would be only lightly contaminated. ORNL leaching tests reported in Appendix K support this conclusion. Based on these results, it was decided that this water could be recycled to serve as part of the water makeup requirement to the gasifier system.

Gas-treating condensates

In the system that processes the gas produced in the gasifier, various aqueous condensates will be generated. These will generally be contaminated with volatile components including H_2S , NH_3 , CO_2 , and HCN . It is planned that these condensates will be recycled for use as purge-water makeup to the dissolver system. Thus, they will not represent a feed to the wastewater treatment systems.

Cooling tower blowdown

A blowdown purge stream will be provided to prevent the buildup of scale or corrosion-producing components in the recirculating cooling-water system. Much of the heat dissipation in the cooling tower will result from the evaporation of a fraction of the circulating water, thus producing a concentration of nonvolatile components. Since clarified river water will be used as makeup to the cooling towers, the main contaminants in the blowdown will be the same components found in the river, but at higher concentrations. Additionally, chromium and chlorine, used respectively for control of corrosion and microbial fouling, are expected in the blowdown stream. Based on average data on the composition of Monongahela River water and on four cycles of concentration, Table C.5 presents an estimate of the blowdown composition expected.

Table C.5. Characteristics of cooling tower blowdown (untreated)

Element	Mol. wt%	Concentration [ppm (a)]	Lb/h	Mole/h	Concentration range	Source	Remarks
H ₂ O	18		544,000				370 gpm processed cooling tower; 718 utility cooling tower
pH		[7.5]				a	Assuming phosphate/low Cr treatment
TSS		20	10.88			b	
TDS		1,280	695				Sum of molecular species
Total solids		1,300	706				
Alkalinity	100	100	54.4	0.544		b	River concentration × four cycles
COD		200	108.8			c	
Oil and grease						b	
Cr	52	2.0	1.09	0.02		a	
SiO ₂	60	20.0	10.9	0.18	150 maximum	d	River concentration × four cycles of concentration
Cl ⁻	35.46	31	16.86	0.476		a,d	River concentration × four cycles of concentration
SO ₄ ²⁻	96	776	422	4.4	1000 maximum	d	River concentration × four cycles
PO ₄ ³⁻	95	10.9	5.9	0.0624		d	Corrosion reduced with increased use
Fe ³⁺	55.85	<1				e	
Hg	200.61						
Zn ²⁺	65.38	5	2.72	0.0416		a	
Ca ²⁺	40	198	107.7	2.69		d	Raw water Ca × four cycles of concentration
Mg ²⁺	24.32	68	37.0	1.52	600 maximum		
Na ⁺	23	53.2	28.9	1.26			

^aHandbook of Industrial Water Conditioning, 7th ed., 1970.

^bBest estimate.

^cHandbook of Environmental Control.

^dRaw water analysis (July 15, 1980, Process Design Guidelines) × four cycles of concentration.

^eW. B. Thomas, "Keys to Successful Cooling Tower Operation," Hydrocarbon Process., May 1980.

Process area runoff

Process area runoff will consist of all waters draining from areas potentially contaminated with process fluids; it excludes runoff from tank-storage areas and coal-feed preparation areas, which are discussed later. This wastewater will consist of both storm water and utility wash water that has been used to clean process areas and equipment.

Coal-handling area runoff

Rainwater and washwater used in the coal-preparation area will be contaminated with solid coal particles and with soluble components leached from the coal.

Tank-storage area runoff

Rainwater falling on the diked storage areas will be accumulated within the dike and will be processed with the process-area runoff.

C.3.6.2.2 Wastewater treatment alternatives

The proposed wastewater treatment system is shown in Fig. C.9. Wastewater treatment alternatives are shown in Fig. C.10. The integrated process sequence shown in Fig. C.9 has not been carried out at any scale. The possibility that trace contaminants will survive the proposed treatment system is recognized. This uncertainty is part of the reason for designing in full wastewater recycle (zero wastewater discharge) capability. The monitoring program (Sect. 4.5) includes monitoring the discharge and the river to determine the effectiveness of the treatment system and to determine when to convert to zero-discharge operation.

Oil-water separation

The various process-wastewater streams and are runoffs may contain floating oils, and these streams may vary widely in flow rate.

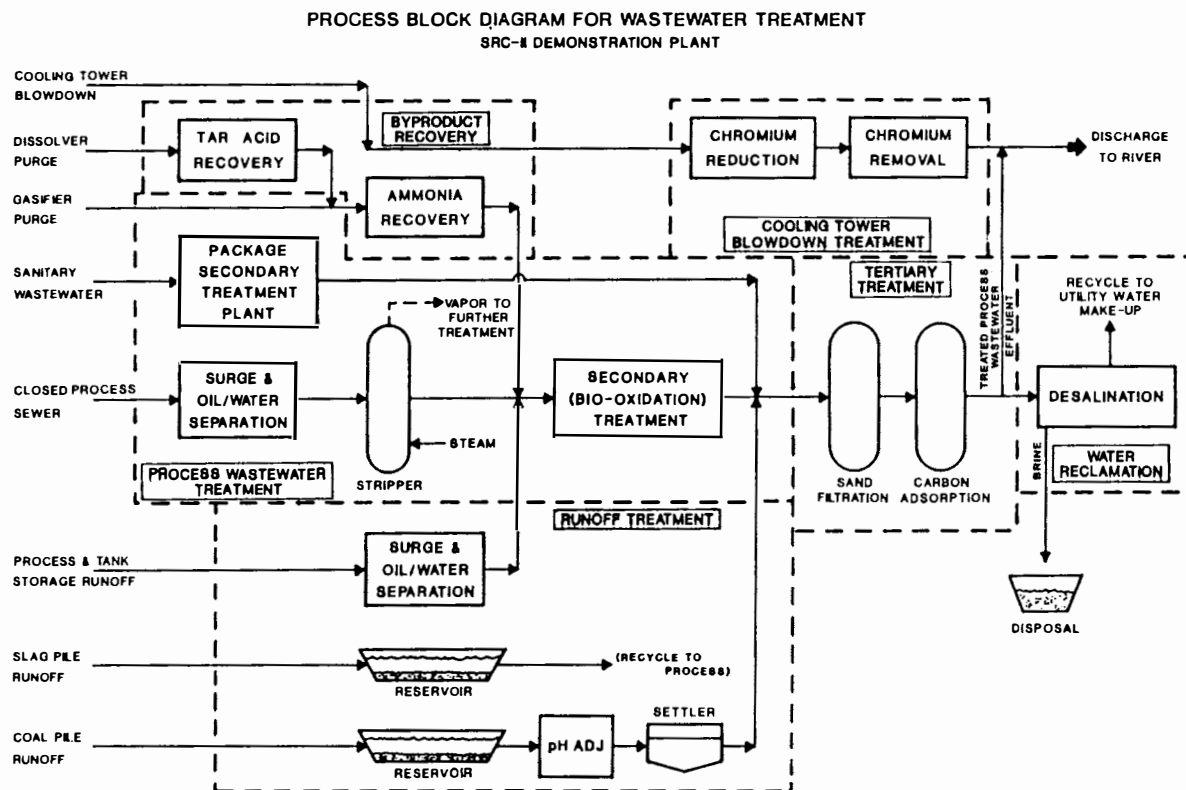


Fig. C.9. Process block diagram of proposed wastewater treatment.

The removal of floating oils from these wastewater streams will be provided in large floating-roof tanks. The wastewater will be pumped from the tanks at a controlled rate to downstream treatment processes. The variable influent to the tanks will cause the tank water level to vary. The floating roof will be equipped with an oil-skimmer device to permit the periodic removal of accumulated oil, which will be recycled to the fractionation area.

Alternative devices for the removal of floating oils include API separators, parallel-plate separators, and dissolved-air-flotation devices.

The floating-roof tank was chosen for the following reasons:

- API separators are not easily equipped for vapor-contained operation.
- Parallel-plate separators do not perform well with a highly variable feed flow. Material tends to accumulate on the plates during low flow, to be flushed out during extremely high flow.
- The performance of dissolved-air flotation devices is more stable under variable flows, but it puts a substantial load on the vapor-control systems.
- Flow equalization is required for these streams in any case, so that the floating-roof tank serves a dual purpose, which none of the other devices provide.

Tar-acid recovery

The primary function of this unit will be the removal of phenol, cresols, xylenols, and other phenolics from the dissolver purge-water streams. Secondly, these materials may be recovered for use as fuel, or for purification and sale as chemicals. The removal of phenolics will be essential to prepare the water for discharge, or for reuse as boiler feed water and cooling-tower makeup. The methods that may be used for the removal of phenolics from wastewater include: solvent extraction, biological oxidation, chemical oxidation, resin adsorption, and steam stripping.

WASTEWATER STREAMS	TREATMENT PROCESSES								
	1	2	3	4	5	6	7	8	9
PROCESS STREAMS	X	X	X	X	X	X	X	X	
COOLING TOWER BLOWDOWN				X	X				X
BOILER BLOWDOWN						X	X	X	
SANITARY WASTE					X	X	X		
PROCESS AREA RUNOFF	X				X	X	X	X	
COAL PILE RUNOFF				X	X		X	X	
SLAG LEACHATE					X				

1 OIL/WATER SEPARATION

2 TAR ACID RECOVERY

3 AMMONIA RECOVERY (STRIPPING)

4 pH CONTROL

5 PRIMARY SETTLING

6 SECONDARY (i.e., BIOLOGICAL) TREATMENT

7 TERTIARY TREATMENT (ACTIVATED CARBON, DEEP SAND
BED FILTRATION, AND OZONATION AS REQUIRED)

8 DESALINATION (TO PRODUCE BOILER FEED WATER)

9 CHROMIUM REMOVAL

Fig. C.10. Applicability matrix for wastewater treatment process used in SRC-II demonstration plant.

Samples of purge water produced in the P-99 pilot-plant dissolver were tested in a laboratory-scale, continuous-flow extraction column by Chem-pro. Very low effluent phenol levels were achieved.⁶ It has not yet been established whether additional test work will be required by the competing technology suppliers.

Biological oxidation of phenolic compounds at low and moderate levels is widely practiced in the petroleum, chemical, and coking industries.⁷ Specific test work on the biodegradation of organics present in the P-99 dissolver purge water is being conducted by GS&TC at Harmorville. Finally, the SRC-II pilot plant at Fort Lewis, Washington, successfully treats the phenolic liquors produced in the process in a biological-oxidation system.⁸

The methods for removal of tar acids being evaluated for use in the demonstration plant are a combination of primary physical removal by solvent extraction or resin adsorption followed by biological oxidation for removal of residual tar acids to a very low level.

The extraction of phenolics from wastewater using crude oil is practiced in oil refineries.⁹ This technique is not considered applicable to the SRC-II plant because fuel-oil streams available for this service are already high in phenolics and other water-soluble components. Chemical (e.g., by H_2O_2) and biological oxidation are not used as primary-removal methods because the high phenolic content of the dissolver-purge water would cause unduly high energy consumption. Oxidation is applicable and economical only for the removal of low concentration of phenolics.

Solvent extraction is a commercially proven technology for the removal of phenolics from wastewater in the coke-production industry.¹⁰ On the other hand, while resin adsorption has been used commercially in the chemical industry, it has only been pilot-tested on coal-processing wastewaters.¹¹

The following commercial technologies are being evaluated for tar-acid recovery in the SRC-II demonstration plant:

<u>Process</u>	<u>Developer</u>
Chem-Pro	Jones & Laughlin Steel/Chem-Pro
Phenosolvan	Lurgi
Resin adsorption	Rohm & Haas

These recovery processes will all produce an effluent very low in phenolic compounds suitable for feed to ammonia recovery (Fig. C.9) and a concentrated stream of tar acids.

Extensive analyses have been performed on the purge water in the P-99 dissolver system.¹² These analyses include a detailed breakdown of the specific compounds which constitute the "phenolic" class; they provide a basis that should be adequate for the design of a treatment system on any of the selected technologies.

Ammonia recovery

The fundamental objective of this unit will be the removal of ammonia and acid gases from the principal wastewater streams. Secondly, these materials may be recovered as by-products. The removal of both ammonia and acid gases from the process stream is essential, whether the water is to be discharged or reused as boiler feedwater and cooling-tower makeup.

Stream-stripping and chemical and biological oxidation are the methods commonly used for removing acid gases from wastewater; steam or air stripping, ion exchange, and biological oxidation are methods for removing ammonia. The probable method to be used in the demonstration plant for removal of both ammonia and acid gases will be steam-stripping followed by biological oxidation, with anhydrous ammonia and sulfur eventually recovered as by-products.

The relatively high concentration of both ammonia and acid gases in the wastewater make steam-stripping the economically preferred alternative. Acid gases, when scrubbed to remove the stripped ammonia, will be combined with the feed to the sulfur recovery unit. The quantity of ammonia removed from the wastewater (approximately 30 tons/d) is sufficient to justify installation of an ammonia-recovery system. The presence of soluble organic compounds in the wastewater necessitates subsequent biological oxidation, which will remove residual sulfides (as BOD) and ammonia (as a nutrient).

Steam-stripping of ammonia and acid gases from wastewater is widely practiced in the petroleum-refining and coke industries.¹³ Under alkaline conditions, ammonia is easily stripped while acid gases are held in solution as ions. Under acidic conditions, the converse is true. Under moderately alkaline conditions (pH 8.0 to 8.5), equivalent quantities of ammonia and acid gas may be stripped without the addition of acid or alkali. Usually, nonvolatile acid ions, which are also present in the wastewater, cause a portion of the ammonia to remain in solution to satisfy

electroneutrality. This ammonia, termed "fixed ammonia," is removed from solution by addition of an alkali before stripping in a second "fixed ammonia" still.

Purge water from the intermediate-pressure separator following the dissolver and blowdown from the gasifier-quench system will be the ammonia and acid-gas-containing streams requiring treatment. Data have been obtained¹⁴ on the composition of the dissolver-purge stream from the P-99 dissolver system. Test work on the composition of the gasifier wastewater has been performed by Resource Conservation Company¹⁵ and HydroQual, Inc.¹⁶ Further test work on the steam stripping of the dissolver-effluent stream is under way at the P-99 pilot plant.

The following commercial technologies have been developed for the separation of ammonia from the stripped acid gases, with economical recovery of both the ammonia and the acid gases:

<u>Process</u>	<u>Developer</u>
Phosam W	U.S. Steel
WWT	Chevron
CLL	Chemie Linz/Lurgi
WAL	Bethlehem International Engineering Co.

All of these processes are expected to produce an acid-gas stream of low ammonia content suitable for further processing in the sulfur-recovery plant, an ammonia product suitable for sale, and a stripped effluent water with ammonia and sulfate content low enough to avoid any adverse impact on the biological oxidation system or on the discharged effluent. Discussions are under way with these technology suppliers in preparation for bid inquiry.

pH control

The purpose of pH neutralization will be to (a) neutralize acidic waste streams, (b) provide hydroxide alkalinity to promote the removal of soluble metals through formation of insoluble metal compounds, and (c) promote the removal of ammonia by stripping. Prospective chemicals that can be used for pH control include: quicklime, hydrated lime, sodium hydroxide, limestone, and magnesium oxide. Limestone and magnesium oxide cannot practically achieve the high pH levels required for metals and ammonia removal. Because sodium hydroxide increases the wastewater TDS level and the limes do not, sodium hydroxide was rejected. The choice between hydrated lime or quicklime will be based on economics. Lime additionally produces a sludge that is more easily settled and dewatered; this will improve operability.

Primary settling

Primary settling will comprise those operations for gravity separation of settled solids and floating matter from the wastewater. Generally, this operation precedes biological oxidation (i.e., secondary treatment) because significant reductions in organic loading to the biological process can be achieved by removing settleable organic matter in settling basins. However, in the case of the demonstration plant, the majority of solids removed in primary settling is expected to result from the liming operations performed on the process waste stream. The design will also provide for the addition of coagulant aids to promote increased solids removals in the primary settling basins.

Alternative primary solids-removal processes that were considered are dissolved-air flotation and parallel-plate (or tube) settlers. These processes, however, can be prone to clogging and operability problems.

Secondary (biological) treatment

Substantial levels of dissolved organic matter are expected to be present in the major continuous purge streams from the SRC-II demonstration plant processes. Analytical testing of the P-99 dissolver purge water has been performed by GS&TC, both before and after solvent extraction.¹⁷ These tests have shown that dissolved organic matter will still be present in the purge water after tar-acid recovery. Test work is being performed by GS&TC to determine the effectiveness of biological oxidation in treating the dissolver purge-water stream for organic removal. Additionally, the effluent from the SRC-II pilot plant at Fort Lewis, Washington, has been successfully oxidized biologically over an extended period of time.¹⁸

Analysis by both Texaco Development Co.¹² and HydroQual¹⁶ on the gasifier-system water-purge stream has demonstrated the presence of dissolved organic matter in that stream. Treatability tests were conducted by HydroQual on the purge stream from the Texaco gasifier pilot plant at Montebello, California. The wastewater was gravity-settled, limed, and stripped to remove ammonia. The pretreated effluent was then tested for amenability to treatment by biological oxidation,

chemical oxidation with hydrogen peroxide, and activated-carbon adsorption. HydroQual concluded that biological oxidation was substantially more effective than the other two systems at removing the dissolved organics from this waste.

Literature data on slag leachates¹⁹ indicate that these streams can be expected to be very low in dissolved organic matter and will not require biological treatment (see also Appendix K).

Tertiary treatment

In the context of this discussion, "tertiary treatment" connotes those treatment processes that follow secondary (biological) treatment. It is expected that biological treatment alone would produce an effluent stream sufficiently low in dissolved organic matter to allow discharge to the Monongahela River. However, because this is a demonstration plant and because many water users lie downstream, it is expected that the effluent will be additionally treated by sand filtration and activated-carbon adsorption and possible ozonation before discharge. Carbon adsorption would provide further removal of dissolved metals and organics,^{20,21} and would protect the river against an operational upset of the biological system. The efficiency of adsorption of metals in wastewater on carbon is not predictable from literature data. Although it may be indicative of prospects for effluent improvement, it should not be used to predict the effluent concentrations that are likely to be achieved in the demonstration plant effluent. Activated-carbon removal efficiencies may differ markedly from predicted values in a specific wastewater because of the influence of complexing agents, pH, total ionic strength, and other factors. Laboratory treatability tests are planned to be conducted during 1981 to more adequately determine the expected removals for demonstration plant waste.

Sand-filter backwash would be returned either to the primary clarifiers or to the sludge storage tank. Flow-equalization facilities would be provided to prevent shock loading of the secondary-treatment system.

Estimates have been made of organic compounds and trace elements in the effluent waters from the process water-treatment plant after tertiary treatment. These estimates are shown in Sect. C.4.2.

Sludge incineration

An incineration system will be provided to handle biological and sanitary sludge, specifically 175 lbs/h of organic material dry basis and 17.5 lbs/h of ash together with 1075 lbs/h of water. This material and alternative feed materials will be fed only on an occasional basis throughout the year. The first alternative feed is an emulsion consisting of 2862 lbs/h of oil, 286 lbs/h of ash, and 1889 lbs/h of water. The other alternative feed is 20 lbs/h of soluble organics, 3 lbs/h of oil and grease, 3 lbs/h of ammonia, 1860 lbs/h of dissolved and suspended solids, and 5214 lbs/h of water.

Desalination

The need for wastewater-reclamation facilities to eliminate or reduce the treated wastewater discharge to the Monongahela River was described above. This system will separate a salt-free water stream for use within the utilities section, and will, when required, concentrate the effluent brine for storage or alternate disposal.

The levels of contamination found in the distillate stream are not expected to adversely affect the performance of the cooling tower and, with minor ion-exchange polishing, will produce acceptable boiler-feed water. This distillate stream will be monitored to ensure that a malfunction of the evaporator does not result in the use of unacceptable water in the utilities section.

The processes considered for this service were the common desalination processes of evaporation, reverse osmosis, electrodialysis, and ion exchange; currently, evaporation is preferred.

Ion exchange was eliminated from further consideration because the required regenerated solutions would increase the salt-disposal problem. Electrodialysis was eliminated because of limited commercial experience, questions of reliability in producing a permeate of very low salt content, and potential membrane-fouling problems.

Reverse osmosis is still under consideration for this application. It has been demonstrated commercially and is being used to produce high-quality water from salty cooling-tower blowdown in the electrical-power industry.²²

The reclaimed water from the desalination equipment will produce water of a quality suitable for boiler-feedwater makeup, with perhaps only minor polishing necessary, using ion-exchange equipment.

An alternative method for making boiler feedwater would involve processing clarified raw water through demineralizers. Not only would this increase the river-water intake requirement, but the discharge of spent regenerant solution to the river would increase the dissolved solids concentration in the Monongahela River.

Data on the salt content of the major continuous wastewaters from the SRC-II demonstration plant have been estimated from analytical testwork on waters produced in the Texaco gasifier at Montebello, California,¹⁴ and the P-99 Pilot-Plant dissolver at Harmarville, Pennsylvania.¹² These streams have been analyzed by Texaco, Resource Conservation Co., HydroQual, and GS&TC.^{16,12} These data, combined with data on the chemical composition of potential feed coals to the demonstration plant, have provided a basis for the design of desalination equipment.

One evaporator configuration was successfully tested by Resource Conservation Co. in pilot-scale equipment.¹⁵ In this test, purge water from the Texaco Gasifier at Montebello was limed and steamed-stripped to remove ammonia; then, it was reconcentrated to a salt slurry in a pilot-plant vapor compression evaporator.

Multiple-effect evaporation is being considered as an alternative to vapor-compression evaporation. The technology finally selected will depend on the availability of low-pressure steam. If the overall steam balance for the demonstration plant indicates that an oversupply of low-pressure steam exists, the use of multiple-effect evaporators would be strongly favored.

It may also be practical to include a reverse-osmosis unit in the desalination system. Although this process would not make water of boiler feed quality, it could produce cooling-tower makeup at a lower energy cost. Both salt precipitation and bacterial residue would present potential membrane-fouling problems, so that a pilot demonstration of this technology would be required to establish its feasibility for the demonstration plant.

Chromate treatment

Cooling tower blowdown can be treated in the desalination equipment to eliminate its discharge to the river. For cases where discharge is desirable, removal of chromates from the cooling-tower blowdown is necessary to produce a treated blowdown stream suitable for discharge to the river.

Chemical reduction of the chromium from the hexavalent to the trivalent state followed by lime addition to a pH of 8.5 to 9.0 will permit the chromium to be removed from the blowdown stream as insoluble chromium hydroxide. Total chromium concentration will then be about 0.2 mg/liter as shown in Table C.21 in Sect. C.4.2.

Alternative methods for chromium reduction are chemical and electrochemical. An alternative to the use of biocides is a phosphate-based biocide.

C.3.7 Disposal of solid wastes

Four types of solid wastes will be generated by the operation of the SRC-II demonstration plant. Their approximate quantities and methods of disposal are shown in Table C.6.

Table C.6. Quantities and disposal methods for solid wastes

Material	In-plant treatment		Method of disposal	Approximately daily quantity (dry basis, tons) ^a
	Dewatering	Incineration		
Gasifier slag	X		Separate secured landfill	720
Water-soluble salts			<i>b</i>	22 ^{c,d}
Process sludges				
Liming sludge	X		Common secured landfill	32
Biological sludge	X	X	Common secured landfill	2
Cooling-tower blowdown treatment sludge	X		Common secured landfill	8
Sanitary sludge	X	X	Common secured landfill	0.1
Rainwater-runoff treatment sludge	X		Common secured landfill	0.7
Catalysts and adsorbents			Offsite reclamation or secured landfill	0.8

^aBased on 6000 tpsd.

^bRefer to Sect. C.3.7.2.

^cBased on average chloride content of coal (.09 wt %).

^dTo convert to gal of brine per day, assume 0.43 lbs of solids per gal of brine (102,000 gal of brine per day at design rate in zero wastewater discharge mode).

C.3.7.1 Gasifier slag

Slag-leaching tests

Leaching tests of the gasified mineral-ash residue (slag), as outlined by the EPA regulations and test methods implementing the Resource Conservation and Recovery Act (RCRA) and other ASTM methods, have been carried out. These preliminary findings indicate that the material will be classified as nonhazardous. Current plans, however, are to design the slag-disposal area to meet RCRA requirements for disposal of hazardous materials until demonstration plant operation confirms the results of the leaching tests. These tests performed on gasifier slag, to date, are discussed in the following paragraphs.

A. Oak Ridge National Laboratories (ORNL)

Ten drums of slag produced by Texaco's Montebello Pilot Plant gasifier from vacuum bottoms produced from Kentucky 9 coal at the Ft. Lewis SRC-II Pilot Plant were received at ORNL on September 25, 1978. Most drums contained a mixture of coarse and fine slag added in proportion to that observed during the gasification run. One drum contained "as-made" slag that had not been separated into coarse and fine fractions (MRL Run 57808). This material was selected for leaching tests. Its analysis is shown in Table C.7.

**Table C.7. Analysis of selected elements
present in feed coal and ash/slag
(determined by neutron activation analysis)**

Element	Feed coal ^a	Ash/slag
Aluminum, %	1.22	9.83
Antimony, ppm	<i>b</i>	<i>b</i>
Arsenic, ppm	7	46
Barium, ppm	57	310
Calcium, %	0.82	2.26
Cesium, ppm	1	7
Chromium, ppm	21	708
Cobalt, ppm	1.4	36.8
Copper, ppm	≤60	≤300
Iron, %	1.17	15.8
Magnesium, ppm	0.16	1.3
Manganese, ppm	11.0	274
Molybdenum, ppm	10	63
Potassium, %	0.258	1.9
Rubidium, ppm	<i>b</i>	<i>b</i>
Selenium, ppm	3.0	17
Silver, ppm	<i>b</i>	≤10
Sodium, ppm	349	2350
Strontium, ppm	38	170
Thorium, ppm	1.4	14
Titanium, ppm	693	4590
Vanadium, ppm	90	457
Uranium, ppm	1.54	18
Zinc, ppm	<i>b</i>	≤600

^aORNL sample of Western Kentucky No. 9, not necessarily representative of actual feed coal producing the ash/slag.

^bNot analyzed.

Batch leaching results. Five types of batch leaching have been completed (EPA-EP, ASTM distilled water, ASTM at pH 4.5 using a sodium acetate - acetic acid buffer solution, 0.1 *N* NH₄OH, and 0.1 *N* HNO₃). All tests were performed using slag/extractant weight ratios, time intervals, and equipment suggested in the proposed standard leaching tests. The last two leaching tests are not "standard," but the same techniques and solid-to-liquid ratios were used. All elemental analyses were performed using atomic-absorption techniques. All of the species and elements in the EPA-Interim Primary Drinking Water Standards (except cyanide and nitrate) were determined, plus beryllium, sulfate, copper, nickel, and iron. Nitric acid is required to preserve samples for later trace-element analysis, and as a result, nitrate analysis has no significance. The additional analyses

were performed because they are of environmental concern, and in the future, they may be added to the currently proposed RCRA list of trace-element limitations in leachates. Results of the five types of batch leaching are given in Appendix K and Table C.8, along with the RCRA Standards where applicable.

Table C.8. Elemental analysis of leachates derived from various batch-leaching protocols

Element ^a	EPA EP	ASTM H ₂ O	ASTM pH 5	0.1 N HNO ₃	0.1 N NH ₄ OH	RCRA Limit criteria ^b
Arsenic, ppb	0.53	<5	<5	6.1	2.4	5000
Barium, ppm	<0.5	<0.5	<0.5	<0.5	<0.5	100
Cadmium, ppb	3.4	4.0	4.9	25	1.3	1000
Chromium, ppb	0.13	3.7	3.9	42	1.9	5000
Lead, ppb	1.6	5.2	2.1	8.3	4.4	5000
Mercury, ppb	0.191	0.025	0.010	0.04	0.33	200
Nitrate (as N), ppm	c	<0.05 ^d	<0.05 ^d	c	c	1000
Selenium, ppb	<1	0.04	0.04	<1	7	1000
Silver, ppb	0.07	0.09	0.23	3.2	0.20	5000
Sulfate, ppm	4.89	23.63	22.90	26.79	36.57	None
Iron, ppm	20.5	147	720	2482	0.06	None
Copper, ppb	0.94	c	c	c	c	None
Beryllium, ppb	0.09	c	c	c	c	None
Antimony, ppb	<2	c	c	c	c	None
Nickel, ppb	758	c	c	c	c	None

^aThe first 10 elements are in Interim Primary Drinking Water Standards.

^bAs of May 18, 1980.

^cNot determined.

^dSamples not acidified before analysis.

Column leaching studies. Column-leaching experiments in laboratory columns (3.75-in. diam) have been completed, but analytical results are only partially complete. These columns have a 30-cm (12-in.) depth of slag and are dosed daily with 1 liter of demineralized water (about one column volume). Results for leaches 1, 3, 10, 20 are given in Table C.9. Generally, column leachate concentrations are less than batch leachates, which may be due to shorter contact time between the water and the slag or other factors.

Table C.9. Elemental analysis of slag leachates derived from laboratory columns [Texaco/Montebello ash/slag (SRC-II vacuum bottoms) (all units in ppb)]

Column number	Element	Leach number			
		1	3	10	20
1	Arsenic	1.16	0.79	2.0	3.1
2		1.36	1.33	1.53	3.4
1	Barium	<0.5	<0.5	<0.5	<0.5
2		<0.5	<0.5	<0.5	<0.5
1	Cadmium	11	0.13	0.014	0.10
2		16	0.11	0.020	0.091
1	Chromium	7.0	3.5	0.25	0.49
2		6.2	3.2	0.24	0.41
1	Lead	1.4	<0.3	<0.3	<0.43
2		0.93	<0.3	<0.3	<0.3
1	Mercury	0.007	0.024	0.013	0.019
2		0.011	0.012	0.003	<0.001
1	Selenium	120	44	16	<5
2		195	34	<5	<5
1	Silver	0.34	0.17	0.13	0.10
2		0.36	0.17	0.12	0.10

Based on RCRA regulations (May 19, 1980), this slag should be classified as "nonhazardous." Subsequent modifications of these regulations, or the addition of bioassay tests or other trace elements not on the current list, could invalidate this conclusion. However, the 0.1 N HNO₃ leach, which is more severe than would be expected in a landfill environment, does not appear to exceed RCRA criteria.

B. HydroQual, Inc.

Tests have been performed on slag produced with Texaco's Montebello pilot-plant gasifier, using mineral-residue slurry produced from the Fort Lewis pilot plant using SRC-II demonstration plant design coal (Powhatan). These data still are considered proprietary by Texaco but are in the process of being declassified. The conclusions of the tests are the same as for the tests performed by ORNL.

C. Gulf Research and Development Company

In order to determine whether organic constituents remain in the slag, further leaching tests were performed. Vacuum bottoms from the Fort Lewis pilot plant were gasified in a Texaco gasifier. At the GR&DC facility at Harmarville, Pennsylvania, the gasifier slag was subjected to a benzene extraction. This procedure was used to extract organics from slag and is far more severe than any condition that would occur in a landfill. Following the extraction, the benzene leachate was analyzed for the presence of benzene-solubles and polynuclear aromatic (PNA) compounds. The results of the extraction under these extreme conditions are shown in Table C.10 and indicate that benzene-soluble constituents are present in the slag in very low concentrations. Because of the very high gasification temperature, no appreciable change in benzene-soluble constituents would be expected in the slag produced by gasifying mineral-residue slurry of other coals. Under actual landfill conditions, leaching of organic constituents is not expected to be of environmental concern.

Table C.10. Concentrations of benzene solubles and selected polynuclear aromatics in SRC slags

	Coarse slag	Fineslag
Total benzene solubles (wt %)	0.0315	0.0165
Benz[a]anthracene (ppb)	12	10
Benz[a]pyrene (ppb)	17	13
Benzo[e]pyrene (ppb)	4	17
Benzo[g,h,i]perylene (ppb)	8	5

Slag disposal

The proposed location of the slag disposal area is shown in Fig. C.1, Sect. C.2. The design of the slag disposal area is shown in Figs. C.11 and C.12. The slag disposal area will be built in a natural depression by constructing two retention dams, removing usable materials, sealing the coal seam, backfilling, and excavating a highwall. A 3 ft-thick clay liner, compacted to a permeability of 10⁻⁸ cm/s, is proposed for use as the base of the disposal area. Fencing and other RCRA requirements will also be provided.

Diversion ditches will prevent precipitation runoff from entering the slag landfill, and precipitation falling on the slag will be pumped from the base of the disposal area back to the wastewater treatment area. When the slag landfill reaches full height, the surface will be graded and contoured to the desired drainage pattern, covered with earth, and revegetated. Monitoring wells as described in Sect. 4.5 of this EIS will be developed to monitor groundwater up-gradient and down-gradient from the disposal area.

The slag disposal area will be of sufficient size and capacity to dispose of the slag generated throughout the demonstration period plus 25 years of operation of an expanded commercial plant with a capacity of 30,000 tons/d of coal. During the demonstration period, the natural depression of the slag disposal area is of sufficient capacity so that the level of the disposed slag will not exceed that of the surrounding area. However, after 25 years of operation of the expanded commercial plant, the upper level of the slag pile will be about 80 ft above the surrounding terrain.

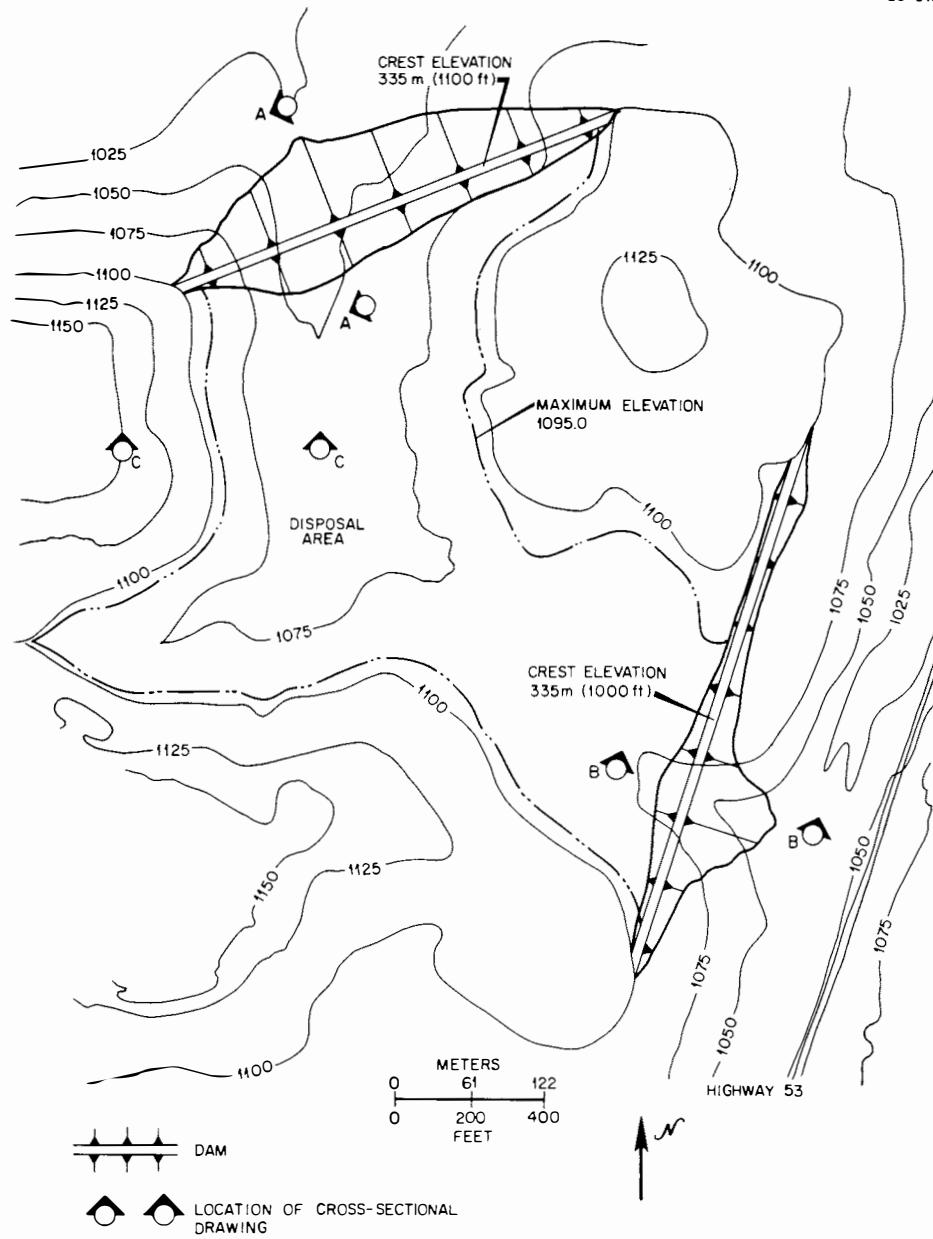
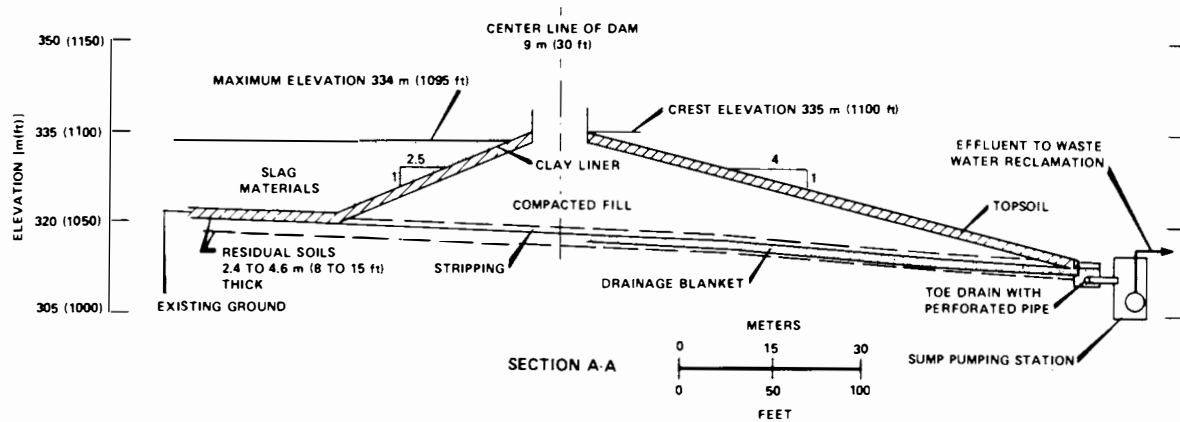
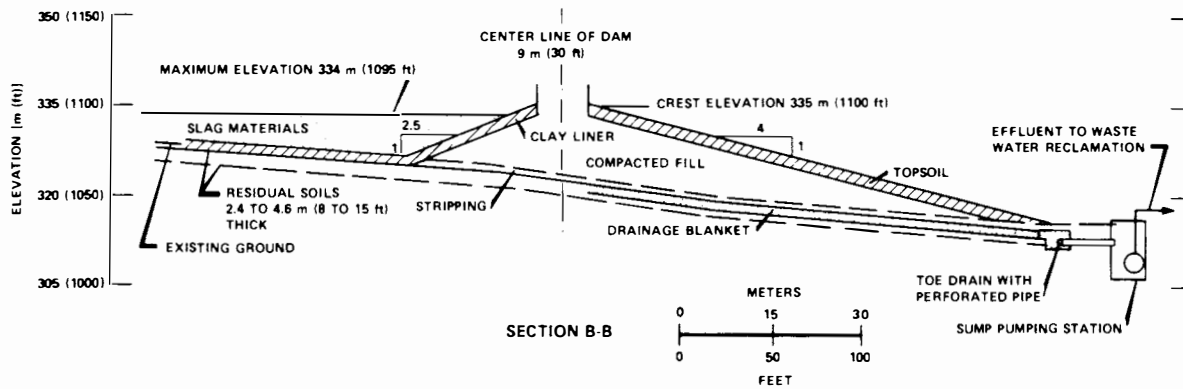


Fig. C.11. Topography of the proposed slag disposal area.

ES-5130R



ES-5152R



ES-5153R

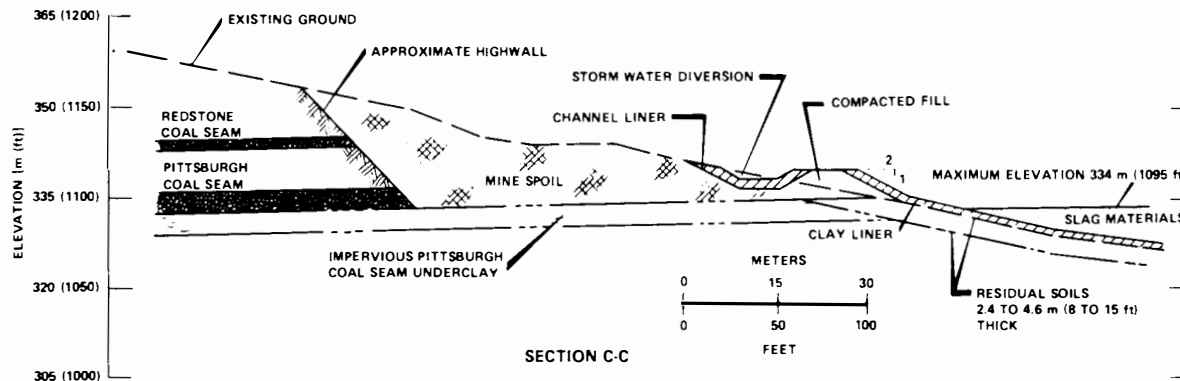


Fig. C.12. Cross sections of the proposed slag disposal area.

Figure C.13 shows a cross section of the slag disposal area conceptual design, depicting the area as it now exists and how it will appear at the end of the demonstration period and at the end of the commercial period.

C.3.7.2 Water soluble salts

As discussed in Sect. C.4.2, it is believed that the soluble salts that result from plant operation will be discharged to the Monongahela River a majority of the time. During times when river conditions dictate a cessation or reduction in the quantity of total dissolved solids (TDS) or other wastewater species discharged, the desalination equipment will be operated, and the soluble salts will be recovered as a concentrated brine. Due to the relatively low initial production rate of brine that is anticipated (see Table C.11), an acceptable plan for brine disposal will not be a pressing need for at least the first two years. (See Table C.3 for plant capacity vs time during the demonstration period.) Consequently, it is planned to retain the brine during this period in a small reservoir (see Table C.11) constructed in accordance with RCRA requirements when issued. This two-year period will provide time to more thoroughly assess the chemical characteristics of the brine and to develop a suitable disposal plan. If it becomes necessary to permanently dispose of the brine during this two-year period, it will be hauled by truck to a certified disposal site unless another environmentally acceptable disposal alternative is verified.

Brine-disposal options currently being considered include chemical landfill, chemical fixation, deep-well injection, and shipping by barge to the ocean.

Operating capacity

Because the coal will be the major source of most soluble wastewater contaminants, the plant's throughput of coal will greatly affect the quantity of salts being handled in the wastewater treatment system. Plant capacity as a function of time during the demonstration phase is discussed in Sect. C.2.

Onstream time

Similarly, salts will be generated primarily when coal is being processed. Estimates of these factors are presented in Table C.2. The coal pile will continue to generate leachates containing soluble metal salts also.

Coal composition

Obviously, the composition of the feed coal will greatly influence the salt production rate. Chlorides, the most important factor in this regard, have been measured at an average value of 0.09 wt % in Pittsburgh No. 8 coal with a standard deviation of 0.12 wt %.

River assimilative capacity

The capacity of the Monongahela River to accept various wastewater contaminants is a function of river flow rate and composition. The assimilative capacity of the river for total dissolved solids (TDS) is illustrated as a statistical probability in a later section (Fig. C.16). Presumably, in the early years of the demonstration plant life, little other industrial development of this watershed will have taken place, so a good deal of the existing assimilative capacity would be available to the demonstration plant if acceptable to permitting agencies, as is believed. As other development occurs in the area, the assimilative capacity available to the SRC-II plant would be reduced, thereby increasing the need for periodic, or even continuous, use of the evaporators and disposal of brine.

Brine disposal requirements

It is not possible to quantify alternative brine disposal requirements at this time. As discussed above, a number of widely varying and relatively unpredictable factors will influence the need to dispose of soluble salts. The greatest potential influence on disposal requirements would presumably be the occurrence of a lengthy drought. Sufficient data on the assimilative capacity of the Monongahela River during such a period is not available.

Crude estimates of the tonnage range in which salts would be produced during non-discharge periods is presented in Table C.11.

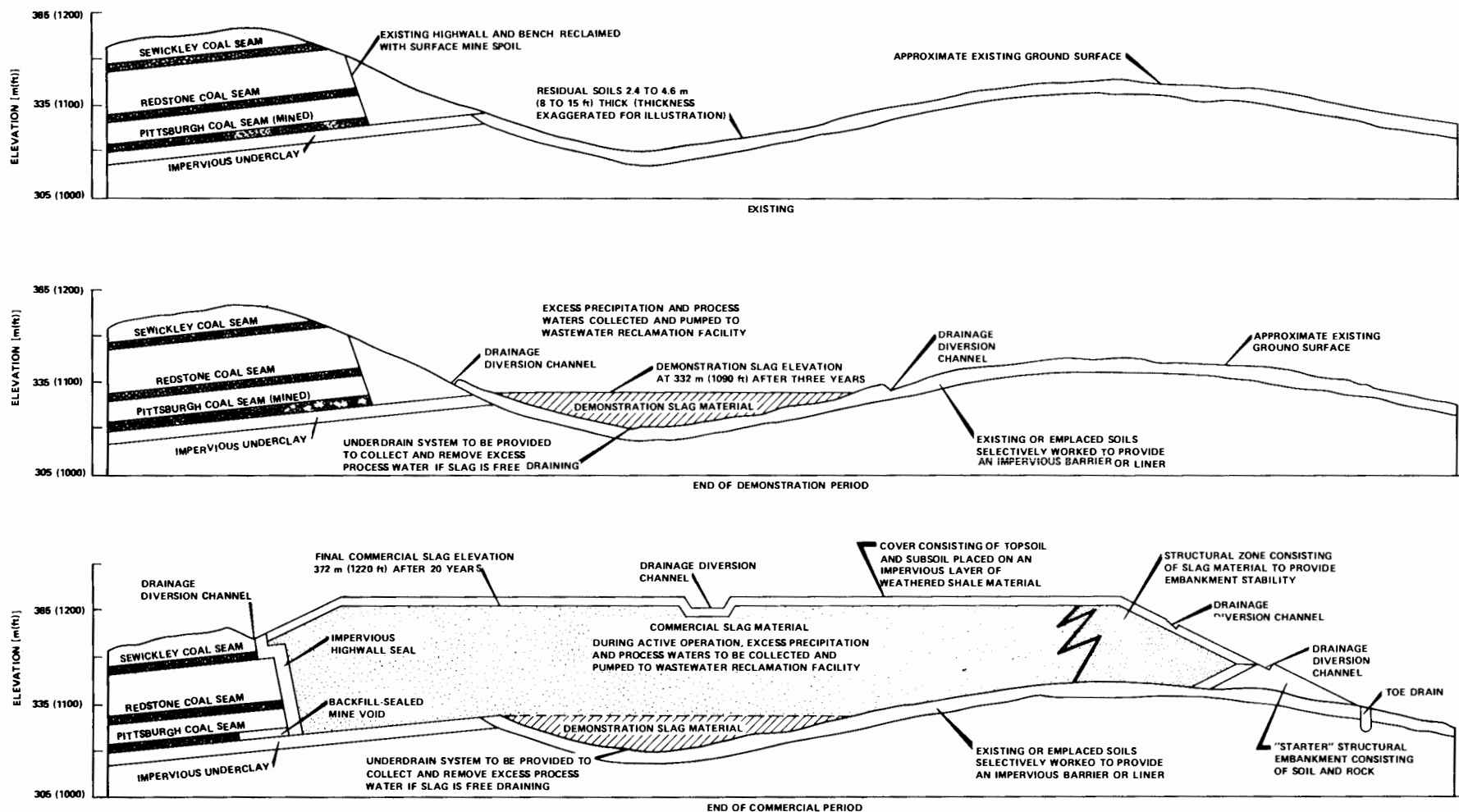


Fig. C.13. Conceptual slag pile cross sections depicting phases from current condition to the expanded commercial phase.

Table C.11. Estimates of soluble salt brine production rate and disposal requirements during the first three years of demonstration plant operation

	Year 1		Year 2		Year 3	
	Average	Worst case ^a	Average	Worst case	Average	Worst case
Chloride content of feed coal (wt %)	0.09	0.2	0.09	0.2	0.09	0.2
Total dissolved solids per ton of coal (lb)	7.2	16	7.2	16	7.2	16
Plant operating capacity ^b (% of design capacity of 6000 tpd coal)	18	50	36	80	50	93
Daily brine production rate ^c (gpd)	18,400 ^d	114,000 ^e	36,700 ^d	182,000 ^e	51,000 ^d	211,000 ^e
Zero wastewater discharge ^{c,f} (% of the year when operating in this mode)	0.1	5	0.5	10	1.0	14
Annual brine production rate ^c (thousands of gal per year)	6.7 _g	2,080	67	6,640	186	10,800
Annual brine storage area ^{c,h} required (acre-feet)	0.02	6	0.2	20	0.6	33
Daily total dissolved solids production rate ^{i,j} (dry basis) (tpd)	3.88	24.0	7.8	38.4	10.8	44.8
Annual total dissolved solids requiring disposal ^{c,i} (dry basis) (tons per year)	1	438 ^k	14	1382	39	2258

^aWorst case assumes that the high value for chloride in coal occurs simultaneously with operation of maximum onstream capacity but does not consider the effect of simultaneous occurrence of low river flow. Data on assimilative capacity of the river during drought conditions are not available.

^bRefer to Table C.2.

^cBrine is produced only when the plant is operating in the zero wastewater discharge mode.

^dBased on 102,000 gal brine per day at 6000 tons of coal per day with 0.09 wt % chlorides.

^eBased on 227,000 gal brine per day at 6000 tons of coal per day with 0.2 wt % chlorides.

^fRefer to Figs. C.15 and C.16.

^gCalculated as follows: (18,400 gpd) (0.1% of the year operating in zero wastewater discharge mode) (365 d/year) = 6,700 gal brine per year.

^h3.259 × 10⁶ gal per acre-foot.

ⁱDaily production of total dissolved solids assumes that these will be largely composed of chloride. A factor of 4.0 is used to convert chlorides to TDS.

^jNote that *brine*, not dry salts, is produced during zero wastewater discharge operation.

^kCalculated as follows: (24.0 tons of dry solids per day) (5% of the year operating in zero wastewater discharge mode) (365 d/year) = 438 tons dry solids per year.

Brine disposal options

Options that have been identified for the alternative disposal of waste soluble salts are:

- onsite chemical landfill,
- onsite chemical fixation and landfill,
- deep well injection,
- barging to sea,
- offsite chemical landfill, and
- storage with subsequent river (high flow period) disposal.

Onsite disposal of these soluble salts, either in a lined hazardous waste facility or by chemical fixation would reduce but not eliminate the long-term risk of contaminating subsurface freshwater supplies with soluble chlorides or other potentially hazardous substances. These alternatives are being considered as disposal options for the intermittent requirements of the demonstration plant and for the long-term requirements of the expanded commercial plant.

Deep well injection is considered a viable option for the long-term disposal of soluble salt. The fully treated wastewater can be injected into a brine aquifer of similar salinity, as is now done in the area near Morgantown, with low potential for environmental effect.

Similarly, barging of the soluble salt to the Gulf of Mexico would not be expected to result in a significant environmental hazard. Operating costs and the impact on barge traffic might preclude use of this disposal option for the long term. It could, however, be an environmentally desirable method for meeting any intermittent requirements of the demonstration plant.

Finally, the concentrated brine could be stored onsite during periods when the assimilative capacity of the river cannot accommodate a wastewater discharge from the plant; it could then be released in a controlled fashion when river conditions permit.

If the options described above are not sufficiently developed to produce an acceptable solution within the time frame demanded by the startup of the demonstration plant, soluble salts produced early in the operation of the demonstration plant can be transported by truck to an offsite chemical landfill.

For the longer term, potential for use of the waste as a chemical feedstock could be explored. This effort, as well as efforts to explore the conventional disposal alternatives described above, is hampered by lack of detailed knowledge of the composition of the product salt. Thorough exploration of these alternatives will, in some cases, have to follow actual production of a product salt.

C.3.7.3 Process sludges

As shown in Table C.6, relatively small quantities of process sludges are expected to be generated from cooling-tower blowdown treatment, coal pile runoff treatment, and raw-water treatment. These sludges will consist primarily of metal hydroxides, calcium sulfate generated through addition of lime, and polymers. Because environmental isolation is necessary to prevent solubilizing the metals caused by contact with rainwater, groundwater, etc., the most practical disposal options available are secured-landfill disposal and chemical fixation. Secured landfill disposal is considered the preferred disposal method, due to the reduced material-handling requirements and increased process reliability. The landfill wall and clay liner design would be similar to Fig. C.12, cross sections A-A and B-B, shown for slag disposal. The process sludge landfill would occupy a smaller area in accordance with the site plan (Fig. C.1).

C.3.7.4 Catalysts and adsorbents

Due to the small quantity of this material, disposal should not be a significant problem. Plans are to return much of the catalyst to the supplier for reclamation. Except for spent activated carbon, the remainder of the catalysts and adsorbents will be disposed of in a secured landfill. It is expected that the spent activated carbon will be either regenerated or incinerated onsite, with disposal of the residue in the common secured landfill provided for process sludges. The landfill wall and clay liner design would be similar to Fig. C.12, cross-sections A-A and B-B, shown for slag disposal. The catalyst/sorbent landfill would occupy a smaller area in accordance with the site plan (Fig. C.1).

C.3.8 Toxic gases

Some combustible and toxic gases such as H_2 , H_2S , and CO will flash when the quench water associated with gasifier operation is reduced to atmospheric pressure. This will be an enclosed operation purged with inert gas; all gases will be directed to the controlled combustor and flare system (Sect. C.3.5.4).

Fugitive leaks of toxic gases in the plant, such as H_2S and CO (and others that are determined to be of concern), will be monitored and corrective action quickly taken to minimize their escape. Continuous-monitoring systems with alarms will be installed. Special operational procedures, such as the restriction of the number of personnel in certain elevated areas, will be used. Respiratory protection equipment will be installed at strategic locations throughout the plant. Sample points for liquid streams with significant H_2S content will be specially designed to minimize the escape of flashed H_2S into the air.

C.3.9 Mechanical considerations

The contract between DOE and the industrial participant states: "The objective of the Phase I effort is to design a demonstration plant with a nominal feed capacity of 6000 tons of coal per stream day using the following design priorities in descending order of importance:

- safety,
- environment,
- operability,
- flexibility, and
- yields and efficiency."

These provisions in the contract emphasize the importance placed on safety and environmental factors by all participants in the project.

It is realized that major mechanical and materials-of-construction problems must be satisfactorily solved for the demonstration plant to be technically and environmentally successful. It is also realized that upset conditions and operability problems causing shutdown, venting, and restart inherently result in environmental problems, because normal operating conditions will generally yield highest levels of emission control performance and offnormal operations may involve by-passing control equipment and going to the flare system. Therefore, in addition to emphasizing conventional environmental controls and equipment during the design, a great deal of effort is being expended and will continue to be expended on the selection of the proper mechanical equipment and materials of construction to provide a plant that can be operated with a minimum of process upsets.

Because only limited information was available on the corrosive and erosive nature of the various plant streams when the Fort Lewis Pilot Plant was designed, a substantial amount of corrosion and erosion problems have been encountered. This was to be expected. One of the major reasons for conducting that particular pilot-plant program was to identify and solve such problems before construction of larger plants. Much has been learned in these areas over the past six years of operation of the Fort Lewis Pilot Plant, and ongoing programs at the Fort Lewis, Exxon, H-Coal, and Wilsonville coal liquefaction pilot plants continue to provide additional data. Data from the P-99 process development unit have provided and will continue to provide information in this area specifically related to the SRC-II process. In addition, much will be learned in the future about general mechanical and materials-of-construction design requirements from the operation of the other larger coal-liquefaction pilot plants that are part of DOE's overall synthetic-fuels development program.

Among the programs under way or planned for the Fort Lewis Pilot Plant to provide supplemental design information are:

- slurry-preheater studies to provide additional mechanical design data, such as heat-transfer rates, pressure drop, and degree of corrosion and erosion;
- specialized pumping tests on several plant streams with particular emphasis on duplicating as closely as possible stream conditions and equipment expected in the demonstration plant;
- continued development of flow-measurement devices for severe services;
- continued development of control and block valves. Much has been learned in this area in the past, but continued improvement is needed and is being pursued. The use of some special valves, such as bellows and diaphragm types, have limited use in the SRC process due to high temperatures and pressures, solids content, and the elevated freezing point of many of the streams;
- continued corrosion and erosion monitoring and testing. In addition to developing more knowledge of the reasons for and corrective actions to be taken to mitigate problems associated with corrosion and erosion, another major objective is to develop non-destructive types of onstream monitoring devices, such as ultrasonic techniques applicable to high temperatures, so that such devices can be used in the extensive onstream-monitoring program planned for the SRC-II demonstration plant; and
- continued development of various types of pump mechanical seals and flushing systems aimed at development of those with maximum integrity.

In spite of the experimental nature of its operation, no major fire or explosion has occurred during the six years of operation of the Fort Lewis Pilot Plant.

Much of the SRC-II demonstration plant will use conventional, well-proven processes and equipment. However, because it is a first-of-a-kind design and has several areas of severe service, special practices will be followed during its design and operations phases beyond what is normally followed in the design and operation of a conventional petroleum plant. These include formalized Safety Hazards Analyses (see Appendix AA), a Reliability, Availability, and Maintainability (RAM) Program, and the increased use of monitoring in the preventive-maintenance program to mitigate equipment failures and leakage of process streams into the environment.

The use of double piping and enclosure of the liquefaction and distillation areas were considered to mitigate leakage of potentially carcinogenic materials outside of the plant area. The use of these design features was rejected for the design, safety, and operational reasons listed below.

Double piping

- This method would prevent monitoring of wall thickness during operation or even during shutdown periods. Reduction of wall thickness and strength of pressure parts is of concern related to corrosion and erosion.
- Many of the pipe runs handling vacuum bottoms at 400°F or more must be heated electrically because steam or Dowtherm tracing are not considered desirable to supply heat at this temperature. In this application, double piping is impractical.
- Leakage into outer piping, at least on many of the streams, would solidify and/or coke. This material would be essentially impossible to remove.
- Differential expansion would present difficult design problems and would increase potential for piping ruptures.
- The greater complexity would increase design, operational, and maintenance problems.
- Double piping does not change the possibility of flange leaks, which are expected to be greater than line leaks.
- Cost would increase significantly.

Enclosing process area

- This method is unacceptable and impractical from a safety viewpoint. Even small leaks of toxic hydrogen sulfide and carbon monoxide would create a serious health and safety hazard for personnel. Even small leaks of hydrogen and carbon monoxide would cause serious explosion hazards because of inadequate dispersion. Firefighting would be hampered and would subject firefighters to far greater hazards. Even closet-sized enclosures present serious problems, such as: the inability to detect small leaks early enough for corrective maintenance to be taken; increased potential of exposure, especially of maintenance personnel, to hot and toxic materials, including hydrogen sulfide; and increased chance of explosion due to confinement of small leaks.
- Some small localized enclosures, such as shrouding, will be considered for some specific areas of high leak potential.

C.4 EMISSIONS FROM THE PLANT

C.4.1 Air

C.4.1.1 Bases for emission estimates

Environmental control equipment and alternatives were discussed in Sect. C.3. The information provided in this section is based on using currently proposed control methods. When more than one alternate is still being considered, such as the sulfur-removal and recovery system, the system that would result in the greatest emission rate (worst case) was used for determination of emissions listed and discussed in this section.

The data in this section are based on the use of the design coal for the plant, with the analysis listed in Table C.3, and on the use of a mixed plant fuel, with 29% of the heating value provided by plant-produced hydrotreated naphtha with a sulfur content of 0.1 weight percent and a heating value of 19,500 Btu/lb, and 71% of the heating value provided by mixed plant gas with a sulfur content of 100 ppmv and a heating value of 634 Btu per standard ft³. The combustion of this mixed plant fuel produces 0.047 pounds of SO₂ per million Btu of energy released. Consideration is now being given to designing the plant so that all fuel will be provided by plant gas, with the naphtha upgraded to a liquid product. If this alternative is followed, sulfur emissions would be substantially reduced (see Sect. C.3.2.2).

The oxides of nitrogen (NO_x), total suspended particulates (TSP), carbon monoxide (CO), and nonmethane hydrocarbon (NMHC) estimates are based on average factors taken from four sources: AP-42, EPA 600/7-78-100, EPA 600/7-78-191, and U.S. Department of Commerce PB-276-681.²³⁻²⁶

Fugitive gas emissions from leaks in equipment, mainly valves, pump and compressor seals, open-ended valves and drains, are based on preliminary information from Radian Corporation, Report EPA-600-2-79-044, February 1979.

The estimates for fugitive TSP are based on available factors from AP-42 and PEDCO reports^{23,27} and on assumed emission factors when literature values are not available.

C.4.1.2 Emissions during normal operation

Table C.12 summarizes the estimated atmospheric-emission rates under normal plant operation of sulfur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (TSP) and nonmethane hydrocarbons (NMHC). Table C.13 shows a sulfur balance for the demonstration plant using these values.

C.4.1.3 Emissions during normal startup

One of the major objectives during the design phase is to design a plant that can be operated in a controlled manner at gradually increasing rates during startup. As shown graphically by Fig. C.14, emissions of SO₂ during such a normal plant startup will be less than during normal operation. Likewise, gaseous emissions of NO_x, CO, NMHC, and TSP would also be less during a startup than during normal operation.

C.4.1.4 Emissions of SO₂ during normal shutdown

The emission rates during a normal shutdown will be similar to those during a normal startup, except that the duration will be less.

C.4.1.5 Emission of SO₂ during controlled reduced rate operation

As a result of several possible operational problems, it may be necessary to continue operation of the plant for extended periods at reduced rates and with some of the environmental control equipment not operating. Estimates have been made of the flaring rate and SO₂ emissions during various non-routine conditions, controlled startup, upsets, etc., and are compiled in Tables C.14 and C.15. Also, the combustion equipment that would be used for each case is shown. The flaring equipment used in the various cases assumed a maximum controlled-combustor capacity of 1600 million Btu/h. Discussions with suppliers indicated such a rate may represent the maximum size obtainable. Such a controlled combustor would have an estimated diameter of 35 ft and a stack height of 75 to 100 ft. Flaring rates above this level would be diverted to the flare while the controlled combustor would continue to operate at its capacity.

Table C.12. Estimate of maximum atmospheric emissions at the SRC-II demonstration plant^a

Equipment name	Stack height ^b (m)	Stack diameter (m)	Gas flow rate (m ³ /s)	Exit velocity (m/s)	Exit temperature (°K)	Pollutant emission rates (g/s)				
						SO ₂	NO _x	CO	TSP	NMHC
Dissolver charge heaters and other proprietary heaters flue gas	45.72	2.05	69.2	21.0	405	3.07	8.64 ^g	0.17	4.28	0.77
Fractionator reboiler ^c flue gas	30.48	0.84	11.7	21.2	450	0.47	3.64	0.03	0.64	0.33
Power boiler flue gas ^d	45.72	3.05	131.6	18.0	405	5.87	26.66 ^g	3.39	3.09	0.81
Superheater flue gas	45.72	0.61	4.8	16.7	405	0.23	1.42	0.04	0.29	0.16
Wastewater incinerator gas ^c	30.48	0.69	7.5	20.4	450	0.30	1.86	0.05	0.21	0.03
Oxygen plant fuel gas heater	30.48	0.91	13.3	20.2	450	0.24	2.43	0.06	0.35	0.29
Heavy oil product flue gas	30.48	0.30	1.14	15.6	450	0.04	0.29	0.01	0.05	0.04
Mineral residue slurry heater ^c	30.48	0.30	1.52	20.9	450	0.06	0.40	0.01	0.09	0.04
Thawing shed emissions	6.1	e	3.4	1.1	325	0.19	1.21	0.04	0.25	0.14
Coal dryer	24.4	1.83	56.6	21.3	381	1.40	10.84	0.08	2.50 ^h	0.30
SCOT burner and incinerator gas	45.72	1.98	57.0	18.5	478	22.74 ^f	1.49	0.04	0.18	0.04
Coal unloading, conveying, slag handling, haul roads, etc.									4.35	
Fugitive losses									1.7	
Coal storage pile										2.88
Valves, flanges, seals										
Total						34.6	58.9	3.92	18.0	5.8

^a Modeling of emissions is based on this table; permit plans include design firing rates for alternative modes of operation using 29% naphtha and 71% gas mixed fuel. The permit forms are not additive because alternative items are included, some of which are not normally operating.

^b Stack heights are in conformance with 40 CFR 51 as proposed on January 12, 1979 (*Fed. Regist.* 44:2613).

^c Stack shown is for largest of a group. For specifics of smaller stacks in the group, see PSD permit forms. Pollutants shown are the total for the group.

^d Plant fuel as 100% naphtha and 0.1% sulfur may be used in some sources, but the total naphtha burned in the plant will be equal to or less than that used in preparing this table.

^e No stack—gases go through roof vents (32 ft²) about 20 ft above grade.

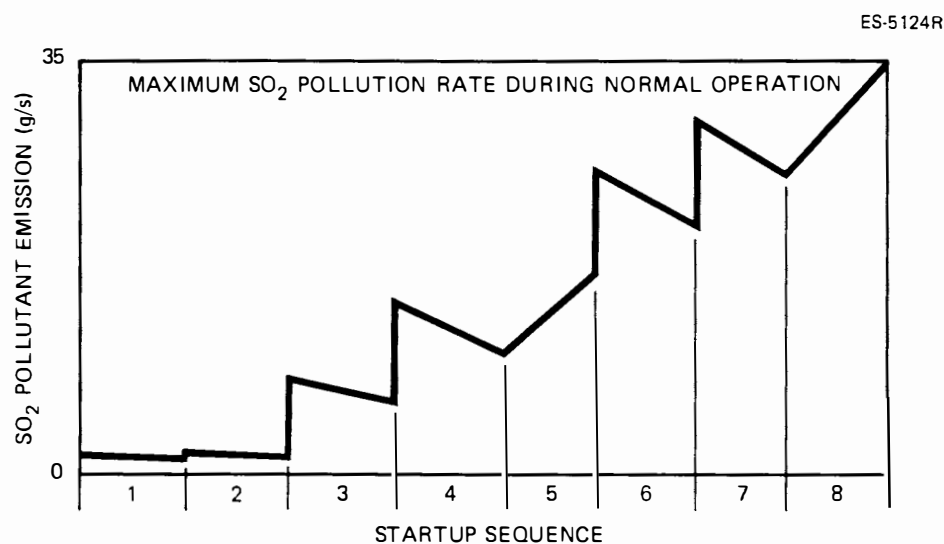
^f Assumes 250 ppm (volume) SO_x from the incinerator, based on dry and oxygen-free stack gas.

^g NO_x emissions are in compliance with Subpart D of the New Source Performance Standard (NSPS) for fossil fuel fired boilers (i.e., 0.3 lb/10⁶ Btu for liquid fuel and 0.2 lb/10⁶ Btu for gaseous fuel).

^h TSP emissions are in compliance with NSPS for coal dryers (i.e., 0.031 grains per dry standard cubic foot).

Table C.13. Sulfur balance during normal operation

Plant stream	Sulfur (lb/h)	SO ₂ emissions (g/s)
Input		
Feed coal	17,950	
Output		
Sulfur product	16,810	
Fuel-oil product	390	
Gasifier slag	600	
Vent gases from coal dryer, coal thawing shed, and waste-water sludge incinerator	10	1.9
Heater and boiler stack gas	40	10.0
H ₂ S incinerator stack gas	90	22.7
Total output	17,950	34.6



NOTE: BASED ON MIXED NAPHTHA/PLANT GAS FUEL.

1. OPERATE UTILITIES SUCH AS BOILER, COOLING TOWER, etc.
2. OPERATE OXYGEN PLANT.
3. START A GASIFIER, GAS PURIFICATION AND SULFUR RECOVERY PLANTS. FEED AT 50% NORMAL RATE. SULFUR RECOVERY PLANT EFFICIENCY IMPROVES WITH TIME TOWARD 99.5%.
4. START COAL FEED TO DISSOLVER AT 50% NORMAL RATE. START THE REMAINDER OF THE PLANTS. SULFUR RECOVERY PLANT EFFICIENCY IMPROVES WITH TIME TOWARD 99.5%
5. GRADUALLY RAISE COAL FEED TO THE DISSOLVER TO 100% OF NORMAL RATE. ADJUST THE SULFUR RECOVERY PLANT TO MAINTAIN EFFICIENCY.
6. START SECOND GASIFIER AT 50% NORMAL RATE. SULFUR PLANT GRADUALLY REGAINS EFFICIENCY.
7. START COAL FEED TO SECOND DISSOLVER AT 50% NORMAL FEED RATE. AGAIN THE SULFUR PLANT GRADUALLY REGAINS EFFICIENCY.
8. GRADUALLY RAISE COAL FEED TO THE SECOND DISSOLVER TO 100% OF NORMAL RATE. THE SULFUR PLANT MAINTAINS EFFICIENCY WITH THE GRADUAL INCREASE IN FEED RATE.

Fig. C.14. SO₂ emissions during a normal plant startup (not initial startup).

Table C.14. Flaring rate and SO₂ emissions during reduced-rate controlled operation

Case	Description	Flaring rate (10 ⁶ BTU/h)	Flare system combustion device used		Duration (h)	SO ₂ emissions	
			Controlled combustor	Elevated flare		Rate (g/s)	Total pounds
A	One gasifier at half-rate, equivalent to 25% of gas- plant capacity. Venting downstream of purifica- tion	400	X		12	3	285
B	One dissolver at half-rate. Equivalent to 25% plant capacity. Recycle H ₂ sys- tem in operation but by- passing cryogenic unit. Venting downstream of DEA to purge CH ₄ . Gasifi- cation providing makeup H ₂ to maintain H ₂ partial pressure in dissolver	600	X		24	0.3	57
C	One dissolver at full rate. Equivalent to 50% plant capacity. Recycle H ₂ system in operation but bypassing cryo- genic unit. Venting down- stream of DEA unit to purge CH ₄ . Gasification providing makeup H ₂ to maintain H ₂ par- tial pressure in dissolver	1200	X		240	0.6	1142
D	One gasifier at half rate. Equivalent to 25% of gas- plant capacity. Gas vented through sulfur purifica- tion and recovery; only 50% efficiency assumed be- cause of low rates	400	X		48	1.3	495

It should be noted that the flaring rates shown in Tables C.14 and C.15 actually would be less than that shown since substantial quantities of the gas would be used as fuel, rather than flared.

The cases shown are believed to be representative of planned startup steps, but other cases are also possible with emissions proportional to the coal feed rate (see description heading in Tables C.14 and C.15). Under controlled startup, emissions will be less than for normal operation at full capacity.

C.4.1.6 Emission of SO₂ during upset and emergency conditions

During upsets and emergencies, the flare system will be used to release gases in a safe manner to prevent equipment damage and personnel hazards. The rate of release of contaminants such as SO₂ may be large, but the time will be limited because the plant will be shut down, or correction will be made in a short time.

The SO₂ emissions during four upset or emergency conditions that could occur in the demonstration plant are shown in Table C.15.

C.4.1.7 Emissions of NO_x, CO, and NMHC during abnormal conditions

Because the formation and emission of NO_x, CO, and NMHC are related to the quantity of material burned, abnormal operation that requires release of gas to the flare system would tend to increase

Table C.15. Flaring rate and SO₂ emissions during emergency and upset conditions

Case	Description	Flaring rate (10 ⁶ BTU/h)	Flare system combustion device used		Duration (h)	SO ₂ emissions	
			Controlled combustor	Elevated flare		Rate (g/s)	Total pounds
A	One dissolver blown down from normal operating pressure to near atmospheric pressure in 45 min. Blocked upstream of preheater and downstream of the second high-pressure flash drum	6,000 max moderate decline	X	X	3/4	333	1,980
B	Two gasifiers at full load, equivalent to full gas-plant capacity. Venting upstream of purification	2,000	X	X	2	1620	25,700
C	One dissolver at full rate without cryogenic unit or purification. Recycle H ₂ partially vented to purge CH ₄ . Gasification providing makeup H ₂ to maintain hydrogen partial pressure	1,600	X	X	4	350	11,100
D	Two gasifiers at full rate and pressure. Equivalent to full gas-plant rate. Blocked in and blown down in 5 min, bypassing purification	3,000 max rapid decline	X	X	1/12	84	56

their emissions. Counteracting this, however, is the fact that most flaring incidents occur at reduced plant rates when less fuel is being burned and fired heater emissions are therefore below normal levels. During most abnormal operations, the venting rate will be such that combustion of all vent gas occurs in the controlled combustor, which will be an efficient burner and thus will provide more complete combustion of the vented NMHC.

C.4.1.8 Fugitive hydrocarbon emissions

Under contract to EPA, Radian Corporation recently published a report (EPA-600-2-79-044) describing methods for estimating NMHC emissions from petroleum refineries that use maintenance procedures similar to those that have been in use for many years (unmitigated) and from the same facilities using a "directed" maintenance program (mitigated). In a "directed" maintenance program, portable total-hydrocarbon monitoring equipment is used extensively to determine when maintenance should be performed on specific items, and, by monitoring while maintenance is being performed, to determine when it is sufficient. Section 3.5.1 discusses the directed maintenance program proposed for the demonstration plant. Because the SRC-II demonstration plant is similar in some ways to a petroleum refinery, the methods described in the Radian report were used to estimate NMHC emissions from the demonstration plant. Based on preliminary flowsheets of the demonstration plant, estimates have been made of the fugitive emission sources in the various units of the plant. These estimates are shown in Table C.16. The emission factors associated with each class of component are shown in Table C.17. Because the average composition of the material in the various units can be estimated, these data were used to estimate the quantities of fugitive emissions which would occur in the SRC-II demonstration plant with and without "directed" maintenance. Table C.18 shows estimated unmitigated and mitigated emissions. In some cases, the emission factors depend on the nature of the hydrocarbon stream. Because the heavy fraction (+600°F) of the SRC-II liquids is believed to have more adverse toxicological properties than the lighter liquids (see Sect. 4.1), an estimate of mitigated emissions of liquids boiling above 600°F also has been made and is included in the same table. The data for unmitigated emissions are somewhat irrelevant since the SRC-II demonstration plant will have a "directed" maintenance program. Comparison of the tables show, however, the improvement which is theoretically possible by proper maintenance practices. The estimated mitigated total of NMHC is about 95 tons per year. Achievement of substantially lower levels does not appear to be practicable.

Table C.16. Number of possible fugitive emission sources

Plant unit	Inline valves	Flanges	Pump seals	Compressor seals	Vents and relief valves	Open-ended valves	Drains
11	1706	1562	47		12	266	62
12	182	128	10	5	6	10	2
21	380	637	27		7	96	16
22,23	155	170	16		1	4	1
24,25	56	60	10		1	4	1
31	160	215	6	1	1	6	2
32	220	315	8	4	3	28	4
33	50	70	12		2	10	4
34	218	300	32		1	59	23
35	60	95	6	1	2	8	2
41,42,43	180	215	48		2	16	6
54	230	390	18	2		14	1

Table C.17. NMHC emission factors for components (lb/h)

	Gas vapor with >50% H ₂ by volume	Gas vapor with <50% H ₂ by volume	Light liquid two-phase streams	Heavy liquid streams
Line valves	0.059	0.018	0.024	0.0005
Flanges	0.00056	0.00056	0.00056	0.00056
Pump seals			0.25	0.046
Compression seals	1.4	0.11		
Vents and relief valves	0.19	0.19		0.19
Open-ended valves	0.064	0.023	0.029	0.0055
Drains			0.07	0.07

Table C.18. Estimate of fugitive NMHC emissions (lb/h)

Source	Emission factor	Unmitigated total NMHC	Mitigated total NMHC	Mitigated +600°F NMHC
Inline valves	^a	82	5	0.09
Flanges	0.00056	2	2	0.15
Pump seals	^a	43	9	0.28
Compressor seals	^a	16	3	
Vents and relief valves	0.19	7		
Open-ended valves	^a	13	1	0.04
Drains	0.07	9	4	0.42
Total		172	24	0.98

^aDetailed in Table C.17.

C.4.1.9 Vehicular emissions during plant operations

Mobile plant equipment

The main contributor to air emissions from mobile plant equipment would be the off-highway trucks used to transport gasifier slag from the process area to the waste disposal area. It should be noted that transport of slag to disposal by belt conveyor, instead of truck, is the plant design basis. Under that method, the emissions related to slag trucking do not exist. As a worst-case assumption, slag transport by truck is used to estimate emissions. About 100 round trips, of about 3 miles each, would be required per day. Assuming 2 miles/gal of diesel fuel, about 55,000 gal of fuel would be used per year, resulting in the estimated emissions shown in Table C.19.

Table C.19. Emissions from mobile plant equipment during operation phase^a

Pollutant	Emissions		
	lb/(10 ³ gal)	lb/d	tons/year
CO	92.2	13.9	2.5
HC	30.0	4.5	0.9
NO _x	52.4	7.9	1.5
SO _x	31.2	4.7	0.8
TSP	17.7	2.7	0.5

^a Worst-case emissions, reflecting truck slag option.

Highway vehicles

During operation of the plant, the total average work force is estimated to be 550, including contract maintenance personnel. Assuming an average of 2.0 persons per vehicle, an average round-trip commuting distance of 30 miles, plus an 8% additional allowance for delivery vehicles, would result in 3.2 million vehicle miles per year, with estimated emission rates shown in Table C.20. Emission factors for all highway vehicles are given in AP42, Table D.7.1, p. D.7.1. The mix includes about 8% heavy-duty vehicles, which commuters would not use. However, because many of the deliveries to the plant will be heavy-duty vehicles, the referenced basis was used for these emission determinations.

Only a small portion, perhaps 10%, of the above emissions would occur at the demonstration plant-site.

Table C.20. Emissions from highway vehicles during operation phase

Pollutant	Total emissions		
	g/mile	lb/d	tons/year
CO	23.0	445	81
HC	4.2	81	14
NO _x	3.1	60	11
SO _x	0.20	3.9	0.7
TSP	0.44	8.5	1.5

C.4.2 WaterC.4.2.1 Characterization of the treated wastewater discharge

The estimated average discharge rate of treated wastewater to the Monongahela River is 1238 gpm. Table C.21 shows the estimated average concentration and estimated average daily discharge rate of contaminants in the effluent from the SRC-II demonstration plant to the Monongahela River. These data are based on (1) leaching tests performed on gasifier slag that are discussed in Sect. C.3.7.1, (2) analyses of untreated and treated wastewater at the Ft. Lewis SRC Pilot Plant, (3) analysis of dissolver-area process wastewater from the P-99 Pilot Plant at Harmarville, (4) gasifier quench water analyses from the gasifier at Texaco's Montebello Pilot Plant, and from (5) coal-pile runoff data from various sources including Appendix K.

**Table C.21. Estimated concentration range of contaminants
in treated composite wastewater discharged
to the Monongahela River^a**

Parameter	Average concentration (mg/liter)	Average daily discharge rate, (lb)
BOD ₅	10	150
Total suspended solids	10	150
COD	100	1,490
Oil and grease	5	75
Phenol	0.1	1.5
Ammonia	5	75
Sulfide	0.0	0
Cyanide (free)	0.15	2.25
Iron	1.0	15
Total chromium	0.2	3.0
Total dissolved solids	3,000	44,000
Sulfate	1,000	15,000
pH	6.0-9.0	

^aBased on discharge flow rate of 1238 gpm.

Table C.22 shows compounds that are known to be in waters generated from coal conversion processes. Estimates of process water contaminant levels were obtained from the following sources:

- (a) P-99 unit — various process water analyses.
- (b) "Engineering Study on Texaco Gasifier Wastewater Reclamation System", Proprietary Report by Hydro Qual Inc.
- (c) "EDS Coal Liquefaction Process Development" Phase IV, Quarterly Technical Progress Report for the period Oct. 1-Dec. 31, 1978.

Process waters will be generated in the SRC-II process in various process areas. These waters will then be combined for treatment, and some of the water will be recycled in the process; the remainder of the treated wastewater may be discharged to the Monongahela River.

Estimates of the compounds in the process waters were weighted to account for this distribution in the various process streams. The resulting contaminant levels are shown in Table C.22 under "Process Wastewater".

Under the assumption that Best Available Control Technology (BACT) is being used, as described by Fig. C.10, the reduction of contaminant levels by primary and secondary treatment resulted in the estimated levels shown in Table C.22 under "Process Wastewater Treatment Effluent." Depending on molecular weight of the PNAs, a reduction of about 75% was assumed by chemical oxidation and biological treatment. This reduction appears reasonable based on some Fort Lewis water analyses, open literature data, process design information and data contained in the SRC-I DEIS.

The remainder of the reduction in contaminant level will be achieved by tertiary treatment, as shown in Fig. C.9, with the possible addition of chemical oxidation, if required.

Table C.22. Estimate of organic compounds in SRC-II process wastewater and tertiary treatment effluent

	Process wastewater (mg/liter)	Process wastewater treatment effluent (mg/liter)	Tertiary treatment effluent (mg/liter)
Fluorene	0.3	0.08	0.02
Pyrene	0.25	0.06	0.015
Phenanthrene	0.36	0.09	0.001
Fluoranthene	0.11	0.03	0.001
Tetralin	0.1	0.02	0.005
Biphenyl	0.2	0.05	0.005
Acenaphthene	<0.1	0.02	0.002
Diphenylmethane	0.3	0.05	0.018
Benz[a]anthracene	0.01		^a
Triphenylene	0.002		^a
Methylbenz[a]anthracene	0.003		^a
Dibenzofuran	0.5	0.12	0.01
Anthracene	<0.05	0.01	0.003
Benzo[a]pyrene	<0.003		^a
Benzo[e]pyrene	<0.002		^a
Xanthene	0.1	0.025	0.002
Benzo[g,h,i]perylene	0.004		^a
Phenol		^b	0.1

^aNo data.^bSee Table C.21.

The estimates of reduction from column 2 to column 3 in Table C.22 are based upon an engineering evaluation of technology sources and open literature, including:

- (a) "Activated Carbon Adsorption of Petrochemicals" by D. M. Giusti, R. A. Conway and C. T. Lawson, Journal WPCF, Vol. 46, No. 5, May 1974.
- (b) "Application of the Polanyi Adsorption Theory to Adsorption from Solution in Activated Carbon" by M. Manes and L. J. E. Hofer, The Journal of Physical Chemistry, 73, 1969.
- (c) "Oxidation of Phenols by Ozone," by J. P. Gould and W. J. Webber, Jr., Journal WPCF, Vol. 48, No. 1, January, 1976.

Table C.23 attempts to define such trace elements that are known to be contained in coal-conversion process waters. Data were gathered from various sources, and flow stream weighting was executed as previously described for the organic compounds.

Estimates of trace elements in the process wastewaters are based on the following sources:

- (a) Harmarville P-99 unit, various process water analyses.
- (b) Fort Lewis pilot plant, various process water analyses: "Solvent Refined Coal (SRC) Process: Trace Elements", Interim Report: Trace Elements in the SRC-Process for the period August 1, 1977 - February 28, 1979 by R. H. Filby et al., Washington State University, Nuclear Radiation Center, Pullman, Washington, July 1980.
- (c) SRC-I DEIS.
- (d) "EDS Coal Liquefaction Process Development" Phase IV, Quarterly Technical Progress Development" Phase IV, Quarterly Technical Progress Report for the period Oct. 1-Dec. 31, 1978.

The reduction in trace element levels due to secondary and tertiary treatment were estimated to be sufficient to essentially meet water effluent standards as delineated in "Coal Conversion Control Technology - Volume 1 - Environmental Regulations - Liquid Effluents" U.S. Department of Commerce. NTIS - PB80 - 126469, October 1979.

Table C.23. Estimate of trace elements in SRC-II process water and tertiary treatment effluent^a

	Process wastewater (mg/liter)	Most stringent EPA standards from DEIS (mg/liter)	Tertiary treatment effluent (mg/liter)	River standards (mg/liter)	
				Pa.	W. Va.
Titanium	<3		0.5		
Vanadium	<0.25		0.08		
Aluminum	<2		0.2		
Arsenic	0.03	0.01	<0.01	0.05	0.01
Selenium	2.5	0.01	0.03 ^b		0.01
Mercury	0.05	0.0005	0.001		
Nickel	0.12		0.01	^c	
Chromium		0.05	0.2	0.05	0.05
Cadmium	<0.006	0.0012	^d	0.01	
Barium	<0.2		<0.15		0.50
Lead	0.2	0.05	0.05	0.05	0.05
Silver	0.05	0.05	0.02		0.05
Zinc	0.5		0.1	^c	
Boron	12		^d		
Iron		0.3	1.0		
Fluoride	70	1.0	1.0	2.0	1.0
Copper	0.11	1.0	0.07	^c	
Beryllium	0.013	1.1	^d		

^a This estimate is based on Fort Lewis liquefaction effluent accounting for one-third of the input flow and the gasifier accounting for the remaining two-thirds after bio-oxidation. There is no coalpile runoff.

^b Exceeds 0.01 standard

^c Standard based on 96-h LC₅₀ (bioassay).

^d No data.

Again, assuming that the proposed system will be BACT for removal of the trace elements from the process wastewater, the determination of the estimated reductions were made by an engineering evaluation of technology sources and open literature, including:

- (a) "Adsorption of Inorganic Compounds by Activated Carbon" by E. A. Sigworth and S. B. Smith, Journal AWWA - Water Technology/Quality, June 1972.
- (b) U.S. Department of Commerce, NTIS PB80-126469, October, 1979, Table 8-6: Removal of Heavy Metals by Lime Coagulation, Settling and Recarbonation.

Wastewater characterization studies are continuing with special emphasis on primary pollutants in the effluent in accordance with EPA guidelines - Water Quality Criteria. These studies are currently in progress using process water generated in the P-99 test loop.

Inadequately treated wastewater could present a significant potential adverse environmental impact; thus, thorough pilot testing of the proposed wastewater treatment system is essential in confirming its adequacy.

Previous pilot testing has been conducted on wastewater purge streams from both the P-99 dissolver pilot plant and the Texaco gasifier purge. However, no tests have been conducted on the combined waste streams. The waste streams judged to have the greatest pollution potential are the purge streams from the dissolver and the gasifier units and the coal pile runoff. Other less contaminated streams that contribute significantly to the flow rate are the process area runoff and the slag pile leachate.

In addition, data is needed for equipment design and system interaction.

To supply the data requirements needed for the design of wastewater treatment equipment and to obtain an increased level of confidence that the proposed treatment philosophy is adequate, a coherent pilot treatability program is being planned. This program will be conducted using the selected feed coal and subjected to the operating conditions that are anticipated in the

Demonstration Plant. Data collection and analysis will be directed toward obtaining data necessary for equipment sizing and design, as well as pollutant abatement.

Because toxic pollutants and carcinogens such as PNAs and heavy metals are contained within some of the wastewater streams, it is essential that the proposed treatment system demonstrates its ability to remove these components to environmentally acceptable low levels.

The quality of the data will be judged on their approaching electroneutrality and achieving a reasonable material balance. Comparisons will also be made with regard to predicted component solubilities based on solubility products and the composition of similar waste streams reported in the literature.

Although it is anticipated that the design effort will be well underway by the time results of the treatability test are available, there will be sufficient time to either confirm the design basis prior to construction and/or make changes in the design as required.

An objective of the testing program will also be to determine the operability limits of the waste treatment system. The limits of biotoxicity and system response to organic and hydraulic shock loading will be assessed.

Alternative wastewater treatment concepts will also be simulated to arrive at the optimum wastewater treatment configuration. The most pressing questions, such as (1) the sequence of tar acid recovery and acid gas stripping on the dissolver purge stream, (2) the effectiveness of carbonation in primary treatment, (3) the effectiveness of powdered activated carbon in activated sludge treatment, and (4) the feasibility of including reverse osmosis in the desalination unit operation, will be answered by the treatability testing program. In this regard, the effectiveness of each unit operation in the proposed treatment process in removing toxic or hazardous components will be assessed.

C.4.2.2 Discharge to the Monongahela River vs zero discharge

The site of the proposed plant is in West Virginia, bordering on Pennsylvania, so, in addition to the NPDES discharge standards, the impact on the Monongahela River with regard to instream water-quality standards for both states has been examined. On the basis of these examinations, it is concluded that the most restrictive standard will usually be Pennsylvania's standard for total dissolved solids — 500 mg/liter. It should be noted that EPA will develop effluent limitations for the plant that will be identified in the National Pollutant Discharge Elimination System (NPDES) permit and factored into the design basis for the wastewater treatment plant.

A preliminary study has been made to determine the impact of the treated-wastewater effluent on the Monongahela River. Data on river flow rate and dissolved solids content (Fig. C.15) taken during 1976, 1977, and 1978 at the Star City Bridge gaging station (about 3 miles upstream of the proposed plant site), were used to calculate the capacity of the Monongahela River to accept dissolved solids without exceeding the 500 mg/l dissolved-solids limit. These values were plotted on a probability grid (Fig. C.16). This grid is one of a family of probability plots for metals and other effluent constituents. Using the estimated quantity of dissolved solids discharged by the demonstration plant of 44,000 lb/d, as shown in Table C.21, and assuming that the demonstration plant will be allowed 10% of the river capacity to accommodate dissolved solids before exceeding the 500 mg/l TDS limit, it is estimated by using Fig. C.16 that treated process wastewater could flow to the river approximately 95% of the time. Conversely, it would be necessary to operate water-reclamation (desalination) equipment only 5% of the time.

Of the various water contaminants for which data pertaining to the Monongahela River are available, total dissolved solids is expected to provide the most severe discharge constraint when operating the demonstration plant. During the first years of operation, it is expected that little additional industrial development would have taken place in the region, so that much of the existing assimilative capacity of the river might be available to the SRC-II plant. However, to provide a conservative estimate of the influence of river capacity on wastewater treatment operations, it is assumed that regulatory agencies would allot 10% of available capacity to the demonstration plant.

Baseline plant design provides for river discharge of tertiary-treated and polished effluent most of the time, as described in Appendix C, Sect. C.4.2.2. This is a revision from the DEIS, which specified a zero-discharge system. The reasons for preferring the discharge mode in normal plant operation include:

- lack of operating history on zero-discharge units at coal conversion facilities, implying that unintended emergency discharges may occur frequently (e.g., as a result of extended plant shutdown or abnormally heavy rainfall);

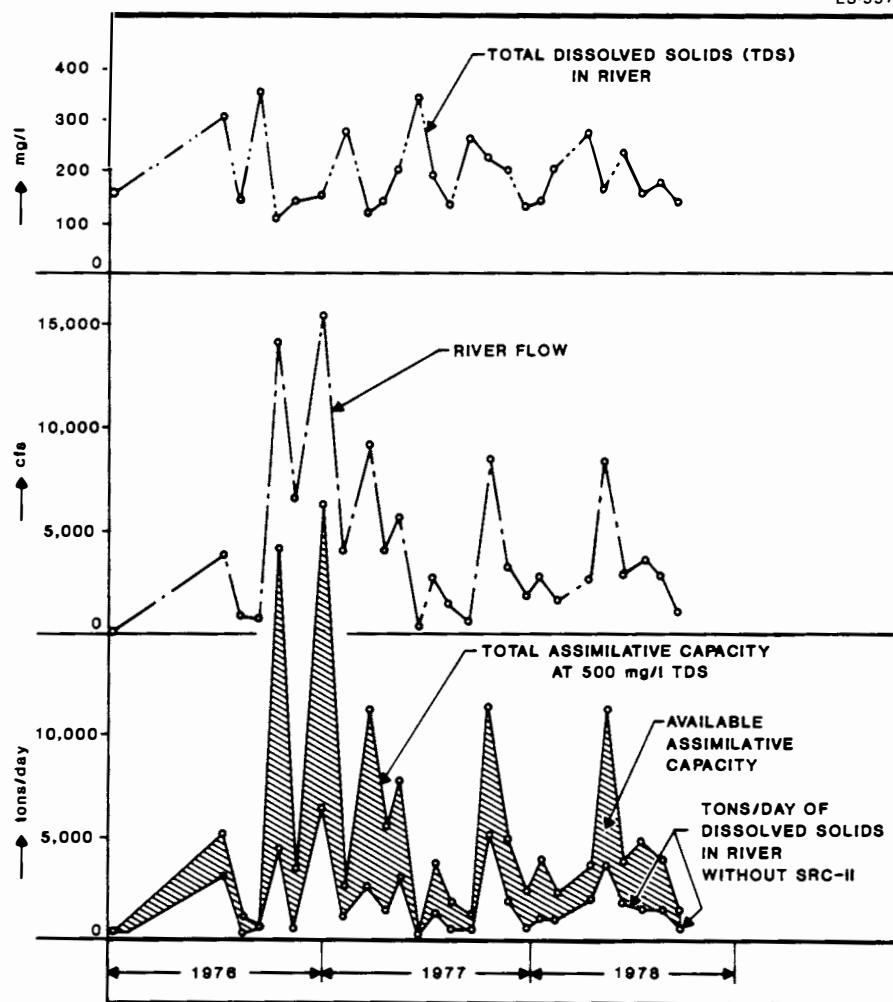


Fig. C.15. Flow rate, total dissolved solids, and assimilative capacity of the Monongahela River immediately upstream of the proposed site for 1976-78.

- increased energy consumption by evaporators in zero-discharge operations;
- problems of brine or soluble salts disposal may exceed the problems of adding trace concentrations of salts, metals, or organics to the rivers; and
- zero-discharge must be applied site-specifically, and its principal applications occur in arid regions, not in the region where the SRC-II plant is proposed to be located.

The capability for zero-discharge operation is retained in the baseline design but will only be used when required by terms of the plant operating permit (i.e., low river flow and/or inability of the river to accommodate TDS or other chemical species due to water quality standards being approached).

In actuality, the periods during which the water-reclamation equipment would be operated would depend on many factors that are difficult to accurately predict at this time: river flow, ambient TDS levels, ambient and effluent levels of particular species or elements, and soluble-salts generation rate in the plant. During periods of low river flow and high TDS levels in the river, which require operation of the water-reclamation equipment, the salts in the treated process wastewater will be concentrated in a brine solution, the brine will be disposed of in an approved disposal method, (see Sect. C.4.7.2 for discussion of alternatives), and the reclaimed wastewater will be recycled to the process to reduce riverwater intake.

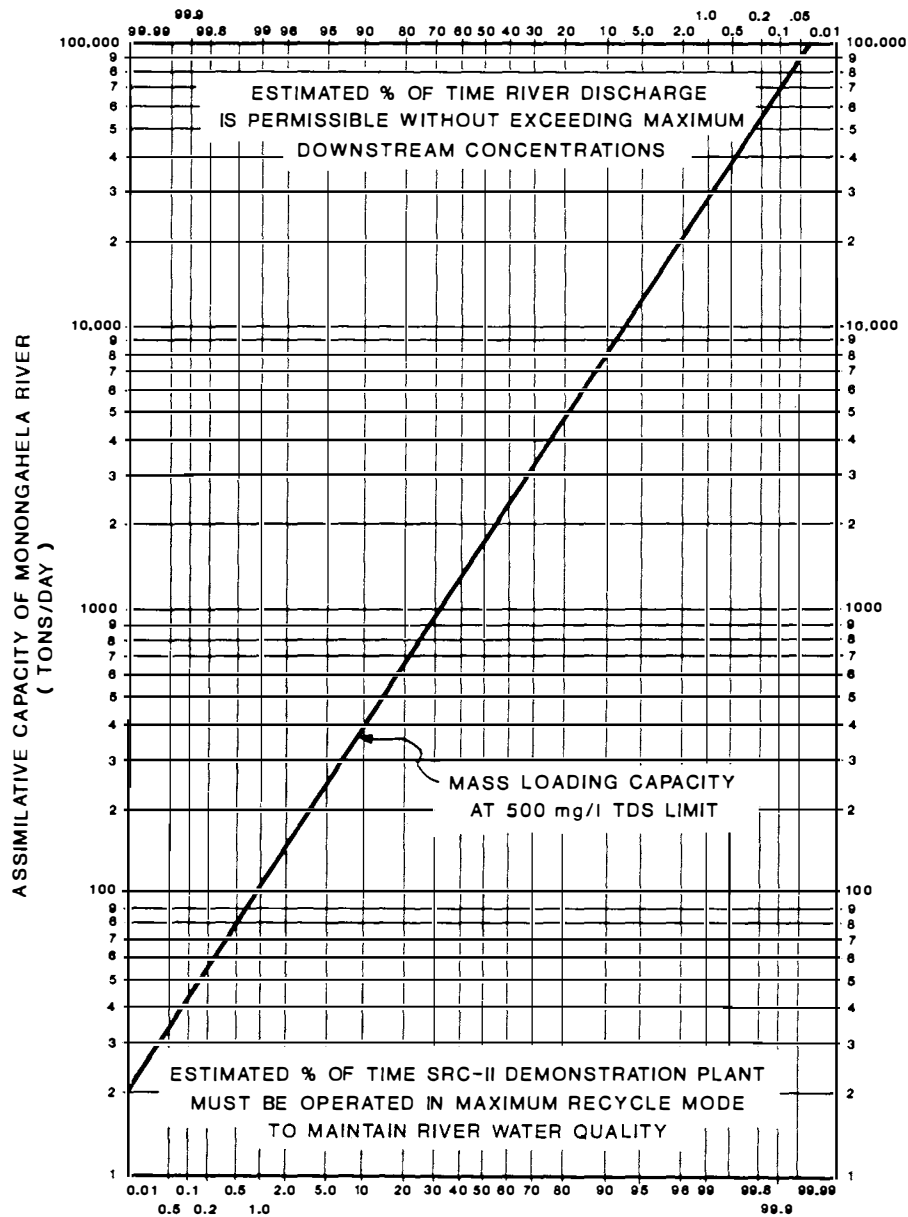


Fig. C.16. Capacity of the Monongahela River to assimilate dissolved solids discharged from the SRC-II demonstration plant.

C.5 CONSTRUCTION ACTIVITIES AND EMISSIONS

C.5.1 Construction burning

Normal state air pollution control regulations generally prohibit open burning, with an exemption from the regulation allowed for open burning of construction and demolition waste, provided that:

- no practical alternative exists,
- health, safety, comfort, and property are protected from the effects of the burning,
- such burning is not to be conducted for salvage purposes,
- in nonrural areas, permission is obtained from the State Director of Air Pollution Control, and
- burning is not to be conducted during a period of air stagnation.

If burning of construction debris becomes necessary, it will be conducted within the above restrictions.

C.5.2 Earthmoving

During construction, an estimated 10×10^6 yd³ of earth will be moved. Reduction of fugitive dust emissions is necessary. Normal construction practice to be followed in this project includes keeping the size of exposed areas to the practical minimum and keeping exposed areas, including non-hard-surfaced roads, sprinkled with water or oil. Pyritic material exposed during construction will be identified and segregated in temporary disposal sites so as to prevent acid contamination of soils. Permanent disposal of these materials, if deemed necessary, will be by compaction and burial with a clay liner protection.

C.5.3 Water runoff

Earth disturbed by surface excavation is easily eroded by rain runoff. The mitigative measures described here will be detailed in the Project Environmental Plan, which is scheduled for delivery to DOE in late January 1981. These mitigative measures will be among the first activities to take place on the site. To prevent pollution of streams by sediment, a system of diversion ditches will be installed to prevent runoff from higher ground from entering the disturbed area; settling ponds will also be installed to catch runoff from the disturbed areas. Ponds will be sized so that water will be retained in the ponds long enough for the discharge to natural drainages to meet state and EPA requirements for suspended solids content. A NPDES discharge permit will be requested and obtained. This permit, issued by EPA, will specify the conditions of the discharge quality. The discharge containing residual TSS and TDS will meet these specifications.

C.5.4 Paints and solvents

If water-based paints are used, essentially no pollutant emissions will be released to the atmosphere. If oil-based paints are used, between 35 and 50% of the paint will be evaporated. Typically, about 45% of the paint is volatile hydrocarbons. Because 1 gal of oil-based paint weighs about 12 lb, about 5 lb of hydrocarbons will be released to the atmosphere per gal of oil-based paint applied.

An estimated 100,000 gal of paint will be used, which will result in hydrocarbon emissions of about 250 tons if oil base paint is used (worst case). In all probability, most of the painting will be done during the last year of construction; substantial use will be made of water-base paint.

C.5.5 Air emissions from construction equipment

From past experience on construction projects of this magnitude, an estimated 1400 to 2000 gal/d of diesel fuel will be consumed. With an average consumption of 1700 gal/d, the emissions shown in Table C.24 would be expected.

Table C.24. Air emissions from construction equipment

Pollutant	Emissions		
	lb/10 ³ gal	lb/d	tons/year
CO	92.2	157	20
HC	30.0	51	7
NO _x	52.4	88	11
SO ₂	31.2	53	7
TSP	17.7	30	4

C.5.6 Air emissions from highway vehicles

During construction, an estimated average of 1700 persons will be employed at the site. Construction is planned for a 5-d work week. The average round-trip commuting distance is estimated to be 60 miles. The average carload is assumed to be two persons. This will result in about 13 million miles of vehicular traffic per year.

Emission factors (1982 basis) for all highway vehicles are given by AP42, Table D.7-1, p. D.7-1. These factors include a mix of vehicle types based on nationwide data. The mix includes 8% heavy-duty vehicles, which the commuters would not use. However, because delivery vehicles to the site would be mostly heavy duty, commuter-vehicle miles are increased by 8% to include truck deliveries to the site. Consequently, highway vehicular travel associated with construction is estimated to be 14 million miles/year. Estimates of total emissions are shown in Table C.25 (assuming no traffic jams, which may be a significant and frequent occurrence near the site without mitigation).

Table C.25. Air emissions from highway vehicles during construction

Pollutant	Total emissions		
	g/mile	lb/d	tons/year
CO	23.0	1945	350
HC	4.2	355	65
NO _x	3.1	262	47
SO ₂	0.2	17	3
TSP	0.44	37	7

It should be noted that only a small portion of the above emissions, perhaps 10%, would occur at the demonstration plant site unless the traffic problem cannot be mitigated, in which case considerably more than 10% would occur in the vicinity of the site. (See Sect. 4.2.4 for the analysis of traffic impacts.)

C.6 RESOURCE REQUIREMENTS

C.6.1 Construction phase

The following quantities of resources have been estimated to be required during the construction phase of the facility:

Concrete	150,000 yd ³
Reinforcing steel	5000 tons
Structural steel	15,000 tons
Paving	870,000 ft ²
Railroad trackage	15,000 ft
Pipe	1,000,000 ft
Glass	5100 ft ²
Wood	2,000,000 bd ft
Water	200 x 10 ⁶ gal

C.6.2 Operations phase

During normal full-scale operation, the plant is designed to process 6000 tpsd of coal. The following estimated quantities of resources will be consumed annually:

Coal	2 x 10 ⁶ tons
Water	1900 x 10 ⁶ gal
Electricity	315 x 10 ⁶ kWh
Diesel fuel	55,000 gal
Lime	7200 tons
Phosphoric acid	20 tons
Sulfuric acid	1250 tons
Diethanolamine	50 tons
Chlorine	170 tons
Catalysts	110 tons
Cation resin	200 ft ³
Anion resin	160 ft ³
Activated charcoal	60 tons
Molecular sieve	40 tons

It is currently planned that all or part of the plant's electrical requirements will be obtained by in-house generation to improve the plant's reliability and to provide additional opportunities

for operationally decoupling the various process units to improve plant operability and flexibility. The worst-case air emissions estimates shown in Sect. C.4.1.1 assume that all electric power will be generated on site. Backup and startup power will be supplied by a nearby utility. Because the methanation section operates best on a constant flow and feed composition, and swings in plant gas composition will occur, the power boiler feed rate will be subject to variation.

C.7 EMISSIONS DURING END-USE COMBUSTION

The principal end use of liquid fuels from the SRC-II demonstration plant is as fuel to replace dwindling supplies of existing liquid fossil fuels in an environmentally sound fashion. A test has been carried out in a utility power plant using product from the Fort Lewis, Washington, SRC-II pilot plant, and small-scale tests have been carried out for other types of boilers and combustion equipment. These tests are summarized in the following paragraphs.

C.7.1 Utility test

A combustion demonstration using distillate fuel oil from the SRC-II process was conducted on a utility boiler at the 74th Street Generating Station of the Consolidated Edison Company of New York (Con Ed). The overall program was sponsored by the Electric Power Research Institute (EPRI),²⁸ Con Ed, and the New York State ERDA in cooperation with the U.S. Department of Energy (DOE), which supplied the SRC-II fuel oil. The oil analysis is given in Table C.26.

Table C.26. Chemical analysis of hydrotreated SRC-II fuel oil and No. 6 fuel oil (dry wt %)

	Petroleum-derived No. 6 fuel oil	SRC-II fuel oil
Carbon	87.02	85.50
Hydrogen	12.49	8.86
Nitrogen	0.23	1.02
Sulfur	0.24	0.22
Oxygen		4.38
Ash	0.02	0.02

The SRC-II fuel oil for this test was produced at the Fort Lewis SRC Pilot Plant, shipped by rail tank car to Bayonne, New Jersey, and transferred to a barge that delivered the oil to Con Ed at the 74th Street dock. The oil was pumped directly from the barge to the boilers during the burning tests. Handling, safety and health procedures for the shipment and testing were provided by the personnel of The Pittsburgh & Midway Coal Mining Co., which operates the Fort Lewis Pilot Plant under contract to DOE.

The test boiler was a corner-fired, Combustion Engineering, Inc. unit with a rated steam flow of 450,000 lb/h. Emissions and boiler performance were investigated at full, half, and three-quarter loads for baseline and low-NO_x (staged combustion) conditions. About 4500 bbl of SRC-II fuel oil were used during the program. Flue gas concentrations of nitrogen oxides, oxygen, carbon monoxide, polycyclic organic matter, total unburned hydrocarbons, sulfur trioxide, particulate mass loading, and particle-size distribution were measured (Table C.27). The performance of SRC-II fuel oil was also examined with respect to combustion characteristics and adaptation to existing boiler hardware. The number 6 fuel oil now used was also burned in the test boiler to compare with the SRC-II fuel oil (Table C.28).

A number of conclusions regarding the combustion and emissions characteristics of SRC-II fuel oil in a utility boiler have resulted from this test program. Although these conclusions are based on results obtained using specific SRC-II and number 6 fuel oils in a specific boiler and should be interpreted on this basis, the data trends and comparative characteristics are considered to be generally valid.

Nitrogen-oxide emissions from firing SRC-II were nominally 70% greater than those obtained for the number 6 fuel oil under both baseline and low-NO_x conditions. Assuming equivalent thermal-NO_x formation, this implies a 10% conversion of the differential fuel nitrogen to NO_x for baseline conditions. Reductions in NO_x levels through staged combustion were on the order of 35% for both SRC-II and number 6 fuel oils. A boiler now capable of satisfying the EPA New Source Performance Standards (NSPS) for NO_x emissions of 0.3 lb/10⁶ Btu would be expected to be capable of satisfying the proposed 0.5 lb/10⁶ Btu NSPS for coal-derived liquids using an SRC-II fuel oil equivalent to that burned in this test program.

Table C.27. SRC-II fuel oil emissions test summary

Test number	Date	Test conditions	Boiler performance			Gaseous emissions							Particulate emissions (lb/10 ⁶ Btu)
			Steam flow (klb/h)	Superheat temperature (°F)	Boiler efficiency (%)	SO ₃ (ppm)	NO ₂ ^a (ppm)	NO ^a (ppm)	NO _x ^b (lb/10 ⁶ Btu)	O ₂ (%)	CO (ppm)	THC (ppm)	
11-1	9/11/78	Full load/baseline	435	955		0.3	0.9	2	258	0.341	3.6	6	2
11-2	9/11/78	Full load/low NO _x /6 burner	430	925	85.7			1	212	0.280	3.7	9	1
11-3	9/11/78	Full load/low NO _x /6 burner	425	955				1	236	0.311	3.4	9	1
11-4	9/12/78	Full load/baseline	430	962				-	298	0.391	3.9	9	2
11-5	9/12/78	Full load/low NO _x /8 burner	440	938				-	228	0.299	2.5	17	2
11-6	9/12/78	Full load/low NO _x /8 burner	436	930	86.3			-	232	0.305	2.7	24	2
11-7	9/13/78	Half load/baseline	251	935				2	261	0.345	4.7	5	1
11-8	9/13/78	Half load/3 burners	246	939	87.8			1	287	0.378	4.1	15	0
11-9	9/13/78	Half load/4 burners	240	948				1	279	0.368	5.0	19	1
11-10	9/13/78	Half load/baseline	230	905				2	301	0.397	4.8	6	0
11-11	9/14/78	Full load/baseline ^d	477	955	86.0			0	239	0.313	2.7	25	1
11-12	9/14/78	Full load/low NO _x /6 burner	472	943				0	194	0.255	3.5	65	0
11-13	9/14/78	3/4 load/low NO _x /6 burner	340	900				2	159	0.211	3.9	12	0
11-14	9/14/78	3/4 load/low NO _x /J-14	305	890				-	186	0.244	3.1	16	
11-15	9/15/78	Half load/low NO _x /N30	243	870	87.1			0	188	0.247	4.1	6	1
11-16	9/15/78	Half load/upper/lower pattern	245	865				0	188	0.247	4.0	5	2
11-17	9/15/78	Full load/low NO _x /6 burner	492	935	86.2			0	175	0.230	2.7	22	2

^aDry @ 3% O₂.^bAs NO₂.^cBoiler setup not typical of usual baseline operation.^d(Value) from ASME in-stack thimble.

Table C.28. No. 6 fuel oil emissions test summary

Test number	Date	Test conditions	Boiler performance				Gaseous emissions						Particulate emissions (lb/10 ⁶ Btu)
			Steam flow (klb/h)	Superheat temperature (°F)	Repeats phase 2 test number	Boiler efficiency (%)	NO ₂ ^a (ppm)	NO ^a (ppm)	NO _x ^b (lb/10 ⁶ Btu)	O ₂ (%)	CO (ppm)	THC (ppm)	
III-1	9/25/78	Full load/baseline	437	976	II-1	84.9	1	154	0.201	2.6	6	1	0.013, 0.012
III-2	9/26/78	Full load/low NO _x /8 burner	459	920	II-6	85.2	1	133	0.173	2.7	10	2	0.038, 0.037
III-3	9/27/78	Full load/low NO _x /6 burner	444	930	II-17	85.3	1	100	0.131	3.2	19	1	0.046, 0.038
III-4	9/28/78	Half load/baseline	227	938	II-10	86.4	0	166	0.215	4.8	4	2	0.015, 0.015
III-5	9/28/78	Half load/low NO _x	240	865			1	141	0.184	4.2	21	2	
III-6	9/29/78	Half load/low NO _x	248	902			1	147	0.192	4.4	6	2	
III-7	9/29/78	Half load/low NO _x	244	862	II-15	86.6	1	117	0.153	4.4	11	2	0.031, 0.022 ^c
III-8	10/4/78	Full load/baseline	458	959			1	136	0.177	3.2	15	1	
III-9	10/4/78	Full load/baseline	448	952	II-11		1	162	0.211	2.7	53	2	
III-10	10/4/78	Full load/low NO _x /8 burner	448	938	II-6	85.2	1	136	0.177	2.9	15	1	
III-11	10/4/78	Full load/low NO _x /8 burner	446	920			0	129	0.167	2.6	56	2	
III-12	10/4/78	Full load/damper changes	443	935			0	113	0.146	3.4	19	1	
III-13	10/5/78	Half load/4 burner	225	893	II-15		1	154	0.201	7.3	2	1	
III-14	10/5/78	Half load/low O ₂	218	835			0	121	0.156	5.2	4	1	
III-15	10/5/78	Half load/low O ₂ /raise tilts	220	838		85.7	1	134	0.175	6.0	7	2	
III-16	10/5/78	Half load/upper/lower pattern	204	895			1	136	0.177	7.8	10	1	
III-17	10/5/78	Half load/upper	204	894			0	112	0.145	2.6	20	1	
III-18	10/6/78	3/4 load/6 burner	335	938	II-13		1	102	0.133	4.6	4	2	
III-19	10/6/78	3/4 load/low NO _x /low O ₂	340	920			1	93	0.122	3.4	16	1	
III-20	10/6/78	Repeats test III-3	430	965			1	101	0.132	3.8	25	1	
III-21	10/6/78	Repeats test III-2	444	955		85.0	1	130	0.170	2.6	13	2	
III-22	10/6/78	Full load/lower O ₂	450	938			1	125	0.163	1.9	37	1	
III-23	10/6/78	Repeats test III-1	460	951			1	145	0.189	1.9	21	2	
III-24	10/6/78	Full load/low NO _x /8 burner	460	951			1	111	0.145	2.4	42	1	
III-25	10/6/78	Repeats test III-7	250	920			1	145	0.189	4.7	3	1	
III-26	10/6/78	Half load/low NO _x /upper burners	225	852			1	111	0.145	3.8	17	1	
III-27	10/6/78	Half load/change dampers	225	852			0	100	0.129	3.9	8	1	
III-28	10/6/78	Half load/upper/lower pattern	220	842	II-16		1	96	0.124	4.4	14	1	

^aDry 3% O₂.^bAs NO₂.^c(Value) from ASME in-stack thimble.

Particulate mass emissions were nominally lower for SRC-II fuel oil than for the number 6 fuel oil and were below the EPA-proposed NSPS of $0.03 \text{ lb}/10^6 \text{ Btu}$ under all test conditions. The emissions at full load exhibited a bimodal size distribution comprised of a large number of carbon particles with diameters on the order of $0.05 \mu\text{m}$ or less and a smaller number of agglomerated particles with sizes greater than $0.1 \mu\text{m}$. The number 6 fuel-oil emissions did not exhibit this agglomerated behavior, although the actual particle concentrations were higher than for the SRC-II fuel oil. No mechanism was determined for the observed agglomeration, which was substantially reduced at lower boiler loads. The number 6 fuel oil emissions contained numerous large particles (greater than $1 \mu\text{m}$), indicating an atomization-related formation mechanism. Such particles were not observed with the SRC-II fuel oil, indicating potentially better atomization characteristics, even though the actual atomizer components were not totally optimum for this fuel.

Total hydrocarbon emissions were less than 3 ppmv under all operating conditions with both fuels.

Carbon monoxide levels were maintained below 50 ppmv for all test conditions at generally equivalent total excess-air levels for both fuels. Thus, the SRC-II fuel oil used in this program did not indicate any greater tendency toward incomplete combustion than the existing number 6 fuel oil.

Polycyclic organic matter (POM) emission levels with both fuel oils were low — less than $6 \times 10^{-6} \text{ lb}/10^6 \text{ Btu}$. Trends indicated by the POM data, although qualified by the overall test uncertainty, indicated that emissions at half load were higher than those for full load with both fuels and that the emissions with SRC-II fuel oil were nominally higher than the number 6 fuel oil levels. All the POM emissions levels with both fuels were substantially lower than those obtained on other programs with coal-fired boilers. Because of the limited number of POM samples and uncertainties in the combined sampling/extraction/analysis techniques, the absolute values of POM emissions obtained in this program must be interpreted with caution. The test methods and procedures used to obtain these data are discussed in the following paragraphs.

Test conditions were classified by steam load and NO_x -control mode. Three load levels were investigated: (1) full load at about 450 klb/h steam flow rate, (2) half load at about 225 klb/h, and (3) three-quarter load at 340 klb/h.

Most testing was at full load, whereas half load was examined to a lesser degree, and three-quarter load was examined the least. The classifications with NO_x emissions include baseline conditions, low- NO_x conditions by air redistribution, and low- NO_x conditions by fuel redistribution. Baseline conditions are associated with nominal operation of the unit in which the operator adjusts the controls to achieve a load level; low- NO_x conditions include special adjustments in the combustion controls to achieve a low- NO_x condition. One low- NO_x mode of operation (air redistribution) includes redistributing the air admitted without affecting the fuel admittance, whereas the other low- NO_x mode (fuel redistribution) entails operating with less than the normal amount of burners. These conditions are explained in more detail in the test report by KVB, Inc.²⁹

C.7.2 Small-scale tests

Numerous combustion tests of SRC-II fuel oil have been conducted with financial support from Gulf, EPRI, and other organizations. Reports from the tests provide information about the technical feasibility of SRC-II fuel-oil use in various markets.

Table C.29 indicates the various boiler and burner designs and flame configurations for emissions suppression in each test. The success of these designs in suppressing emissions from SRC-II fuel oil combustion is indicated by the resulting NO_x concentrations, fuel- NO_x yields, smoke numbers, and particulates concentrations, shown on Table C.30. Comments about each test are summarized in the following paragraphs.

C.7.2.1 Staged boiler zones in utility boilers

KVB, Inc.,³⁰ demonstrated the effectiveness of staged combustion by simulating the first and second-stage zones in staged combustion in a utility boiler.

C.7.2.2 Staging burner designs for industrial boilers

The small size and geometry of industrial boilers prevent the use of the same staging flame configurations used in utility boilers. Instead, staging in industrial boilers should be achievable by new aerodynamic designs for burners. Three new burner designs have been tested with SRC-II by Babcock & Wilcox, Gulf Oil Canada, and Southern California Edison.³¹⁻³³ The burners either were currently impracticable or produced excessive emissions; however, further development is indicated.

Table C.29. SRC-II fuel oil combustion research projects—equipment and conditions

Author	Fuel oil (MD/HD) ^a	Equipment boiler or furnace	Flame configuration for emissions suppression	Firing rate [10 ⁶ Btu/h (MW)]
KVB	SRC-II (2/1)	3 package boilers	Fuel-rich burner, downstream 2" air injector	3 each
Con Ed	SRC-II (5.75/1)	44-MW field boiler	Staging by fuel redistribution to lower burners and air redistribution	(44)
MIT				
Babcock & Wilcox	SRC-II (5.75/1)	Package boiler	"Dual-register" burner, separate control of inner and outer air flows ^b	45
Ontario Research Foundation		Vortometric burner 4-ft ID ^c tunnel	Vortometric burner and 8-ft tunnel section, fuel rich; 2" air; 20-ft second-stage tunnel	5
Southern California Edison	SRC-II (4/1)	Test tunnel 3-ft ID ^c	TRW/SCE burner, nonstaging radial fuel jets	10
Energy & Environmental Research				
Gulf Science & Technology	Various blends	Package boiler	Conventional air-atomizing burner, no staging; effect of blends on unreduced emissions	1
Westinghouse	Range of coal liquids	Single combustor in duct	Conventional combustors for stationary gas turbines, subscale and full scale	0.6
Pratt & Whitney	Doped No. 2 oil 0.5 N	Single combustor	Gas turbine combustor, low-NO _x design	
DOE/NASA Program				

^aRatio of SRC-II middle distillate (MD) to heavy distillate (HD).

^bDue to scaledown error, this unit functioned like a conventional Babcock & Wilcox burner.

^cInside diameter.

A "distribution mixing burner" design has been developed by EER, Inc. EER has used fundamental modeling of flame chemistry and aerodynamics to optimize this design, which has achieved low NO_x emissions with other nitrogenous fuels and will be tested with SRC-II fuel oil in 1980. Gulf Science and Technology Company³⁴ has conducted tests of the combustion effects of various blends of SRC-II and petroleum oil; these tests and distillation cuts reveal effects of composition on emissions.

C.7.2.3 Stationary gas turbines

The high potential of SRC-II for the stationary gas turbine market was recognized relatively recently. For baseline purposes, Westinghouse Electric Company³⁵ conducted tests in conventional combustors with excessive NO_x and smoke resulting from some coal liquids. Pratt & Whitney Aircraft Group developed a rich-lean combustor design for nitrogenous fuels that performed successfully with petroleum oils and will be tested with SRC-II fuel oil. Other important projects planned include a large DOE combustor development program, which includes major turbine manufacturers and will incorporate rich-lean concepts.

C.7.3 Conclusions and recommendations

These reports lead to three conclusions:

1. A large fraction of existing utility boilers could now burn SRC-II fuel oil within emissions standards and without operating problems.

Table C.30. SRC-II fuel oil combustion research projects—emissions results

Author	Excess air overall (%)	Total air entering first stage (%)	NO _x , ppm corrected to 15% excess air (lb/10 ⁶ Btu)	Fuel—NO yield ^a (%)	Smoke number, particulates (lb/10 ⁶ Btu) ^b
KVB	6 6 40	80	225 (0.3) 320 780		(0.2) (0.1) ^c
Con Ed		50	175	8-13	(<0.03)
MIT					
Babcock & Wilcox	1-2	a	400-480		(0.02)
Ontario Research Foundation	11	50	150		(150 ppm CO)
Southern California Edison	6.5	a	330	22	Acceptable
Energy & Environmental Research					
Gulf Science & Technology	10-60	a	200-600	20-60	0.5-9
Westinghouse	300-400	100	160-320	40-95	Various
Pratt & Whitney	300-400	75	75 ^d		Acceptable
DOE/NASA Program					

^a There was no second-stage air injection downstream from burner.

^b Measured according to American Society for Testing and Materials procedures.

^c With combustion-improver additive.

^d Corrected to 15% O₂ in exhaust; at full load.

2. The three burner designs for the industrial market tested were initially unsuccessful, although the Babcock & Wilcox and the Gulf Canada vortometric design each have certain potentials which should still be explored. The EER project appears to be the most effective burner research and development program and should include SRC-II fuel oil in laboratory and field tests.
3. Advanced gas turbine combustor development is required, and the rich-lean principle, as demonstrated by Pratt & Whitney, should be developed. This is included in the new DOE/NASA program, where SRC-II fuel oil will be used.

C.8 EXPANDED COMMERCIAL PLANT (ECP)

A preliminary assessment has been made of the environmental characteristics of an expanded-capacity commercial plant at the Fort Martin site. The assessment was made on the assumption that an additional capacity of 24,000 tons/d of coal would be provided, resulting in a total facility capacity of 30,000 tons/d. For several reasons, including available suitable site area and coal-supply logistics, expansion to 30,000 tons/d appears to be the maximum capacity that will be considered for this site. Technical and economic factors could result in a smaller expansion, but at this time, the best available knowledge and judgments indicate that a 24,000 tons/d increment would be added.

C.8.1 Plant layout

As is usually the case with major expansion of production facilities, the availability of suitable land area is an important consideration. However, a preliminary plot plan has been developed which indicates that a 24,000 tons/d expansion is feasible (Fig. C.17).

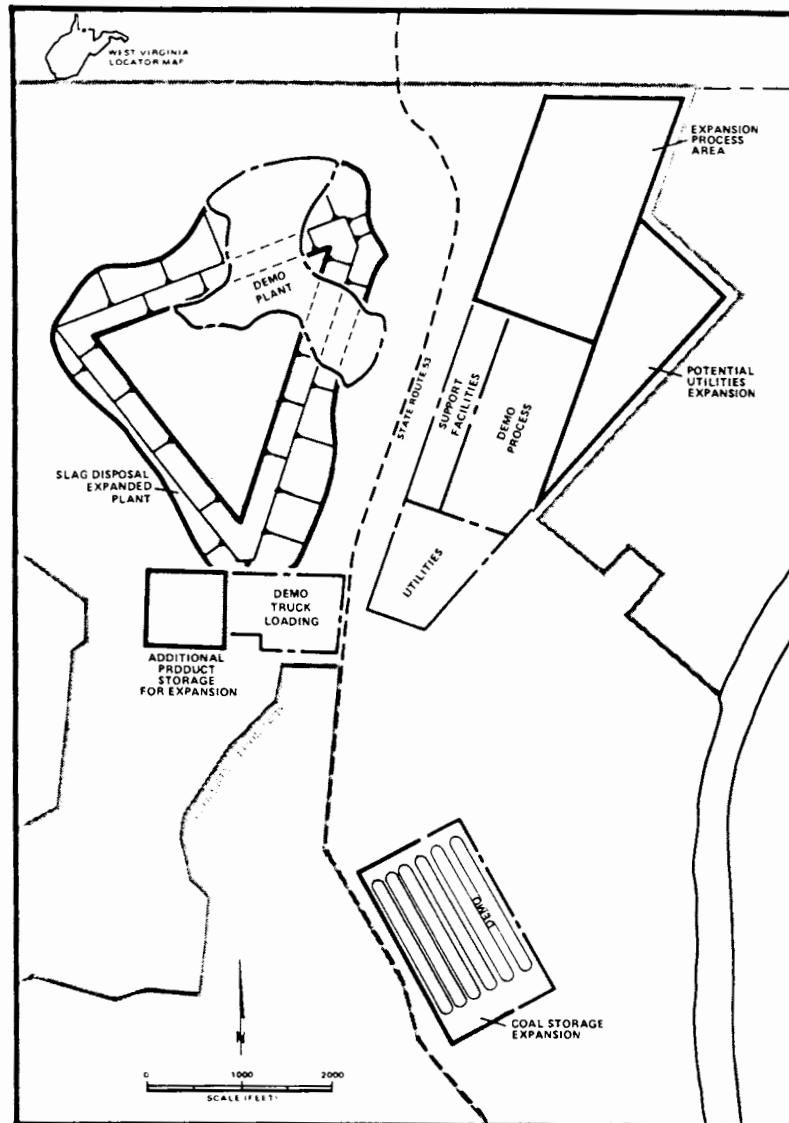


Fig. C.17. Preliminary site layout map for the expanded commercial plant at the Fort Martin site.

Of major importance was the determination of the adequacy of the site for expansion of the following areas: process, coal storage, product storage, and slag disposal. Each is discussed in this section.

C.8.1.1 Process area

Although space is somewhat limited, it appears that the area immediately north of the currently planned demonstration plant process area would be sufficient for construction of the main processing units of the 24,000 tons/d expansion. Figure C.18 shows the projected layout of the process area. The additional utilities and water treatment facilities that would be required would be constructed in open areas that have been left in the demonstration plant layout for this purpose, plus the triangular area northeast of the demonstration plant process area, which is expected to be purchased.

The space availability for the increased capacity of the main process equipment was based on the expected technical feasibility of doubling the size and capacity of major equipment and processing units.

C.8.1.2 Coal storage

As is planned for the demonstration plant, space would be provided for a maximum coal inventory of 30 d at design coal feed rate. The coal storage area would consist of the addition of four more windrow-type coal-storage piles identical to the two provided for the demonstration plant. In planning for coal storage for the demonstration plant, this future expansion requirement was considered, and adequate space was reserved.

For both the demonstration plant and the ECP, coal is reclaimed from only one pile at any specific time. Thus, for the demonstration plant, the two piles will provide storage equivalent to one full pile; for the ECP, the six piles will provide storage equivalent to five full piles.

C.8.1.3 Product storage

As currently envisioned, additional product storage would be provided west of Highway 53, west of the planned storage and loading facilities for demonstration plant truck shipments. Because the major portion of the liquid-product distribution is anticipated to be by pipeline from the ECP, the product-storage requirements would be much less, proportionately, than for the demonstration plant. Some barge shipments of liquid products and sulfur would be expected from the ECP.

C.8.2 Atmospheric emissions

Estimates have been made of the total suspended particulates (TSP), SO_2 , NO_x , CO, and non-methane hydrocarbons (NMHC) for the 30,000 tons/d ECP. Insufficient detailed equipment information makes an estimate of fugitive hydrocarbon emissions impractical at this time. Because the layout of the ECP is still conceptual, the location of emission sources (e.g., heaters, boilers, sulfur-recovery plant, etc.) cannot be identified to the extent required for dispersion modeling.

C.8.2.1 Total suspended particulates (TSP)

Estimates of the various contributions to TSP for the ECP, compared with those for the demonstration plant, as well as the rationale used in their determination, are shown in Table C.31. Referring to Table C.31, it can be seen that the estimated total particulate emissions increase from 18.0 g/s for the demonstration plant to 37.6 g/s for the ECP, or a factor of 2.09.

C.8.2.2 Sulfur dioxide (SO_2)

A comparison of SO_2 emissions from the demonstration plant and the ECP is shown in Table C.32. For the ECP, it was assumed that the fuel for all heaters and boilers would be plant gas, with a sulfur content of 100 ppmv; for the demonstration plant, a mixed fuel of plant-produced hydro-treated naphtha, with a sulfur content of 0.1 wt %, and plant gas, with a sulfur content of 100 ppmv, was used. Therefore, only about one-half as much SO_2 would be emitted per Btu of fuel burned in the ECP as in the demonstration plant. Also, it was assumed that the ECP would have a substantially higher thermal efficiency because of additional process and design information and because of such design features as increased waste-heat recovery, higher gasification pressure, and the use of combined cycle-gas turbine drives for large compressors, with the hot turbine-exhaust gases utilized for steam generation. Fuel requirements for the ECP are estimated to be 4.5 billion Btu per hour, compared to 1.47 billion Btu per hour for the demonstration plant.

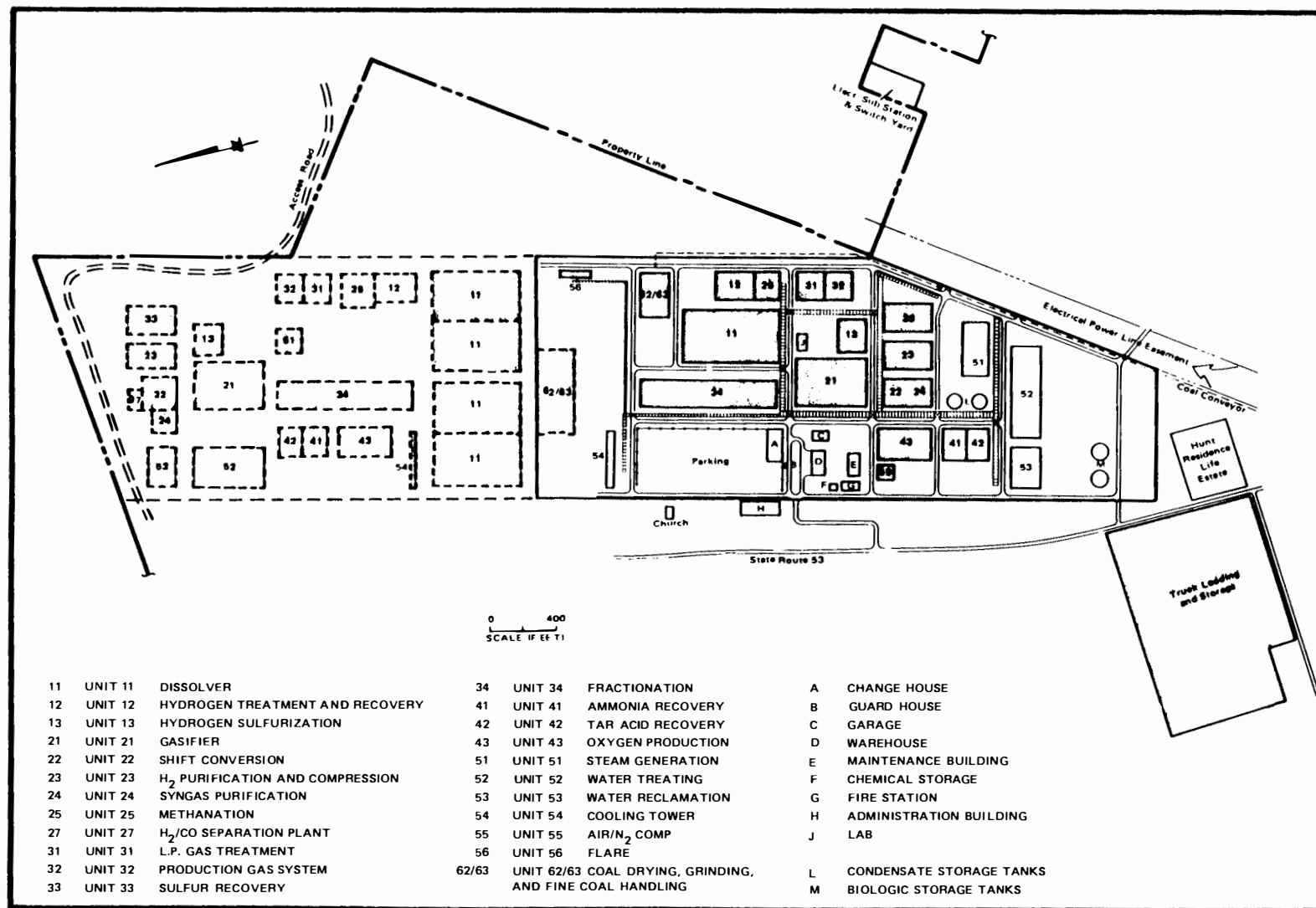


Fig. C.18. Projected layout of the process area for the expanded commercial plant.

Table C.31. Estimated TSP emissions for the ECP (g/s)

Sources	Demonstration plant	Expanded commercial plant
Coal unloading, conveying, and reclaiming ^a	0.9	4.5
Active coal storage ^b	1.7	5.1
Coal dryer/pulverizer ^c	2.5	2.5
Pneumatic transfer ^c	1.0	1.0
Slag handling ^d	1.4	7.0
Haul road ^d	0.4	0
Miscellaneous ^e	0.7	2.1
Heater and boiler stacks ^f	9.4	15.4
Total	18.0 ^g	37.6

^aEmissions are directly proportional to coal feed rates.

^bSix coal piles will be used for the ECP, compared with two for the demonstration plant, as shown in Fig. C. 17. All piles will be of the same size. For the demonstration plant, one of the piles will usually be empty. However, it is assumed that the residual coal on the ground would contribute as much dust as would a full pile. As discussed in Sect. C.3.1.1, it is anticipated that it will be feasible to use a polymer-crusting agent on the piles added for the ECP to decrease dusting. However, no credit for this was allowed in this table.

^cBased on grinding the coal with slurry or solvent in ball or rod mills for the 24,000 tons/d expansion and continuing to use the pulverizer for the 6,000 tons/d portion of the plant provided for the demonstration plant.

^dA slurry pipeline is planned for transfer of slag to the slag disposal area for the ECP. The value of 0.4 for the demonstration plant was based on a worst case of transporting the slag by truck.

^eAn increase over the demonstration plant by a factor of three was assumed for the ECP.

^fThe use of all-gaseous fuel for the ECP limits the increase in particulate emissions.

^gAs shown in Prevention of Significant Deterioration Permit Application Supplement No. 2, Table 1, Revised 7/15/80.

In Table C.32, it further was assumed that the technical performance and reliability of some of the sulfur recovery technologies discussed in Sect. C.3.2.1 would be improved and alternatives chosen so that the sulfur concentration in the H₂S-incinerator stack effluent would essentially be cut in half. For example, Selexol desulfurization (a commercially proven technology) could be used in place of Benfield and would reduce sulfur emissions by more than 50%. (For the demonstration case, Benfield was assumed in the estimate of emissions and air quality impact analyses to provide a worst case.)

Referring to Table C.32, the ratio of SO₂ emission from the ECP, compared with that from the demonstration plant, is 2.21.

C.8.2.3 Nitrogen oxides (NO_x), carbon monoxide (CO), and nonmethane hydrocarbons (NMHC)

The major factors affecting increased emissions of NO_x, CO, and NMHC from the ECP, as compared with the demonstration plant, are:

- The ECP will have a fuel consumption rate about three times that of the demonstration plant.
- Fuel used in the ECP would consist entirely of plant gases (low nitrogen content) rather than a mixture of naphtha and plant gas.

The plot plan of the ECP shows two commercial processing trains added on to the 6000 tons/d demonstration processing train. A 200% increase in piping and NMHC fugitive potential is probable. As a worst-case assumption, ECP emissions of 5 times the demonstration plant are used in the air quality analysis.

Table C.32. Estimated SO₂ emissions from the ECP (g/s)

Sources	Demonstration plant	Expanded commercial plant
All process heaters and boilers ^a	10.3	15.0
Thawing shed ^b	0.2	1.0
Coal pulverizer/dryers ^c	1.4	1.4
Sulfur-recovery plant incinerator ^d	22.7	59.0
Total	34.6	76.4

^aNonproportional increase for ECP due to the use of plant gas totally as plant fuel rather than the 29/71% mix of naphtha and plant gas used for the demonstration plant. SO₂ emissions for all gas is about one-half as much per 10⁶ Btu as for the mixed fuel. Also, the fuel usage for the ECP is 3.6×10^6 Btu per ton of coal, compared with 5.9×10^6 Btu per ton of coal for the demonstration plant.

^bEmissions are primarily due to coal decomposition. Therefore, these emissions are proportional to coal throughput.

^cBased on the continued use of pulverizing/drying for the 6,000 tons/d demonstration plant equipment but drying by the direct injection of coal into the coal-slurry mixer for the 24,000 tons/d expansion.

^dBased on 230 ppmv H₂S to H₂S incinerator for the demonstration plant (Benfield case) and assumption that alternative controls (e.g., Selexol) would allow reduction to 120 ppmv for the entire ECP.

Table C.33 compares the estimated emission rates of NO_x, CO, and NMHC from the two plants.

C.8.3 Water impacts

The estimated consumptive water use for the ECP is 12,500 gpm, compared with 3588 gpm for the demonstration plant. The reduction in water consumption, per unit of capacity, for the ECP is due primarily to those design features discussed in Sect. C.8.2.2 that resulted in increased thermal efficiency for the ECP. The ECP consumption of 28 cfs (12,500 gpm) is somewhat greater than the 23 cfs (10,267 gpm) used by the Water Resources Council (WRC) in their evaluation of water use impact on the Monongahela River (Federal Register, Thursday, August 21, 1980, Part VI, Water Resources Council, Coal Liquefaction Demonstration Plant near Morgantown, W. Va., Water Assessment Report).

The wastewater handling and monitoring system envisioned for the ECP is similar to the one being planned for the demonstration plant. This includes provision for discharging treated wastewater to the Monongahela River when river conditions allow and performing wastewater treatment recycle within the process when river conditions do not allow discharge. Concentrations of dissolved species will be similar to those shown in Tables C.21 through C.23 in Sect. C.4.2.1, with reductions in specific species, depending on improvements in the state of the art. Due to the increased quantity of treated effluent water, the impact of the ECP on the Monongahela River with regard to total dissolved solids will be greater than for the demonstration plant. Therefore, it is anticipated that the plant will operate in the zero discharge mode more frequently, and proportionately less water and dissolved solids will be discharged to the river from the ECP as compared to the demonstration plant. As a result, more soluble salts will be recovered on site per ton of coal feed for the ECP than for the demonstration plant.

The ECP discharge potential may be estimated in the following manner, based on demonstration plant output and river assimilative capability outlined in Sect. C.4.2.2.

Salts production is basically proportional to coal input to the plant, so the ECP would produce 120 tons/d of salts compared with 24 tons/d for the demonstration plant. This illustrates that ECP soluble waste or brine disposal needs will increase more than proportionally to the coal feed rate. If the demonstration plant produces 24 tons/d of TDS and is allowed 10% of the Monongahela River's assimilative capacity, the river's capacity to assimilate TDS would have to be 240 tons/d. The probability graph in Sect. C.4.2.2 indicates that the river would have this

Table C.33. Estimated emission rates of NO_x, CO, and NMHC from the ECP and the demonstration plant (g/s)

	Demonstration plant	ECP
NO _x	58.9	145.0
CO	3.9	10.2
NMHC ^a	5.8 ^a	21.1 ^b

^aPoint source, 2.8; fugitive, 3.0. See Table C.18 in Sect. C.4.1.8.

^bPoint source, 6.1; fugitive, 15.0. See Table C.18 in Sect. C.4.1.8.

assimilative capacity 95% of the time. If the salt production for the ECP is 120 tons/d and 10% of the river's capacity to assimilate TDS is allowed for the plant, the river's capacity to assimilate TDS would have to be 1200 tons/d. The probability graph indicates that the river would have this assimilative capacity 60% of the time. It is therefore estimated that the ECP would be allowed to discharge treated wastewater 60% of the time and would operate in the zero discharge mode 40% of the time. This estimate assumes that TDS are the governing discharge limitation. It should be noted that EPA will develop effluent limitations for the plant that will be identified in the National Pollutant Discharge Elimination System (NPDES) permit and factored into the design basis for the wastewater treatment plant.

C.8.4 Slag disposal

The slag-disposal facility for the demonstration plant is being designed for possible future expansion for the ECP. Adequate space is available for storage of slag which would be produced during 25 years of operation of the ECP at the 30,000 tons/d feed rate. See Sect. C.3.7 for a discussion of slag and leachate characteristics, design of the landfill, and a cross-sectional diagram of the landfill after 25 years of commercial operation.

C.8.5 River and rail impacts

At the 30,000 tons/d design rate, the ECP would require 11 million tons per year of coal. The Corps of Engineers has indicated that the navigational system for the Monongahela River has residual capacity for about 4 million tons per year. Thus, the anticipated maximum use of barge transport for supplying coal to the commercial expansion is 4 million tons per year. Two alternatives are being considered for the remaining 7 million tons: (1) unit-train shipments using about four 50-car trains per d, 7 d per week, and (2) a slurry pipeline, which may be a viable and environmentally sound way to transport the non-barged coal or perhaps the entire requirement. Contaminated slurry water could be consumptively used in the plant (e.g., for gasification).

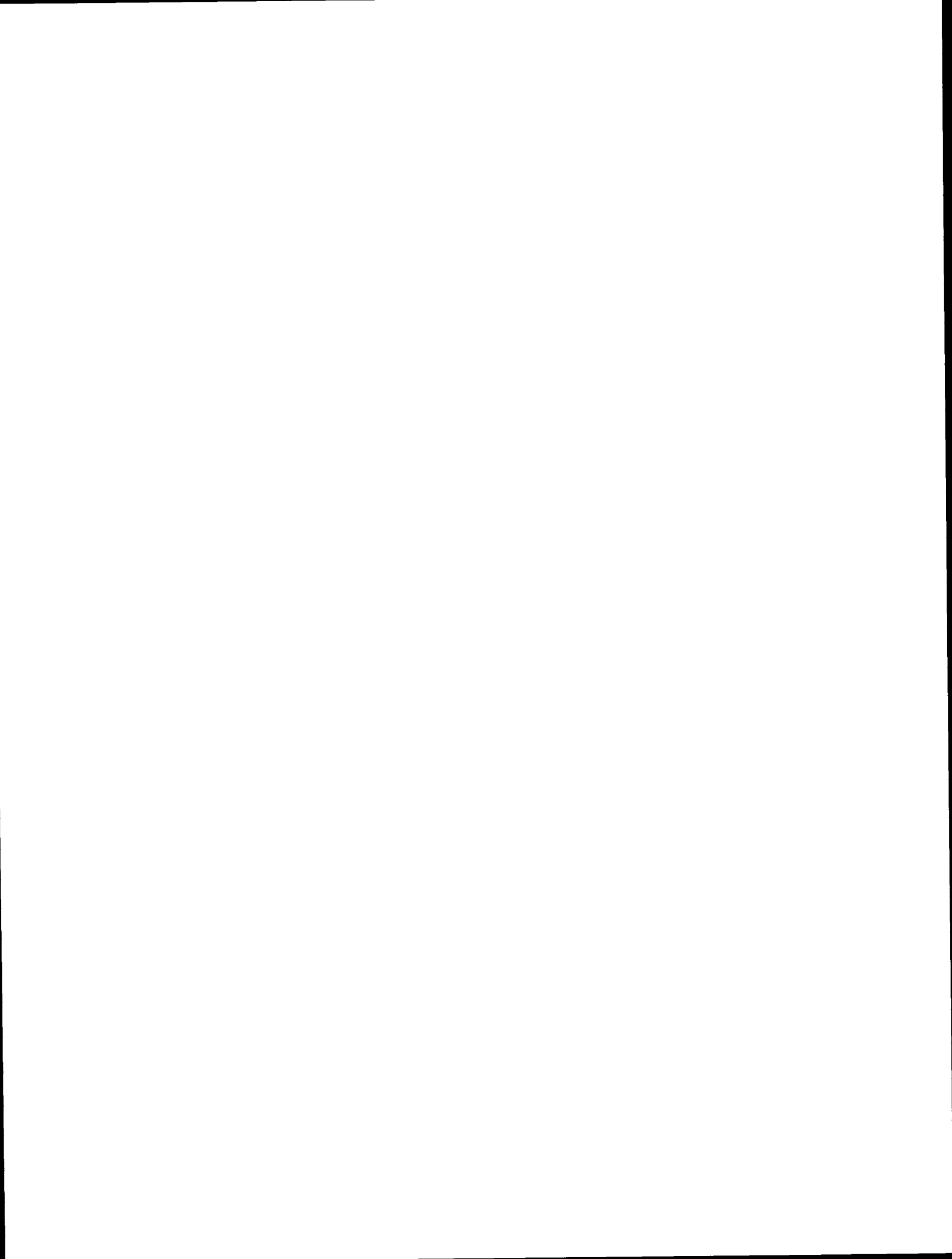
C.8.6 Impacts on floodplains and wetlands

Rail service is provided at the base of the hillside, out of the 500-year floodplain. The storage and loading facilities on the upper terrace of the Belldina property will not be enlarged. There will be no new encroachments and thus no adverse impacts on either wetland or floodplain as a result of the ECP.

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Appendix D
FLOODPLAIN/WETLANDS REVIEW

Appendix D
FLOODPLAIN/WETLANDS REVIEW

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Appendix D
FLOODPLAIN/WETLANDS REVIEW

D.1 INTRODUCTION

Development of the proposed SRC-II demonstration plant at Fort Martin, West Virginia, will necessitate the use of the west bank floodplain of the Monongahela River between river miles 93.2 and 94.5. Facilities to be located in the floodplain below the 100-year flood elevation are a barge unloading slip, process water intake facility, sections of a haul road and access road, and coal-barge unloading and fleeting facilities. A limited amount of fill will be needed to support the product storage area and its associated spill-containment facilities.

Development in the floodplain and in upland areas will necessitate the elimination of several small areas of wetland habitat. The elimination of these wetland habitat values is not considered a major project impact. Mitigation measures, including facility design modifications, have been incorporated into the overall site development plan, and the resultant floodplain/wetlands impacts for the proposed SRC-II demonstration plant are considered to be minimal.

To comply with Executive Order 11988, "Floodplain Management," and Executive Order 11990, "Protection of Wetlands," this appendix to the SRC-II FEIS identifies, evaluates, and assesses the practicable alternatives to the floodplain and wetlands impacts associated with the proposed action. This assessment follows the regulations established by the Department of Energy (DOE) published in the *Code of Federal Regulations*, titled "Compliance with Floodplain/Wetlands Environmental Review Regulations" (10 CFR Part 10.22), and the guidelines established by the Water Resources Council (WRC) published in the *Federal Register*, titled "Floodplain Management Guidelines for Implementing EO-11988," (43 FR 6030, Feb. 10, 1978). This analysis reflects public comments made during the Draft Environmental Impact Statement review period.

D.2 PRELIMINARY FLOODPLAIN/WETLANDS DETERMINATION

The following is a preliminary floodplain/wetlands determination of the practicability of locating a Federal action in a floodplain/wetlands. Pursuant to Executive Orders 11988 and 11990, a floodplain/wetlands determination for the project will be made by the Secretary of DOE and will be included in the Record of Decision.

The proposed development of the Fort Martin site for the SRC-II demonstration plant will encroach on an active floodplain and will impact wetlands at the site. It is therefore necessary under Executive Orders 11988 and 11990 to determine if any other sites offer practicable alternatives to locating the proposed project in a floodplain/wetlands.

D.2.1 Siting criteria

In selecting the primary and alternative sites for the proposed SRC-I demonstration plant, several siting constraints were established to define minimum requirements for such resources as land, water, feed coal, etc. (see Appendix B.3). A total of 27 alternative sites were evaluated. Of primary siting importance were access to suitable feed coal; site area large enough to accommodate construction of the demonstration plant and potential commercial expansion; a water supply sufficient to satisfy design criteria of 4000 to 5000 gpm for the demonstration plant and as much as 10,200 gpm for the future commercial plant; and access to barge and rail facilities for the delivery of construction materials and feed coal and for the shipment of plant products.

A raw water intake facility, a wastewater diffuser, and a barge slip must be constructed for the demonstration plant. A barge docking facility is required for delivery of feed coal and for receipt of equipment and materials required for construction. It is estimated that as much as 300,000 tons of construction equipment will be delivered to the site by barge. Because of limited capacities of railroads and highways for size and weight, much of the larger equipment, such as dissolvers, is not suitable for shipment by rail or highway.

In the initial planning stage for the SRC-II plant, feed coal was proposed to be delivered to the site by unit trains. A railcar coal-unloading system consisting of a siding long enough for 100-car, 10,000-ton unit trains and a rotary car dump capable of unloading a unit train in about 4 h was proposed. However, during a reanalysis of this system, it became apparent that the mines that produce sufficient quantities of previously tested feed coal transport only by barge. Because of this, an analysis of coal transport options was performed.

The coal transport analysis evaluated the capital and operating cost for receipt of feed coal by barge, by rail, and by a combination of barge and rail (Table D.1). This analysis demonstrated the economic practicability of only barge transportation of feed coal.

Table D.1. Alternative coal unloading cost

Facility	Capital cost (Dec. 1978 \$)	Five-year operating cost ^a (Dec. 1978 \$)
Barge unloading	8,522,000	3,755,000
Rail unloading	19,099,000	4,095,000
Combined	27,621,000	

^aOperating cost includes maintenance, operations personnel, and utilities.

In addition to the rail costs illustrated in Table D.1, it is estimated that the purchase of unit train rolling stock will require an additional capital investment of about \$4 million and about 3.5¢/car-mile for maintenance. Based on these factors, a 100-car unit train would require an operating maintenance investment of about \$105,000/year for a 200-mile round trip 150 d/year (\$525,000 for 5-year operation). Because barge transport of coal is cheaper than rail, about \$1.50/ton cheaper, barge transportation will save about \$11,000,000 in freight costs over the 5-year operation of the demonstration plant (based on 75% capacity and 330 d/year).

Combining the rail vs barge freight cost differentials with the capital and operating costs illustrated in Table D.1, barge transport proves to be a more favorable means of coal delivery (Table D.2). It is estimated that about \$26,000,000 will be saved during the life of the plant by using only barge transportation for coal delivery to the demonstration plant. Even if the dual rail/barge alternative is implemented and nonunit trains are utilized, an additional cost of \$12 to \$15 million would be required.

Table D.2. Total projected transportation costs for the SRC-II demonstration plant

Mode	Capital cost	Five-year freight cost ^a	Five-year operating cost
Rail	\$23,099,000	\$28,363,500	\$4,620,000
Barge	8,522,000	17,671,500	3,755,000
Difference	\$14,577,000	\$10,692,000	\$ 865,000

^aTotal life cycle cost saving by using barges is \$26,134,000 exclusive of any salvage value allowance.

In conclusion, it is not economically or physically practicable to utilize rail transportation for the delivery of SRC-II process feed coal and major equipment. This need for barge docking facilities, in conjunction with the need for a process water intake structure, will necessitate some degree of floodplain encroachment at the proposed or alternative sites.

D.2.2 Practicability of alternative sites

As indicated in Appendix B.3, 7 sites survived the initial screening of 27 potential sites. Because of the design and site criteria necessary for construction and operation of the proposed plant, each of the 7 sites would require barge facilities and intake and discharge structures.

Each of these facilities, located close or contiguous to a navigable river, would be at least partially located in floodplains. Therefore, all 7 sites would be expected to experience some degree of floodplain encroachment.

It is concluded that there are no practicable alternatives to locating in the base floodplain. This conclusion is not surprising in view of the requirements that are basic to the type of demonstration plant being proposed. In particular, the need for barge access for delivery of equipment during construction and of feed coal during operation necessitate some floodplain encroachment.

Both the Equality and Ravenswood sites contain wetlands that could be affected by construction. However, the degree of wetlands involvement cannot be determined because plant layouts at these sites are not available. At the Equality site, hardwood swamp forest occurs along three streams entering the Green River. This habitat is excellent for wood ducks, raccoon, mink, and other species of wooded swamps. Depending on plant layout, reduction or elimination of these wetland areas might occur if the proposed facility were constructed at this site. This could affect potential habitat for seven animal species that are rare in Kentucky (Sects. 3.3.1.3 and 4.3.1.3). At the Ravenswood site, a backwater pond occurs near the mouth of Spring Creek. This pond occurs in an area of relatively undisturbed floodplain forest, and provides very good habitat for waterfowl, amphibians, and other semi-aquatic wildlife. Depending on plant layout, construction of the proposed facility at the Ravenswood site could reduce or eliminate this wetland (Sects. 3.4.1.3 and 4.4.1.3).

D.3 FLOODPLAINS/WETLANDS ASSESSMENT

D.3.1 Project description

Flood elevations at the proposed Fort Martin site were supplied by the U.S. Army Corps of Engineers. The 100-year "base" flood was defined at 808 ft MSL and the 500-year "critical" flood was defined at 811 ft MSL. About 2.5 ha of the site is below the 500-year flood elevation. Of this area, it is projected that 1.2 ha will be filled for the storage tank facilities, and the remainder will be changed during construction of the barge docking facilities (Figs. D.1 and D.2).

The siting of the SRC-II facilities at the Fort Martin site are constrained by project requirements and the site's topography. The project requirements for coal and construction material shipment to be made by barge necessitates the construction of dock facilities, and the location of the existing rail access necessitates product handling adjacent to the Monongahela floodplain. These factors and the lack of sufficient terraced area above the 500-year flood elevation necessitate a small amount of floodplain encroachment and the removal of a small amount of wetland for the construction of permanent transportation facilities.

The development of the main process area, slag disposal site, and coal stockpile area will also eliminate several small upland ponds and a portion of grazed sedge rush meadow adjacent to the Fort Martin Community Center.

The layout of the terrace and floodplain facilities is illustrated in Figs. D.1, D.2, and D.3. These facilities have been carefully sited and designed to reduce the amount of floodplain encroachment and dredging and to provide suitable flood security. The permanent facilities, as illustrated in Fig. D.2, are located in or adjacent to the 500-year floodplain and consist of

1. one naphtha tank (50,000 bbl capacity),
2. one middle distillate tank (50,000 bbl capacity),
3. one heavy fuel oil tank (50,000 bbl capacity),
4. two blended fuel oil tanks (50,000 bbl each),
5. two sulfur tanks (28,000 bbl each),
6. six tank-spill containment reservoirs,
7. tank support facilities,
8. rail sidings and rail car loading systems,
9. roadways and access ramps,
10. barge slip,
11. coal-barge unloading dockage and conveyor facility,
12. water intake facility, and
13. wastewater discharge structure.

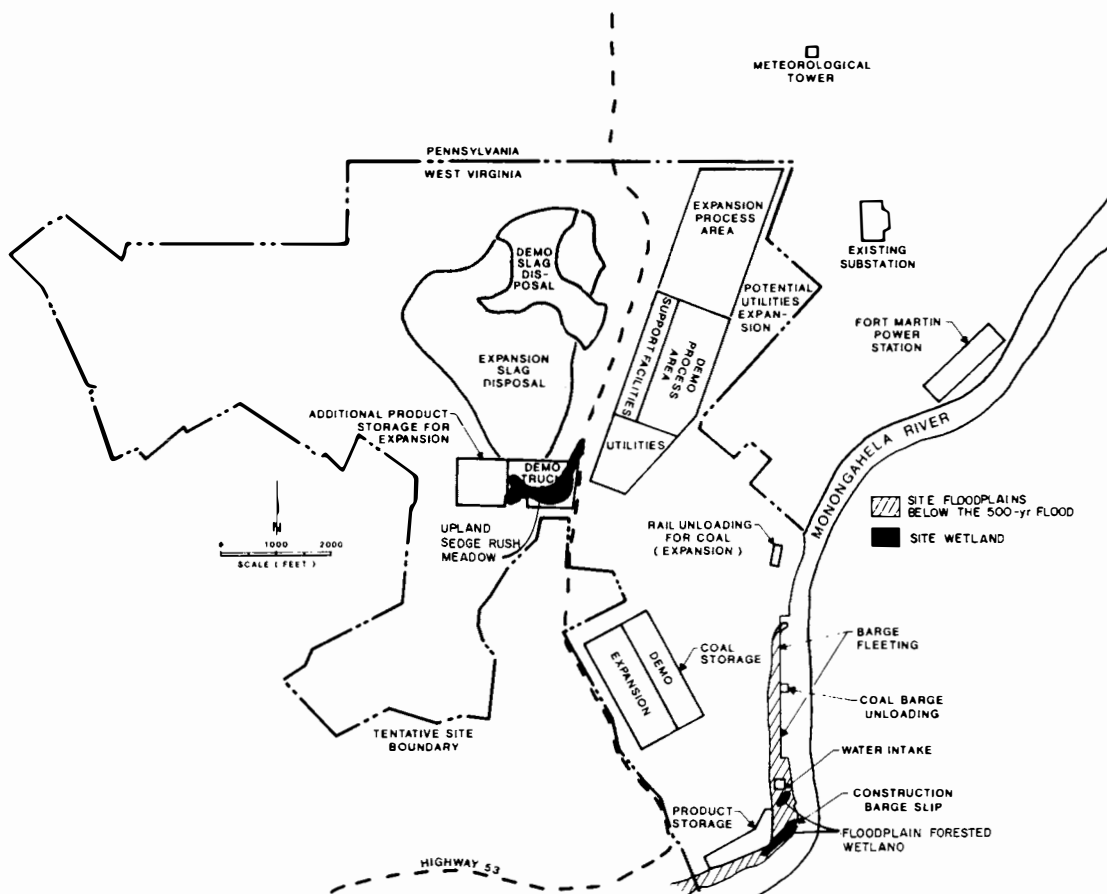


Fig. D.1. Site floodplain and wetland areas.

Exclusive of the roadways and access ramps, the total area occupied by these facilities is about 16 ha (40 acres), of which about 3.5 ha (8.6 acres) is below the 500-year flood elevation. The areas within the 500- and 100-year floodplains are about equal due to the closeness of the two floodplain limits at the site, as illustrated in Fig. D.1. About 1.6 ha (4 acres) of 500-year floodplain will be precluded due to the required elevation of the tank bases above the 500-year flood elevation and the small encroachment of the containment reservoir dikes. The remaining facilities will not be elevated above the 500-year flood elevation but will be floodproofed for the 100- and 500-year flood events.

Barge slip

The dredged barge slip, as illustrated in Figs. D.2 and D.4, will be used for unloading equipment, structured steel, pressure vessels, and other equipment transported to the site by barge. The barges will be unloaded by mobile cranes. Ramp facilities will be available for drive-off vehicles and loads. An estimated 300,000 tons of construction material will be brought to the site by barge. As illustrated in Fig. D.1, the necessity of providing access to the slip will require the leveling of the small bluff in front of the dock, which will reduce project encroachment impacts by smoothing the flood flow lines past the site.

Coal barge unloader

Coal will be barged to the site, and commercially available barge unloading equipment will be utilized. The facility is designed to handle 44,000 tons of coal per week. The dock area, shown in Figs. D.5 and D.6, require dredging for the unloading area as well as for the barge holding area. Dredged material will be used either for landfill or stored for later use in accordance with the Corps of Engineers, Section 404 permitting process. The unloading facility itself will be floodproofed to keep all essential machinery above the 100-year flood elevation.

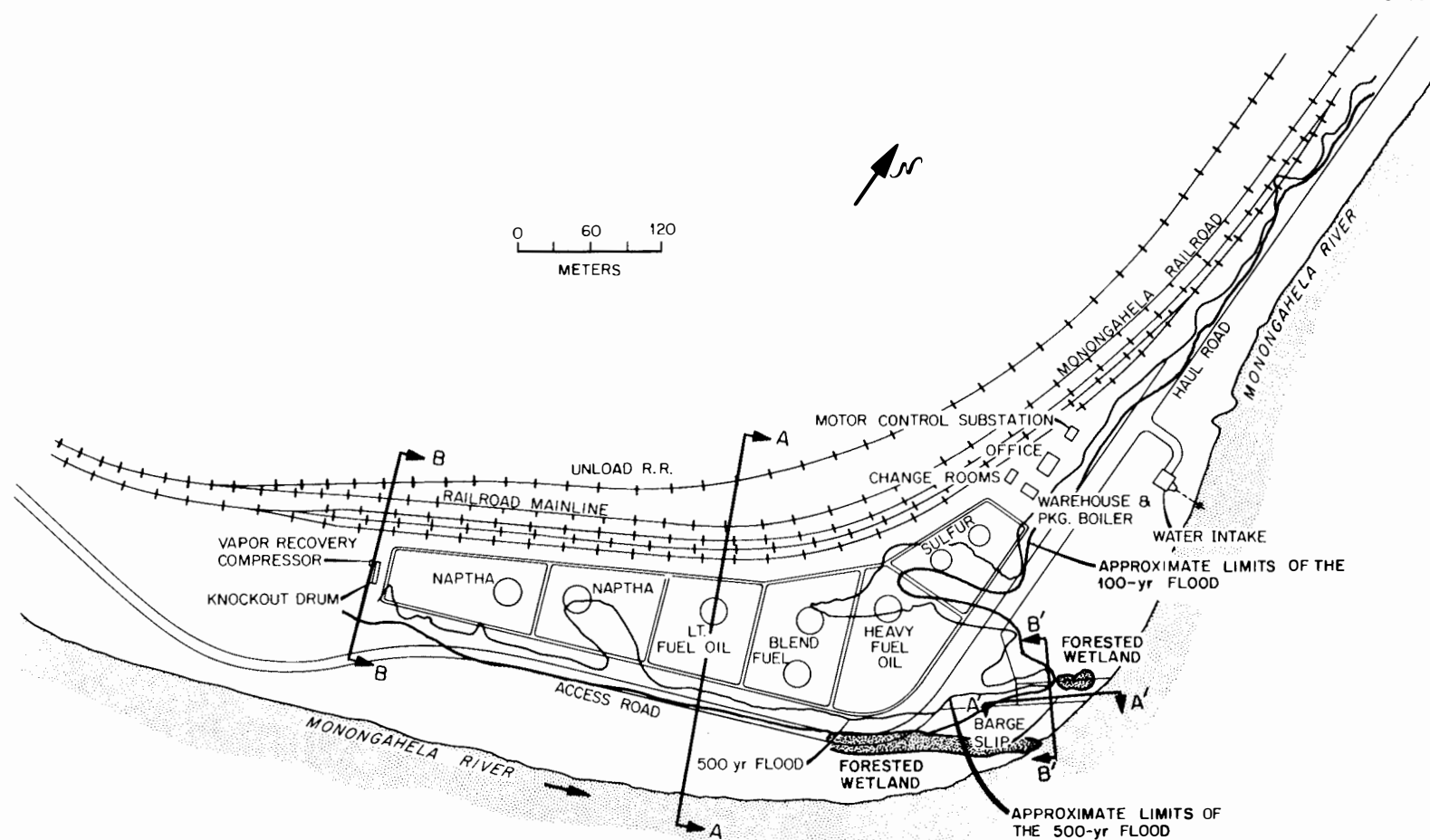


Fig. D.2. Detail of the site's major floodplain areas and the detailed DOE layout. See detail of Sections A-A and B-B in Fig. D.3 and Sections A'-A' and B'-B' in Fig. D.4.

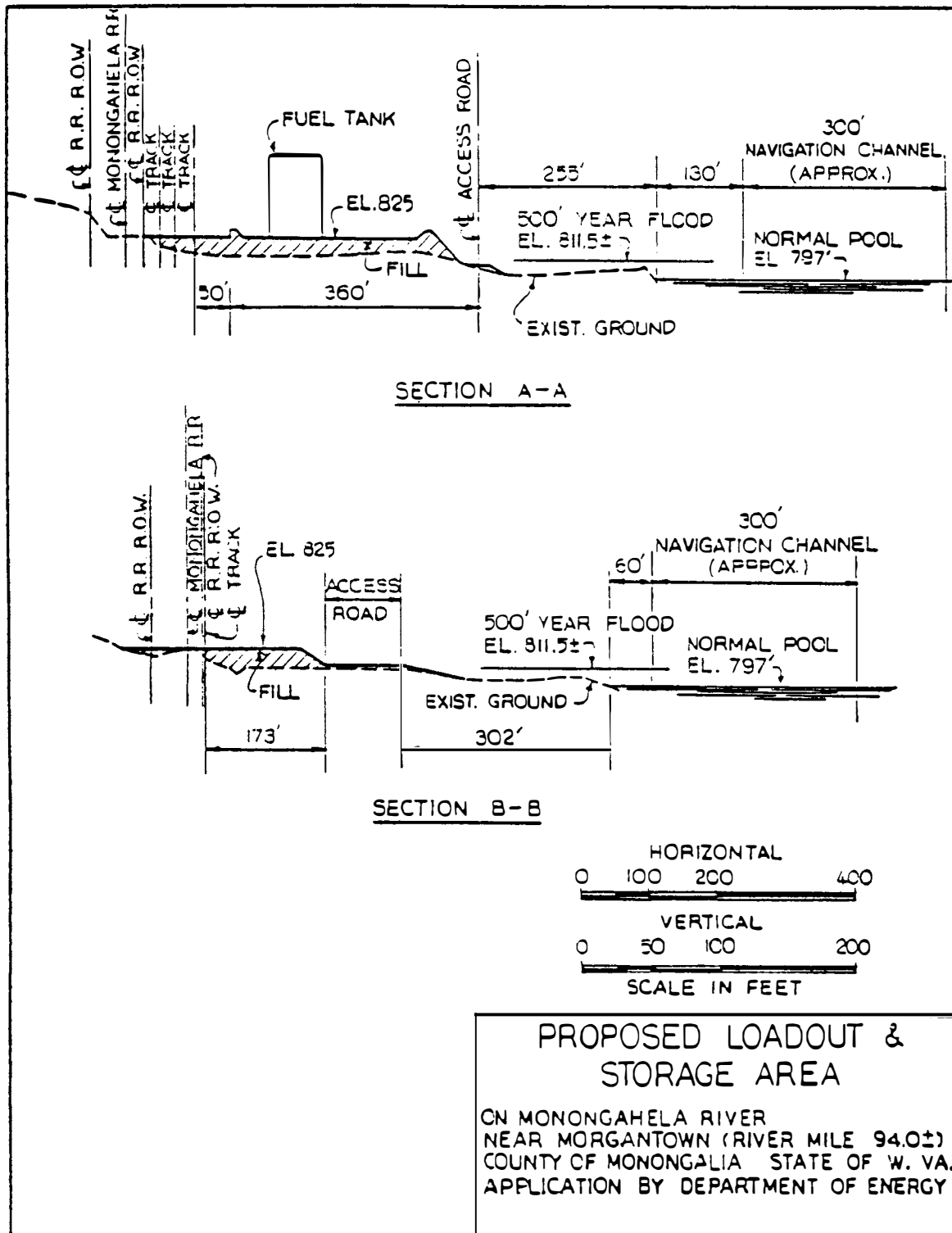


Fig. D.3. Detailed cross sections and flood elevations of the proposed product, loadout, and storage area. Sections A-A and B-B are also shown in Fig. D.2.

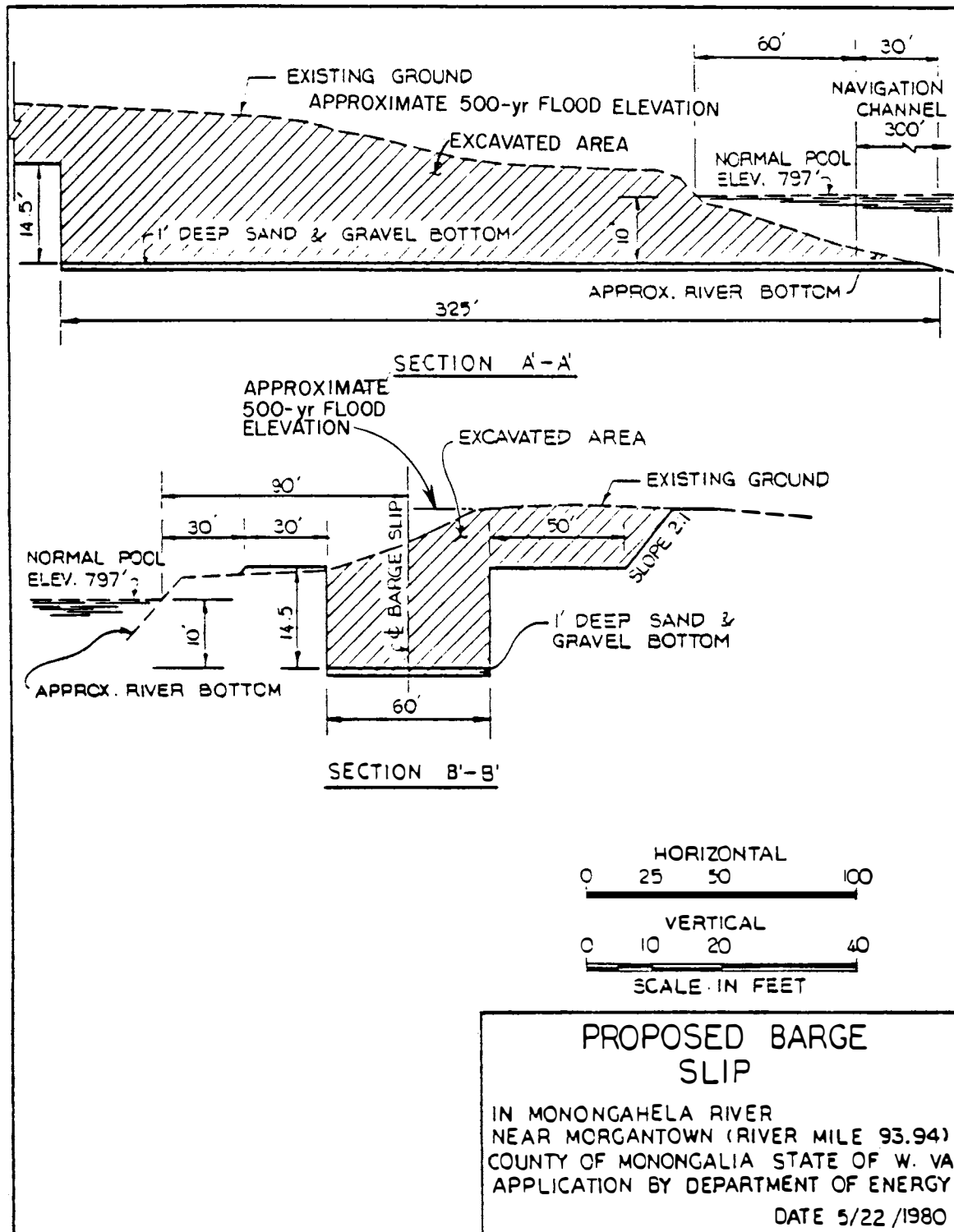


Fig. D.4. Detailed design of the barge slip. Sections A'-A' and B'-B' are also shown in Fig. D.2.

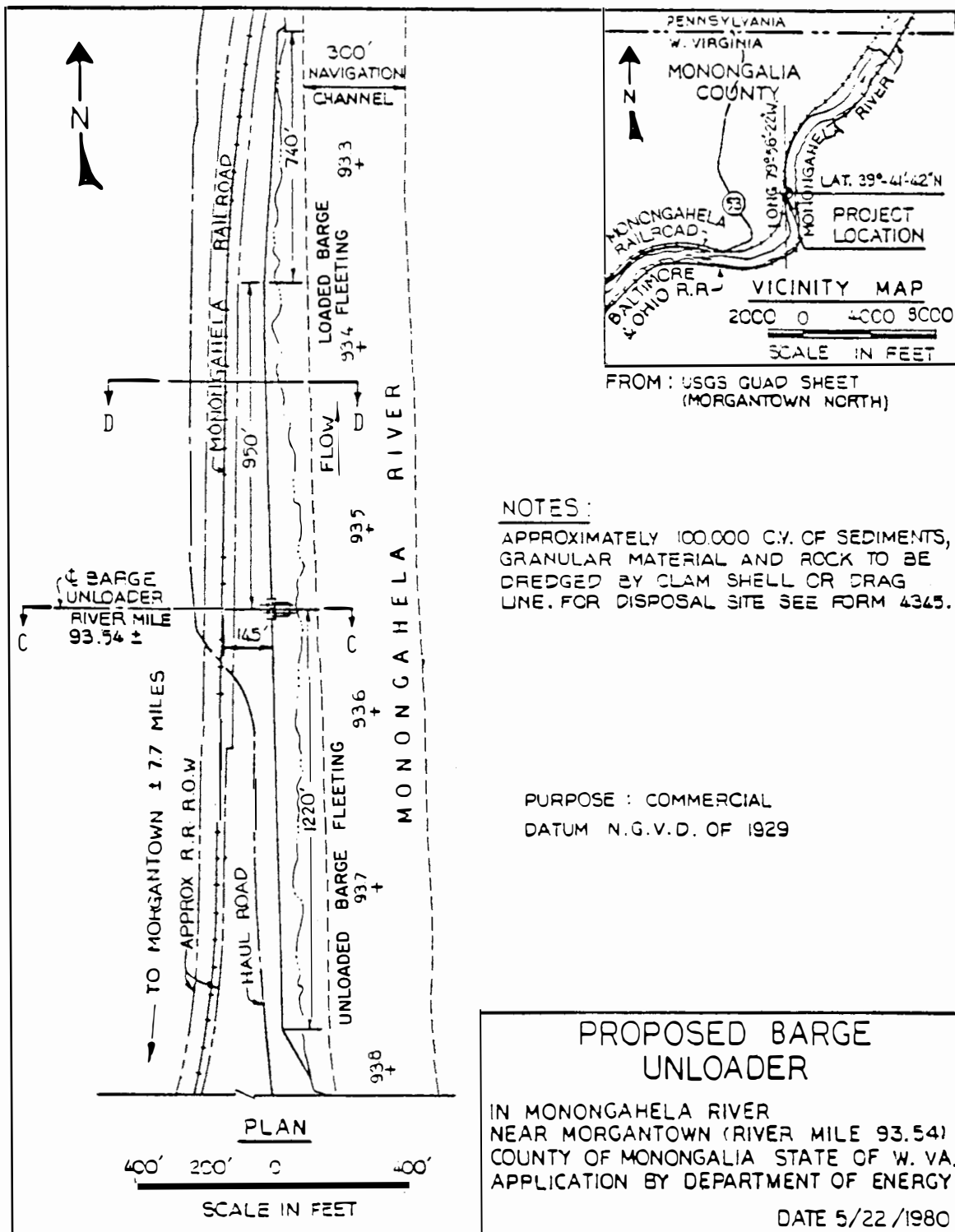


Fig. D.5. Location of the proposed coal barge unloading and holding areas.

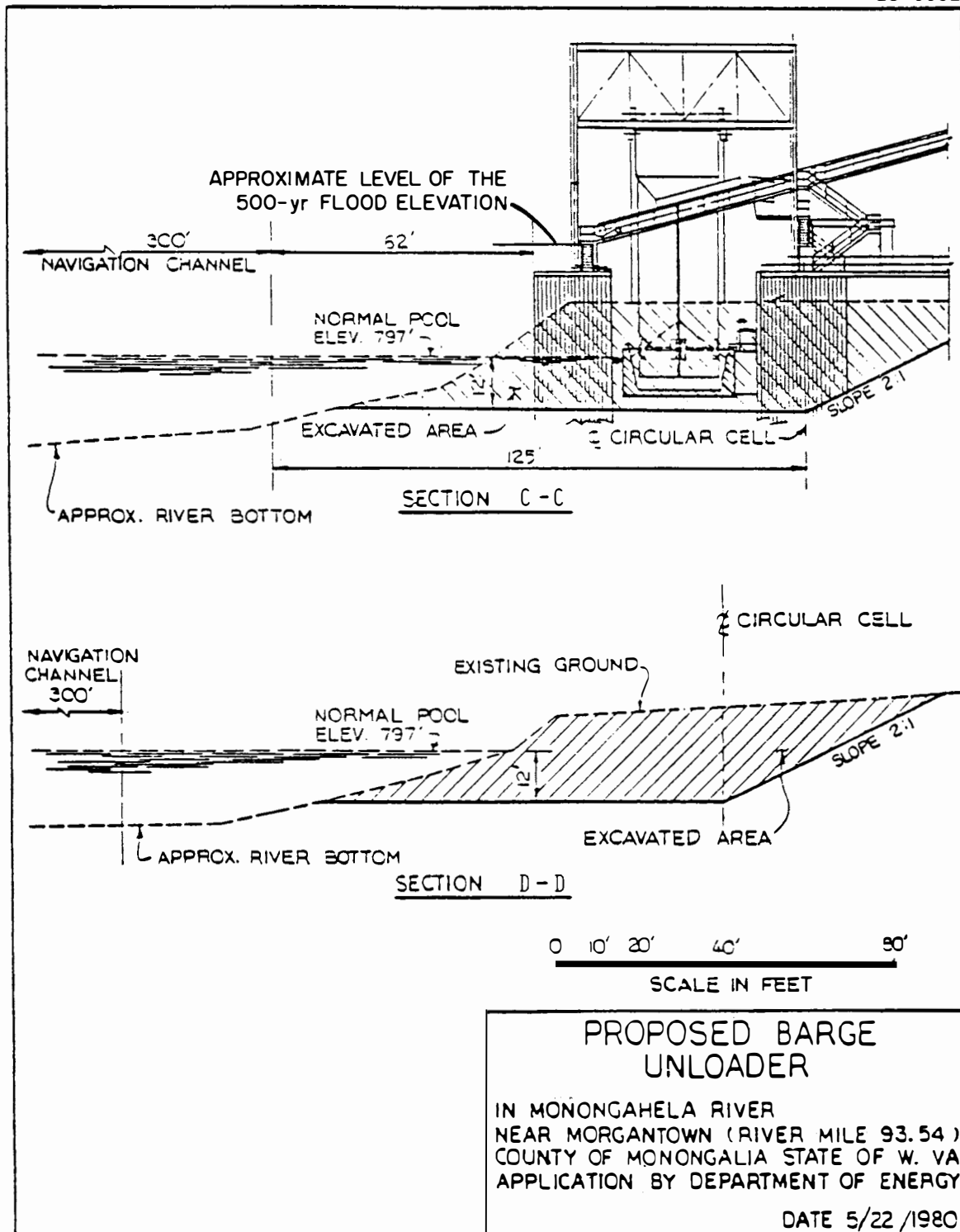


Fig. D.6. Detailed cross section of the coal barge unloading and holding areas.

Product load-out and storage area

The product storage area occupies about 12 ha (30 acres) of high terraced area between the 500-year flood elevation and the railroad. The tanks, illustrated in Fig. D.3, will be within individual spill control reservoirs lined with an impervious material and will have a drainage control system designed to reclaim all rainfall and spillage. The construction of this facility, as illustrated in Figs. D.1 and D.2, necessitates a small amount of 500- and 100-year floodplain encroachment. The base of the tanks will be at an elevation of 825 ft, or about 13 ft above the 500-year flood elevation.

Raw water intake facility

The raw water intake facility, illustrated in Figs. D.2, D.7, and D.8, is designed for the commercial plant to provide process water and emergency fire-fighting water demands. The maximum water withdrawal during commercial operation will be 17,000 gpm. The intake structure, illustrated in Fig. D.8, will be a perforated pipe located in an excavated channel out of the navigation channel. The base of the pump building will be at an elevation of 814 ft (2.5 ft above the 500-year flood elevation). The facility will be floodproof and designed to avoid erosion and bank failure. Dredged material will be either used for landfill or stored for later use in accordance with the Corps of Engineers, Section 404 permitting process.

Other facilities

Other facilities such as roadways, access ramps, and temporary open storage areas will not be elevated and will be allowed to become inundated. Other buildings, which house pumps, personnel, and product transfer equipment, will be located on the upper terrace above the 500-year flood elevation.

The truck loading facility will eliminate 3.5 ha of sedge-rush meadow and several small ponds near the Fort Martin School/Community Center. This represents about 14% of the 25 ha of this type of wetland on the site.

Within the floodplain areas, no known faults or geological hazards or other constraints, except for the inherent flood hazards, exist. Some landslide potential exists for the steep valley walls. The ability of this floodplain to resist severe scour and lateral erosion is considered adequate for process requirements.

D.3.2 Floodplain effects

The floodplain structures discussed in Sect. D.3.1 have been carefully located to avoid backwater effects on flood elevations, reduce impacts on waterborne commerce in front of the site, and reduce the amount of floodplain construction required. The largest amount of floodplain encroachment is due to construction of spill containment dikes in the product load-out area. As illustrated in Fig. D.2, the base of the dikes will fall below the 500-year flood elevation, and 4 acres of floodplain filling will be required for the construction of sulfur, heavy fuel oil, and blended fuel oil storage tanks and spill containment reservoirs. This construction will only result in a minor floodplain encroachment, as illustrated. The construction of the spill reservoir dikes and the leveling of the ground at the inland access ramp of the barge slip (Figs. D.2 and D.4) should smooth the flood flow lines past the site and not create a measurable flood profile change. Consequently, offsite impacts resulting from changes in flood elevations are not expected to occur (see Appendix J).

Flood protection and floodproofing design have been taken into consideration in the structures located within the 500-year floodplain. These designs are made to ensure the security of the structures as well as to avoid generating onsite and offsite short- and long-term impacts due to failure. The current waterfront layout is designed to avoid interference with waterborne commerce and, conversely, to avoid risks on the project and its operation. Surface drainage from the product loadout area will be collected and reclaimed, thus avoiding potential floodplain contamination from product spills.

The construction of the facilities will permanently alter the topography of a portion of the 500-year floodplain. These encroachment impacts do not significantly alter the onsite and off-site flood potentials (Appendix J). The current design does not entail the elimination of the narrow riverbank treeline except where the water intake barge slip and coal unloading facility must be constructed. The construction of the larger product load-out area and access roads have sufficient elevation and distance from the navigation pool to preclude direct construction impacts on the wooded riverbanks. The maintenance of the majority of wooded riverbank will provide an aesthetic screen for the major facilities located on the higher terraced areas.

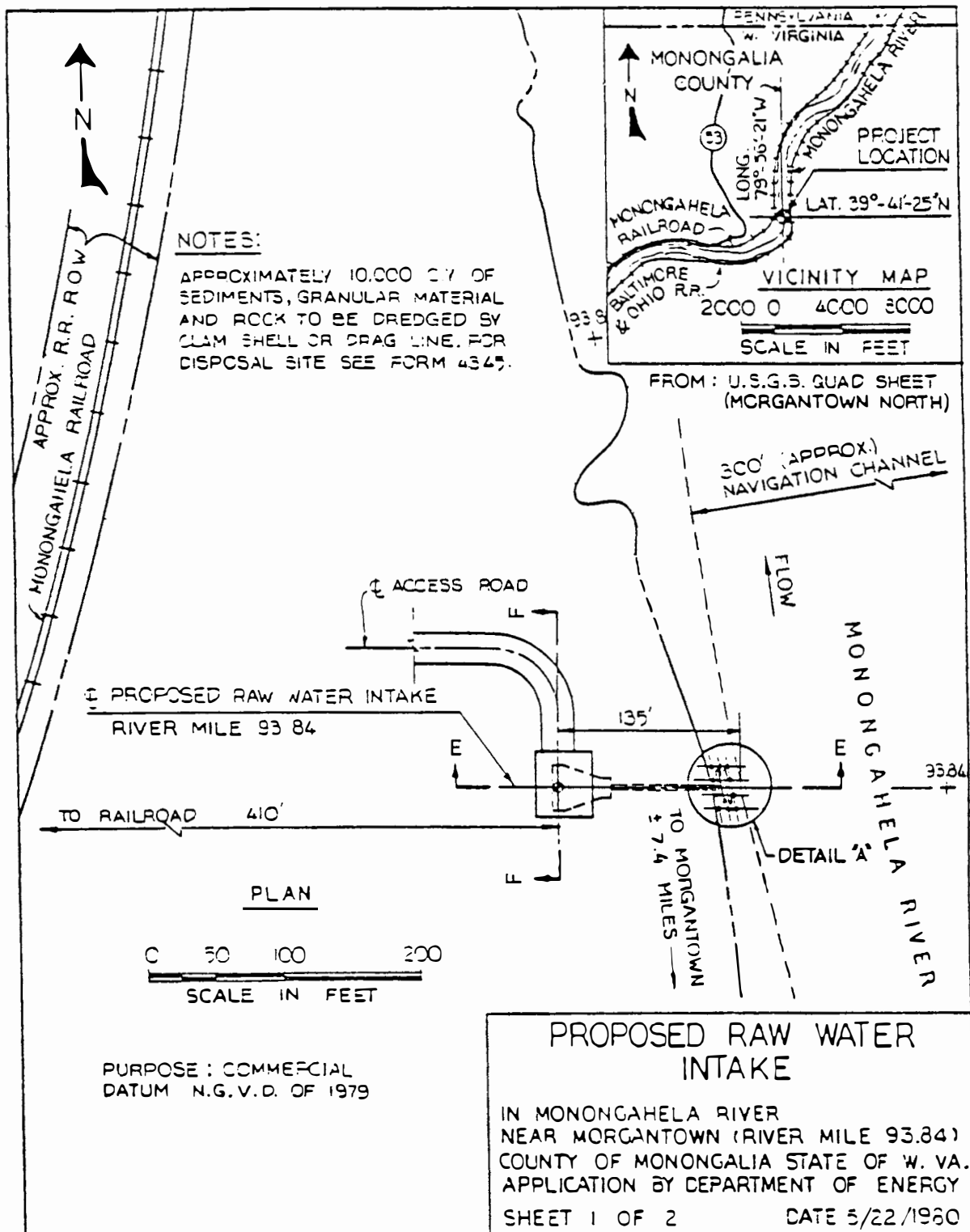


Fig. D.7. Location of the raw water intake facility.

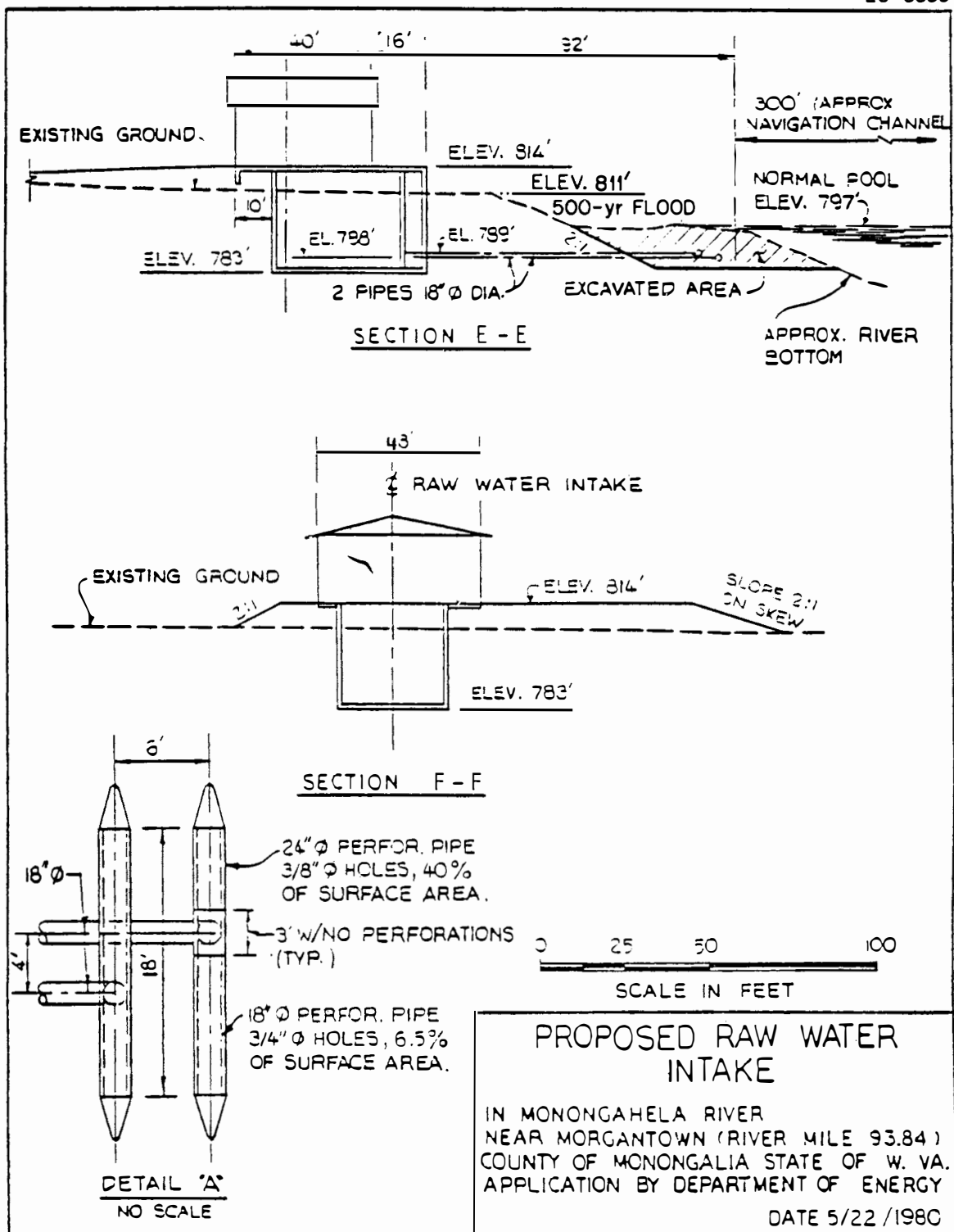


Fig. D.8. Detailed layout of the raw water intake facility.

Rail service is currently provided at the base of the hillside, out of the 500-year floodplain. Therefore the storage and loading facilities on the upper terrace of the Belldina property will not be enlarged during commercial expansion. There will be no new encroachments; thus, no adverse impacts on either wetlands or floodplain will result from the expanded commercial plant (Appendix D).

D.3.3 Wetland effects

A variety of procedures were utilized to determine the extent and number of wetland resources at the proposed site. Primary wetland data were collected by in-field site surveys and analysis of aerial photographs. An attempt was made to use data from the West Virginia Department of Natural Resources, but wetland information for the Monongahela River area had not been collected. From the reconnaissance data, it is estimated that about 3% of the proposed site is wetland (Figs. D.1 and D.2). Wetlands along the Monongahela River are not abundant, although about 10 ha of wetlands has been located in the 17-mile stretch of the river in the vicinity of the site (Sect. 4.2.1.3).

By superimposing the SRC-II plot plan on the site map that delineates wetlands, it becomes obvious that several of the site's wetland resources will be affected by the construction of the SRC-II demonstration plant (Fig. D.1). There are two small forested wetlands, comprising about 1 ha, in the Monongahela River floodplain. A minimum of 10% and as much as 100% of these wetlands will be lost due to filling for the product storage area and possibly for the barge docking facilities. Because the product storage area has been redesigned to avoid as much of the floodplain and wetland area as possible, it is felt that this encroachment is unavoidable. The sedge rush meadow, located out of the floodplain in the site's upland area, is projected to be affected by the truck loading facility (Fig. D.1). It is anticipated that about 3.5 ha of the 25 ha of sedge rush meadow wetland and several small ponds on the site will be lost due to construction. In addition, the construction of barge docking and unloading facilities and the access road will necessitate removal of 2800 ft of forested riverbank. The majority of the floodplain that will be required for the tank storage and access roads is currently devoted to agricultural cropland. Because of their small size and lack of ecological uniqueness, the utilization and elimination of these small amounts of floodplain and upland wetlands is not considered a major impact.

D.4 ALTERNATIVE ACTIONS AT THE PROPOSED SITE

Alternative actions at the proposed site include alternative layouts and designs for plant facilities. These alternatives constitute environmental impact mitigation measures when they result in reduced impacts. This section describes facility layout and design alternatives, along with other potential environmental impact mitigation measures, which have been evaluated during the various phases of development of the proposed SRC-II demonstration plant.

D.4.1 Alternative site layout and design

Throughout the development of the SRC-II facility, layout and design alternatives that could reduce floodplain/wetlands impacts of the proposed facility were considered. Major design alternatives affecting floodplain/wetlands include

1. alternative design of the barge slip,
2. alternative layout of the product storage area, and
3. elimination of the coal-barge docking facility (the exclusive use of railroads for coal shipments).

D.4.1.1 Alternative design of the barge slip

An alternative proposal reviewed in lieu of the proposed barge slip was the use of a breasting dock. An analysis of the project requirements indicated that a breasting dock may be cheaper to construct and would use less shoreline. However, this type of dock facility would not lend itself to the direct off-loading of large process equipment. In light of project requirements, this alternative was not considered feasible.

D.4.1.2 Alternative layout of the product storage area

From the beginning of site layout design, the spill security of the product storage area has been a prime design consideration. The proposed design is a modification of an earlier design. This modification decreased the amount of floodplain encroachment. The tank layout as earlier proposed in the DEIS, shown in Fig. D.9, was located closer to the river than the currently proposed tank layout and would have entailed larger floodplain encroachment. An HEC-2 computer flood profile analysis of the amount of floodwater hydraulic changes caused by the earlier design indicated that the backwater curve would raise the 100-year flood level by 0.02 ft at a location 0.5 mile upstream of the tanks and increase the flood velocities from 7.2 to 7.3 fps. These flood changes were considered minimal. The reduction of encroachment in the current design will further reduce this small flood impact.

An alternative location for the product storage area at an upland location, which required pipelining of the product down to the train loading area, was also considered. An engineering analysis indicated that a hilltop storage facility would cost an additional \$1,200,000, would create operational problems due to its remoteness from process and loading areas, and would potentially lead to a greater spillage risk. From this analysis it was concluded that a storage site adjacent to the railroad loading area was preferable.

D.4.1.3 Elimination of the coal-barge docking facility

During the initial design of the facility, the concept of rail shipment of the coal to the site was proposed. A reanalysis of the feasibility and economical merits of this concept was performed. This analysis indicated that coal rail shipment was impractical and would cost an additional \$26 million over the five-year project life. In view of these factors, coal shipment by barge became the preferred transportation mode. In addition, a barge docking facility is required for delivery of equipment and materials needed during construction.

The ability to reduce the minor wetland impacts at the site by alternative site layouts is not considered feasible. Radical changes in the site's layout of disposal and process areas have already been made because of existing site conditions.

D.4.2 Mitigation measures

The design and construction of the floodplain facilities has been carefully designed based on a balance between project requirements and environmental protection. The mitigation measures that have been designed into the facilities and planned for the construction and operation of the facilities include surface water runoff and spill containment and treatment, minimization of floodplain filling and grading, and possible development of wetlands and wildlife habitats at different locations within the site. The project will be constructed under the conditions of the Corps of Engineers and the State of West Virginia construction permits.

D.4.3 Determining not to proceed with construction at any site — no action

Encroachment on floodplain/wetlands areas at the Fort Martin site cannot be avoided if the proposed SRC-II demonstration plant is constructed and operated at this site. The project's requirement for barge transportation of coal and construction equipment and water withdrawals for plant use necessitate some degree of floodplain encroachment. Impacts at the Fort Martin site can be eliminated only if the plant is not constructed and operated at this site. The use of an alternative site would avoid impacts at the Fort Martin site but would result in floodplain/wetlands encroachment at the alternative site, as has been described previously in Sect. D.2.2. The only way to avoid floodplain/wetlands encroachment is to terminate the contract for this demonstration program — the no-action alternative.

If the decision is made to choose the alternative of terminating the contract to go forth with the demonstration project, the opportunity to obtain the intended environmental, technical, and economic data on the SRC-II process at near commercial scale would be greatly reduced. The proposed SRC-I demonstration program could provide information of a generic nature, such as hydrogen production via gasification; ash and slag disposal; pressure letdown; large-scale oxygen production; wastewater treatment; solid-liquid separation; and high-temperature, high-pressure handling of hydrocarbon, hydrogen, and oxygen mixtures. However, the conceptual designs for each of the two SRC demonstration plants have unique features. Demonstration of both technologies would provide a valuable diversity of information and operating experience about alternative designs.

Demonstration plants are a key factor in reducing scale-up risks (technical, financial, and environmental) from pilot plant to commercial facilities to a reasonable level. Because the SRC process is nearer commercial readiness than is any other direct coal liquefaction process,

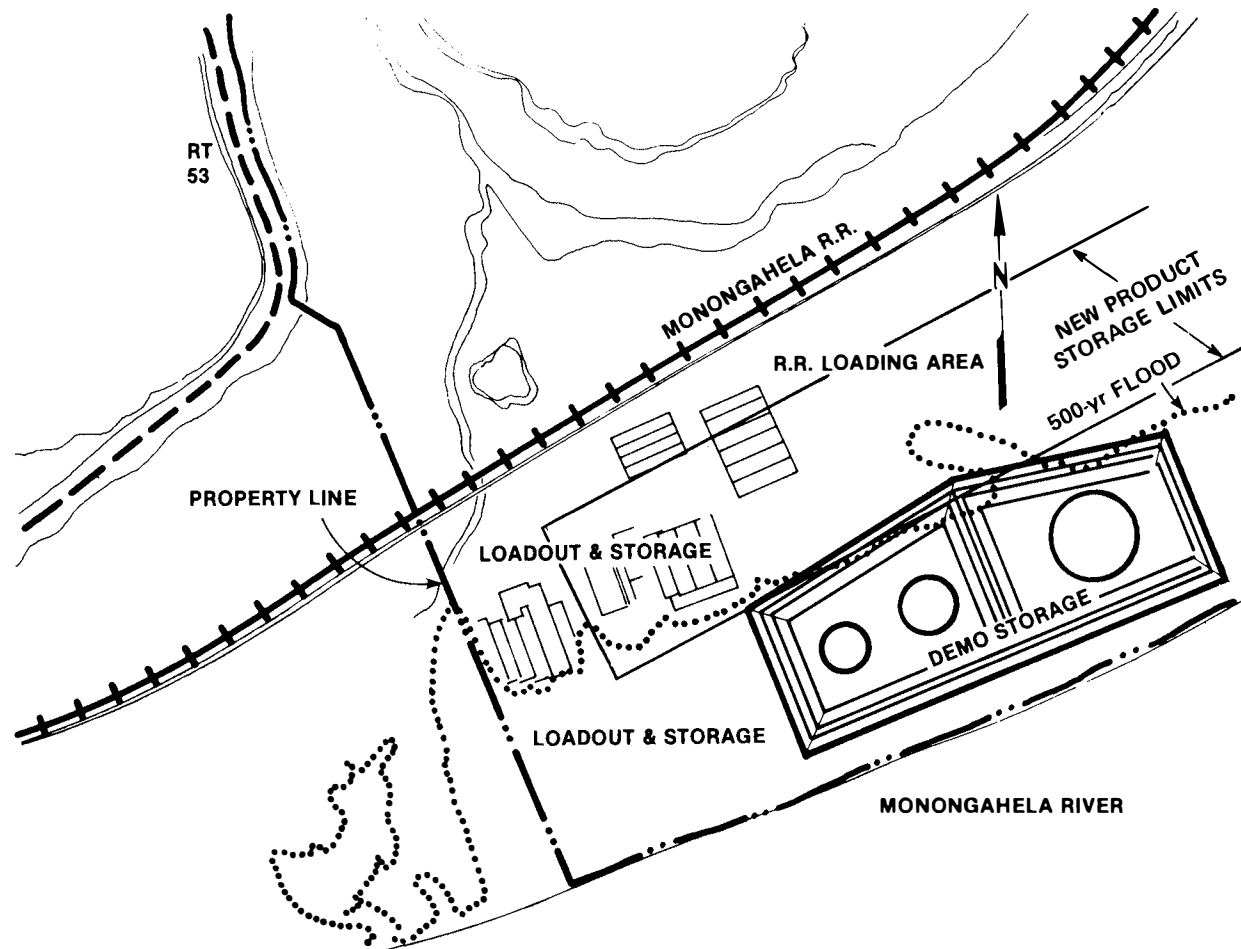
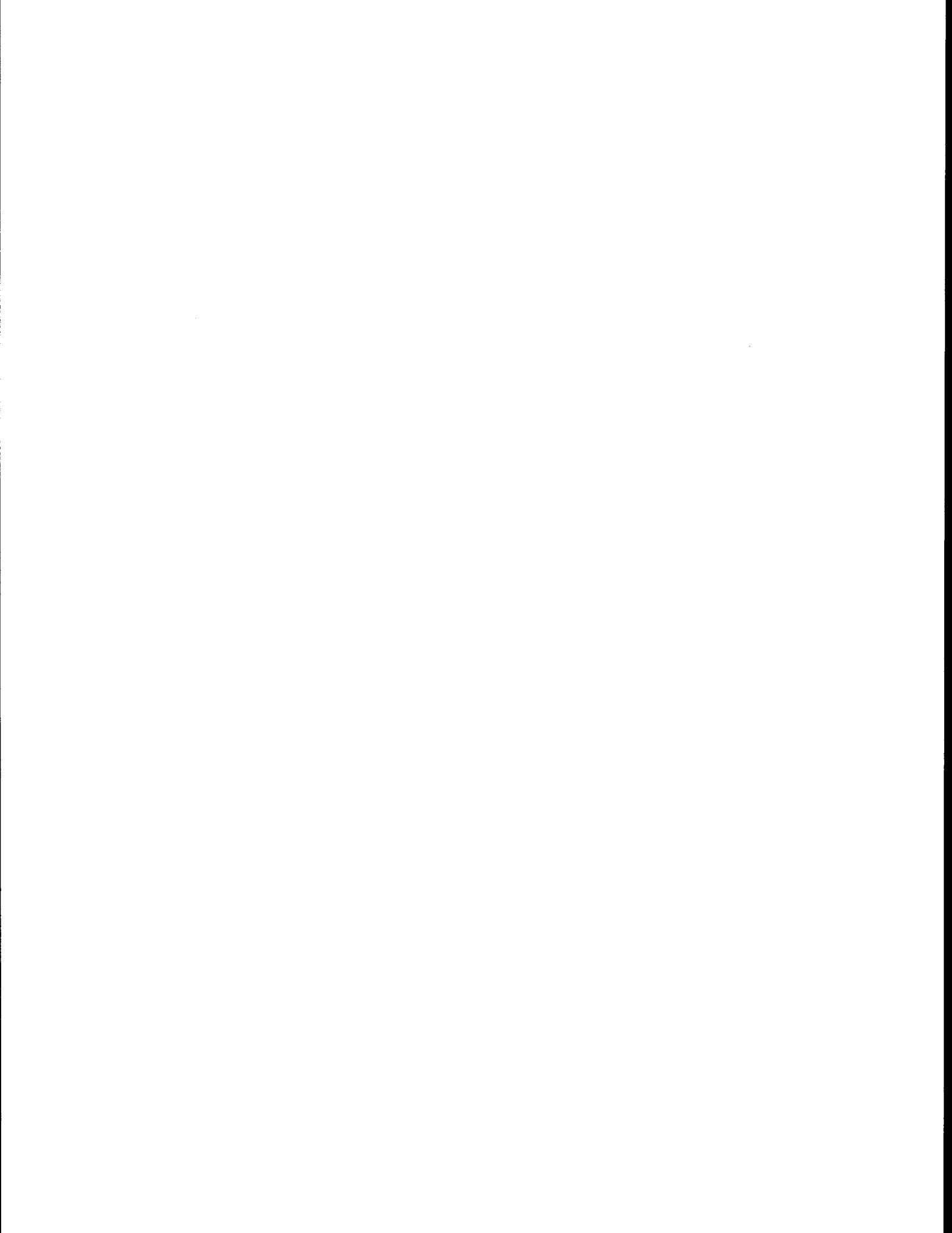


Fig. D.9. Relocated product storage areas in comparison with the earlier design.

decisions that restrict or inhibit its path to commercial development may delay DOE's response to national energy goals through the use of direct coal liquefaction technology. Also, in the absence of a synfuel industry producing clean-burning fuels, conventional coal utilization and its associated environmental impacts would likely continue.

On the other hand, commercial synfuel development may take place in the private sector when economic conditions make it attractive. If commercialization takes place without the benefits of a demonstration program, it is likely that development would proceed in a less controlled manner, with large-scale technical and environmental problems being solved during the operation of the plant rather than during the design of the plant.

Appendix E
DOE/DOI-USFWS COORDINATION





Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

April 9, 1980

Mr. Howard N. Larson
Regional Director
U. S. Fish & Wildlife Service
Northeast Region
One Gateway Center
Newton, MA 02158

Dear Mr. Larson:

SRC-II - ENVIRONMENTAL IMPACT STATEMENT

The U. S. Dept. of Energy (DOE) is preparing an Environmental Impact Statement on the proposed construction and operation of a Solvent Refined Coal (SRC-II) Demonstration Plant near Morgantown, WV. During the preparation of the Environmental Report, the industrial partner of DOE, Pittsburg & Midway Coal Mining Company, has contacted the U. S. Fish and Wildlife Service and other agencies and has made an assessment of the potential impact the proposed facility would have on endangered or threatened species and on critical habitat for such species.

In compliance with Section 7(c) of the Endangered Species Act, Amendments of 1978 (P.L. 95-362, November 10, 1978), the Department of Energy requests that you provide any information available to the Fish and Wildlife Service regarding: 1) the presence of any listed or proposed to be listed endangered or threatened species in the area of the proposed project, 2) the presence of any critical habitat for a listed or proposed species, or 3) any potential impact of the proposed project on such species. To assist in your review, a copy of the Preliminary Draft Environmental Impact Statement (PDEIS) and appropriate sections of the Environmental Assessment Report (EAR) are enclosed. A general site location map is provided on page 3-2 of the PDEIS, and site specific maps are provided throughout Chapter 3 and the extract of the EAR.

Mr. Howard N. Larson

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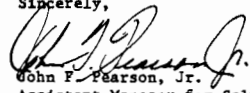
April 9, 1980

As the PDEIS is incomplete and is intended primarily for review by the Department of Energy and its contractors, we are requesting that it not be circulated outside your agency and that it not be distributed or cited.

Preparation of the Environmental Impact Statement is critical to the project schedule and receipt of your response by May 1, 1980, would be greatly appreciated. If you cannot respond by this date, please advise us as soon as possible of the expected date of your response.

If you or your staff have questions regarding this matter, please contact me or James Reafsnider at (615) 576-1055.

Sincerely,


John F. Pearson, Jr.
Assistant Manager for Solvent
Refined Coal Projects

MS:331:RCM

Enclosures:
As stated

cc: L. M. Joseph, DOE/FE-40, w/o encl.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
One Gateway Center, Suite 700
NEWTON CORNER, MASSACHUSETTS 02158

APR 25 1980

Mr. John F. Pearson, Jr.
Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

Dear Mr. Pearson:

This responds to your April 9, 1980, request for information on the presence of Federally listed or proposed endangered or threatened species within the impact area of your proposed Solvent Refined Coal Project (SRC-II) in Monongalia County, near Morgantown, West Virginia.

Except for occasional transient individuals, no Federally listed or proposed species under our jurisdiction are known to exist in the project impact area. Therefore, no Biological Assessment or further Section 7 Consultation is required with the Fish and Wildlife Service (FWS). Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to endangered species under our jurisdiction. It does not address other FWS concerns under the Fish and Wildlife Coordination Act or other legislation.

The authority for responding to requests for lists of Federally listed or proposed threatened or endangered species within the impact area of a project has been delegated to area offices of the FWS. In the future please address such requests, plus general information needs to:

Mr. Norman R. Chupp, Area Manager
U.S. Fish and Wildlife Service
Harrisburg Area Office
100 Chestnut Street, Room 310
Harrisburg, Pennsylvania 17101.

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The authority to issue Biological Opinions, however, remains with Regional Directors of the FWS. Therefore, if a project may affect endangered or threatened species or their critical habitat and formal Section 7 Consultation is anticipated, contact should be made with:

Mr. Howard N. Larsen, Regional Director
U.S. Fish and Wildlife Service
One Gateway Center, Suite 700
Newton Corner, MA 02158.

A list of Federally listed endangered and threatened species in West Virginia is attached for your information. Please contact us if we can be of further assistance.

Sincerely yours,

Howard N. Larsen
ACTING Regional Director

Attachment

E-4

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES
IN WEST VIRGINIA

Common Name	Scientific Name	Status	Distribution
<u>FISHES:</u>			
None			
<u>BIRDS:</u>			
Eagle, bald	<u>Haliaeetus leucocephalus</u>	E	Entire state
Falcon, American peregrine	<u>Falco peregrinus anatum</u>	E	Entire state - re-establishment to former breeding range in progress
Falcon, Arctic peregrine	<u>Falco peregrinus tundrius</u>	E	Entire state migratory - no nesting
Warbler, Kirtland's	<u>Dendroica kirtlandii</u>	E	Entire state - occasional migrant
<u>MAMMALS:</u>			
Bat, Indiana	<u>Myotis sodalis</u>	E	Entire state - critical habitat, Hellhole Cave Pendleton County
Bat, Virginia big-eared	<u>Plecotus townsendii virginianus</u>	E	Primarily northwestern County - critical habitat Hellhole Cave, Cave Mountain Cave, Hoffman School Cave, and Sinnit Cave in Pendleton County Cave Hollow Cave in Tucker County
Cougar, eastern	<u>Felis concolor cougar</u>	E	Entire state - may be extinct
<u>MOLLUSKS:</u>			
Snail, flat-spined three-toothed land	<u>Trindopsis platysayoides</u>	T	Monongalia County Summit of Copper's Rock
Mussel, tubercled-blossom pearly	<u>Epioblasma (=Dysnomia) torulosa torulosa</u>	E	Kanawha River Kanawha and Fayette Counties
Mussel, pink mucket pearly	<u>Lampsilis orbiculata orbiculata</u>	E	Kanawha River Kanawha and Fayette Counties
<u>PLANTS:</u>			
None			



Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

December 8, 1980

Mr. Christopher Clower
Assistant Field Supervisor
U. S. Fish and Wildlife Service
P. O. Box 1278
Elkins, West Virginia 26421

Dear Mr. Clower:

COORDINATION WITH FISH AND WILDLIFE SERVICE FOR DOE'S PROPOSED SRC-II
COAL LIQUEFACTION PLANT AT MORGANTOWN, W VA

As a follow-up to the meeting held in Morgantown, West Virginia on October 28 relative to implementation of Section 622(a) of the Fish and Wildlife Coordination Act for the proposed SRC-II coal liquefaction plant to be erected near Morgantown, West Virginia, I am enclosing information which should answer some of the outstanding questions raised during the meeting.

The report entitled, "Response to U. S. Fish and Wildlife Service (FWS) Concerns," specifically addresses the concerns of the FWS from the Morgantown meeting. In several areas, particularly Item 4, "Habitat Mitigation Plan", a conceptual plan to mitigate project impacts has been outlined. These plans, however, are conceptual in nature; and the details of any agreements and implementation, including timing, will have to be worked out as the project progresses.

Also enclosed for your review are related portions of the SRC-II Environmental Report, which contains pertinent data on wildlife and aquatic ecology for the proposed Morgantown, West Virginia site. A report entitled, "Preliminary Investigations of Adult, Juvenile, and Larval Fish of the Monongahela River and Tributary, Morgantown, West Virginia", is also enclosed for your information.

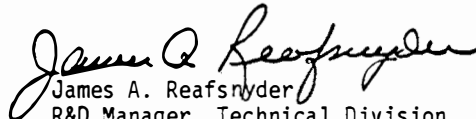
We ask that you please review the enclosed information and proposals. We believe the information substantiates that the proposed SRC-II plant

U. S. Fish and Wildlife
Service, ATTN: C. Clower

-2-

does not pose a significant threat to wildlife resources. If you have any questions or comments on the enclosed, or require additional information, please call me at FTS 626-1055 or contact Gabriel Marciante at FTS 626-0850. Commercial numbers are 615-576-1055 or 615-576-0850.

Sincerely,


James A. Reafsnnyder
R&D Manager, Technical Division
Solvent Refined Coal Projects

MS-331: GJM

Enclosures
As stated

cc: David Callaghan, w/encl
W VA Dept. of Natural Resources

Robert Miles, w/o encl
W VA Dept of Natural Resources

USF&WS, Annapolis, MD
Dr. Glen Kinser

USF&WS, Annapolis, MD
Andy Moser

USF&WS, Newton, MA

SRC-II DEMONSTRATION PLANT
RESPONSE TO U. S. FISH AND WILDLIFE SERVICE (FWS) CONCERNS

As a result of specific concerns expressed by members of the U.S. Fish and Wildlife during a site visit at the Morgantown site, the following areas have been addressed by SRC International:

- (1) Size of Barge Unloading Area. Present plans call for usage of approximately 2800' of shoreline on the Monongahela River for coal unloading. This amount is considered necessary, and the proposed use is broken down as follows:
 - (a) Approximately 800' of shoreline is required for the operation of the barge unloader, based on vendor information and visits to other facilities.
 - (b) Two "fleeting areas" for storage of full barges at one end and empties at the other are required. Barges will be stored two abreast, with room for a total of eight jumbo barges, each 195' long, in each "fleeting area" The fleeting areas are expected to occupy a total of 1600 feet.
 - (c) The fleeting areas have to be separated from the barge unloader area by clearance areas for safety and operability reasons. A clearance of 200 feet is planned, using an additional 400 feet.

The existing barge facilities of the Fort Martin Power Station are approximately 1½ miles downstream.

- (2) Use of a Barge Slip. A barge slip, rather than a breasting dock, is planned for the riverfront facilities due to the nature of equipment and materials brought to the site during construction.

The dissolvers are an example of equipment that can only be unloaded at this sort of facility. The dissolvers are expected to arrive at the site by barge, sitting atop crawlers that need to be driven off. The expected size and weight severely limits options for transporting these vessels to the site. Transport by road is considered unfeasible.

Based on FWS comments, SRC International has recognized that stagnant water could become a problem in the slip if no corrective measures are taken. Possible options to minimize this problem are as follows:

- Rerouting of natural drainage through the slip.
- Piping water from the intake pumps through the slip.
- Aeration.
- Using the area for docking work boats, creating turbulence and water flows.
- Any other engineering solutions developed during design.

The best option will be defined during detail design.

- (3) Undermining of Disposal Area. Early geotechnical work at the site indicates the areas within the proposed slag disposal area are undermined. These studies indicate that for the Demonstration Plant Disposal Area, these areas will be avoided.

For the Commercial Plant area, further geotechnical studies will be made to determine the extent of undermining. Where impossible to avoid these undermined areas, during Commercial Plant Design, the area will be excavated to the Pittsburgh seam elevation. These areas will be appropriately filled, and sealed with a layer of material impervious to potential leachates.

- (4) Habitat Mitigation Plans. A conceptual plan has been developed to help mitigate the effects of the project on wetlands and wildlife habitats. Three separate areas are addressed by this plan.

- (a) Approximately 2800 feet of shoreline along the Monongahela River will be utilized in the construction of barge unloading facilities. As compensation for this loss, public access to river shoreline could be provided in the Belldina's bottom portion of the floodplain, to the south and east of the product storage area (see area A on attached plan). Such access would be afforded via a road connecting with State Highway 53 near West Van Voorhis.
- (b) Due to proposed floodplain development, 3 to 5 acres of wetland will be lost. Also, a sedge meadow west of the Fort Martin School will be impacted by construction of the proposed product storage and truck loadout area. In order to mitigate the loss of these wetland habitats, a pond could be created to the west of the existing sedge meadow (see area B on attached plan). Appropriate management measures, including the introduction of important food and cover plant species, would insure that the created wetland would be attractive and beneficial to waterfowl and other wildlife.

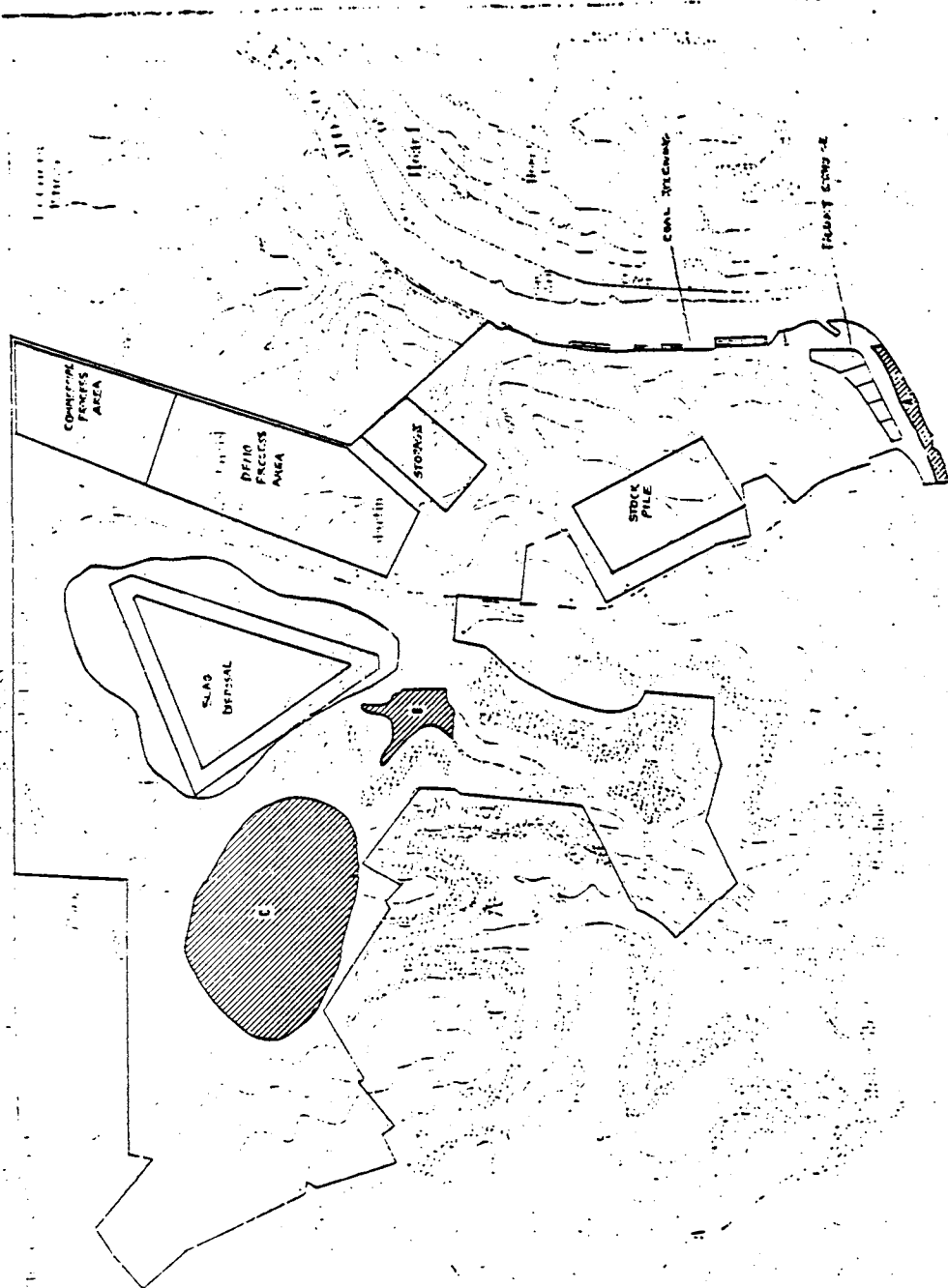
- (c) As compensation for the loss of upland wildlife habitat due to the construction of process area facilities, a wildlife habitat enhancement program is proposed. Such a program would be established in an area, not to be disturbed by plant construction or operation, located in the western portion of the site (map area C). Management techniques designed to benefit upland game birds (primarily ruffed grouse), deer, and other wildlife, would be employed. Any cattle grazing, hay mowing, or other agricultural use of these areas would cease. Appropriate reclamation techniques would be implemented on strip-mined land to accelerate plant succession to shrubby and young hardwood forest communities. Important food and cover plant species would be planted.

While certain game species would benefit by this management and could be expected to increase in population density, it would not be advisable to permit the use of Area A for hunting, due to its close proximity to the SRC-II plant facilities.

- (5) Water Intake Structure. The water intake structure proposed for the Demonstration Plant will be sized for possible eventual Commercial Plant Operation. The water intake structure for Commercial Plant Operation will be designed for a maximum approach velocity of 10 cm/sec. The Demonstration Plant will demand less water and result in lower approach velocity.

Investigations of adult, juvenile, and larval fish of the Monongahela River, performed by Stearns-Roger Environmental Services, have been forwarded to the Fish and Wildlife Service to help evaluation of the Project impacts on aquatic wildlife.

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Appendix F
AQUATIC ECOLOGY

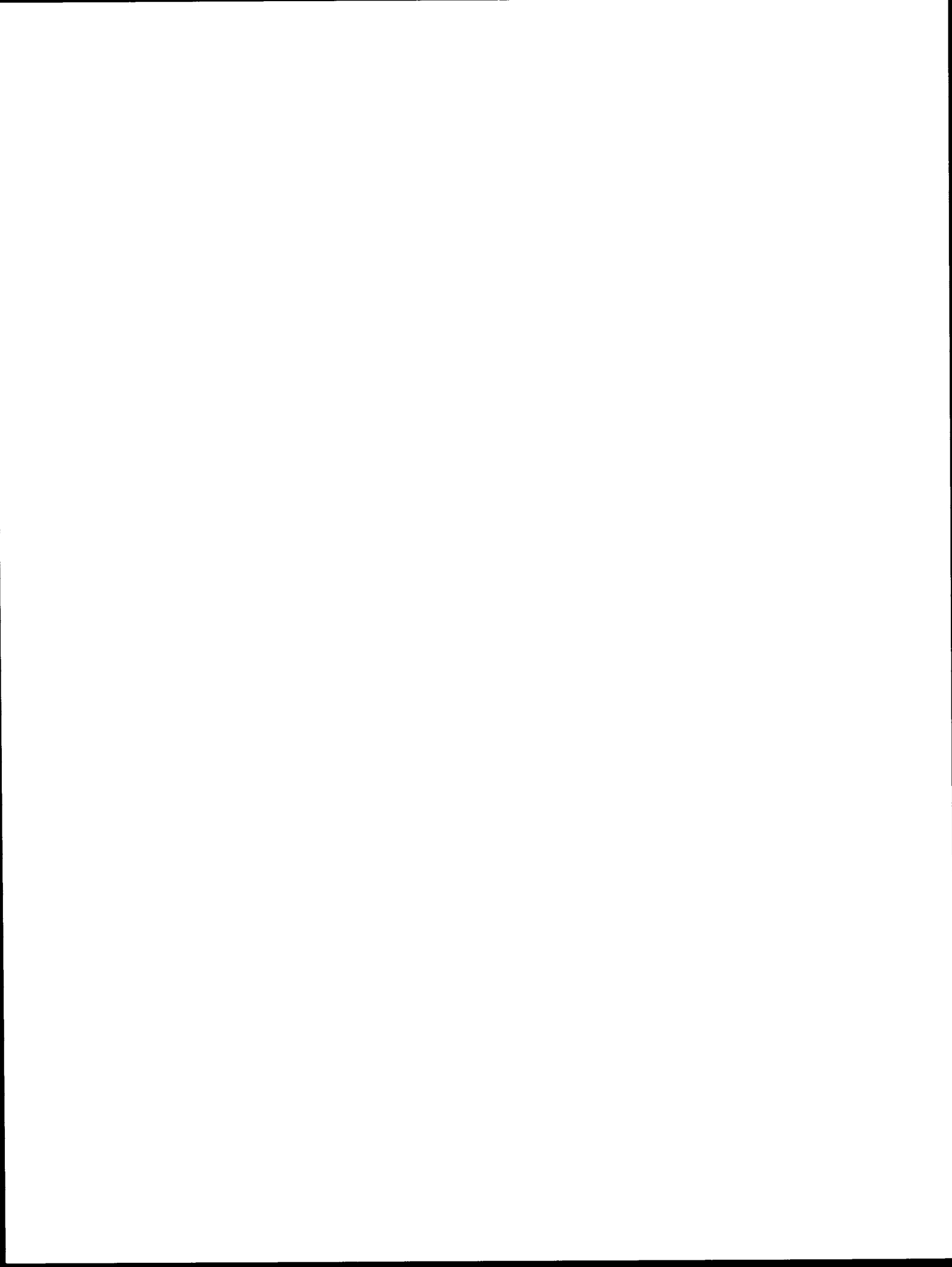


Table F.1. Summary of sampling efforts conducted during baseline monitoring of aquatic biota in the Monongahela River

Group of aquatic organisms	Sampling station		
	M-1	M-2	M-3
Phytoplankton			
No. of quarters sampled	4	4	4
Density, units/ml	1349–5627	68–9671	0–22,099
Composition	Green and blue-green algae, diatoms	Green algae, diatoms, euglenophytes, cryptophytes, and other flagellates	Similar to M-2
Periphytic algae ^a			
No. of quarters sampled	3	3	3
Composition	Primarily diatoms at all stations		
Macrophytes ^a			
No. of quarters sampled	1	1	1
Composition	Primarily pondweed at all locations		
Zooplankton			
No. of quarters sampled	4	4	4
Density, organisms/m ³	16–3875	24–9409	4–27,584
Composition	Rotifers, cladocerans, and copepods at all stations		
Benthic macroinvertebrates			
No. of quarters sampled	4	4	4
Density, organisms/m ³	0–3784	42–6157	0–2394
Composition	Primarily chironomids and tubificids at all stations		
Ichthyoplankton			
No. of quarters sampled		2	1
Total No. of times sampled		13	3 ^a
Density, larval fish/m ³		0–0.146	
Composition		Sunfish, carp, and minnow	Sucker and minnow
Adult fish ^a			
No. of quarters sampled		1	
Composition		Pumpkinseed and bluntnose	

^aQualitative survey performed.

Source: Adapted from ER, Vol. 1, Sect. 8.3.

Table F.2. Summary of the sampling efforts conducted during baseline monitoring of aquatic biota at the Monongahela tributary drainages and onsite ponds

Group of aquatic organisms	Sampling station						
	Tributary drainages				Ponds		
	R-1	K-1	C-1	C-2	1	2	3
Periphytic algae ^a							
No. of quarters sampled	1	1	3	4	1		
Composition ^b							
Macrophytes ^a							
No. of quarters sampled	1	1	1	1	1		
Composition ^c					Pondweed		
Benthic macroinvertebrates							
No. of quarters sampled			3	4	2	1	
Density (organisms/m ³)			0–5067	33–620	1304–4490	1069	
Composition			Chironomids and tubificids	Amphipods, chironomids, and other insects	Chironomids, other dipterans, and freshwater clams	Chironomids	
Ichthyoplankton ^a							
No. of quarters observations made			1	1			
Composition ^d							
Adult fish ^a							
No. of quarters sampled			1	1			
Composition ^e							

^aQualitative survey performed.

^bPrimarily diatoms at all locations.

^cHabitat unsuitable except at pond 1.

^dSpawning activity for white sucker and johnny darter observed at both locations.

^ePrimarily river chub at both locations.

Source: Adapted from ER, Vol. 1, Sect. 8.3.

Table F.3. Adult fish collected in lock pools, Monongahela River, September 1978

Scientific name	Common name	Location	
		Morgantown locks	Hildebrand locks
Centrarchidae	Sunfish		
<i>Lepomis cyanellus</i>	Green sunfish	2	
<i>Lepomis gibbosus</i>	Pumpkinseed		7
<i>Lepomis macrochirus</i>	Bluegill		6
<i>Lepomis</i> sp.	Unidentified hybrid		68
<i>Micropterus salmoides</i>	Largemouth bass		8
<i>Pomoxis nigromaculatus</i>	Black crappie	8	36
Clupeidae	Herrings		
<i>Dorosoma cepedianum</i>	Gizzard shad	1	
Cyprinidae	Minnows and carps		
<i>Carassius auratus</i>	Goldfish		2
<i>Cyprinus carpio</i>	Carp	1	2
<i>Nocomis micropogon</i>	River chub	1	
<i>Notemigonus crysoleucas</i>	Golden shiner	1	6
<i>Notropis atherinoides</i>	Emerald shiner	288	1398
<i>Notropis atherinoides</i> x ^a	Emerald shiner x ^b	1	1
<i>N. stramineus</i>	Sand shiner		
<i>Notropis buechanani</i>	Ghost shiner	9	41
<i>Notropis</i> sp.	Unidentified shiner	2	91
<i>Notropis spilopterus</i>	Spotfin shiner	2	2
<i>Notropis stramineus</i>	Sand shiner	97	49
<i>Notropis volucellus</i>	Mimic shiner	4	6
<i>Pimephales notatus</i>	Bluntnose minnow	182	3336
<i>Semotilus atromaculatus</i>	Creek chub		1
Esocidae	Pikes		
<i>Esox mosquinongy</i>	Muskellunge	1	1
Ictaluridae	Catfish		
<i>Ictalurus catus</i>	White catfish	2	
<i>Ictalurus natalis</i>	Yellow bullhead	76	7
<i>Ictalurus nebulosus</i>	Brown bullhead	4	12
<i>Ictalurus punctatus</i>	Channel catfish	39	8
Percidae	Perches		
<i>Etheostoma nigrum</i>	Johnny darter	37	58
<i>Percina caprodes</i>	Logperch	40	
<i>Stizostedion vitreum</i>	Walleye	4	6
Total		802	5152

^aHybrid fish species.

^bData collected by West Virginia Department of Natural Resources.

Source: Adapted from ER, Table 8-1.

Table F.4. Adult fish found in baseline survey, May 1979

Scientific name	Common name	M-2		C-1	C-2
		May 16	May 23	May 15	May 15
Catostomidae	Suckers				
<i>Catostomus commersoni</i>	White sucker				2
Centrarchidae	Sunfish				
<i>Lepomis cyanellus</i>	Green sunfish		5	2	5
<i>Lepomis gibbosus</i>	Pumpkinseed	15	19		
<i>Lepomis macrochirus</i>	Bluegill		3		1
<i>Micropterus salmoides</i>	Largemouth bass		1		1
Cyprinidae	Minnows and Carps				
<i>Cyprinus carpio</i>	Carp		3		
<i>Nocomis micropogon</i>	River Chub			10	15
<i>Notemigonus crysoleucas</i>	Golden shiner		3		
<i>Notropis atherinoides</i>	Emerald shiner	1	1		
<i>Pimephales notatus</i>	Bluntnose minnow	10	35		
Ictaluridae	Catfish				
<i>Ictalurus natalis</i>	Yellow bullhead		6		
Percidae	Perch				
<i>Etheostoma nigrum</i>	Johnny darter				3
Total		26	76	12	27

Source: Adapted from ER, Table 8-2.

Table F.5. Larval fish collected at station M-2, Monongahela River, April-August 1979

Scientific name	Common name	Stage of development	Number collected
Castostomidae			
Unidentified	Sucker	Mesolarvae	2
Centrarchidae			
<i>Lepomis</i> sp.	Sunfish	Mesolarvae	34
		Metalarvae	3
		Juvenile	1
<i>Pomoxis</i> sp.	Crappie	Metalarvae	1
Cyprinidae			
<i>Cyprinus carpio</i>	Carp	Protolarvae	32
		Mesolarvae	9
		Metalarvae	3
<i>Notropis atherinoides</i>	Emerald shiner	Juvenile	2
<i>Pimephales notatus</i>	Bluntnose minnow	Juvenile	1
Unidentified	Minnow	Protolarvae	4
		Mesolarvae	35
		Metalarvae	1
Ictaluridae			
<i>Ictalurus natalis</i>	Yellow bullhead	Metalarvae	2
<i>Ictalurus nebulosus</i>	Brown bullhead	Mesolarvae	1
Percidae			
<i>Etheostoma nigrum</i>	Johnny darter	Protolarvae	8
		Mesolarvae	1
		Juvenile	1
<i>Etheostomitini</i>	Darter	Mesolarvae	1
		Metalarvae	1
		Unidentified	1
Unidentified larvae and remains			18
Total			161

Source: Adapted from ER, Table 8-3.

Table F.6. Larval fish per square meter of water filtered, Station M-2, Monongahela River

Date		Day collection		Night collection	
		S ^a	B ^b	S	B
April	11	0	0	0	0
	24	0	0	0	0
May	14			0.012	0
	15	0	0		
	23			0.006	0
	29			0.019	0.006
	30	0.030	0		
June	5			0	0
	6	0	0		
	13	0.009	0		
	14			0.146	0.025
	25			0	0.140
	26	0	0.008		
July	10	0	0	0	0
	18			0.146	0.018
	19	0.017	0.027		
	25			0.006	0.018
	26	0.003	0.003		
August	1	0	0.006	0	0
	14	0	0	0	0.005
Total		0.005	0.004	0.026	0.016

^aS = surface sample.

^bB = bottom sample.

Source: Adapted from ER, Table 8-5.

Appendix G
TERRESTRIAL ECOLOGY

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Appendix G
TERRESTRIAL ECOLOGY

G.1 INTRODUCTION

Negative effects of air pollutants on plants include reduced growth and reproduction resulting from various physiological changes caused directly by the pollutants, increased susceptibility of plants to parasites and diseases, and mortality of individual plants. Each plant species is generally categorized by its level of sensitivity to air pollutants — sensitive, intermediate, or tolerant. At low dosage levels, vegetation and soils may function as important sinks for airborne contaminants without adverse effects. Under intermediate dosage, subtle adverse effects (e.g., reduced growth) may occur, particularly in sensitive plant species. Exposure to high dosage may induce acute morbidity or mortality in sensitive and intermediate plants.

Effects of air pollutants on natural ecosystems in different areas have ranged from virtual elimination of vegetation to subtle changes, including reduced productivity of certain species and slight reductions of species diversity because of the loss of one or a few sensitive species. In forest ecosystems, certain plant species, which could be important to wildlife, could become less abundant because of the effect of air pollutants on the species' competitive interactions.¹ Present ambient levels of air pollutants in many areas of the eastern United States adversely affect plant productivity.² Annual national economic losses to plants caused by effects on crops and ornamentals, for example, have been estimated at \$135 million³ to \$500 million.⁴ If all plant species and other factors were considered, annual loss estimates would exceed a billion dollars.⁴ Increased air pollution from industrial development will increase this impact.

Sulfur dioxide (SO₂), nitrogen dioxide (NO₂), carbon monoxide (CO), other gases, and particulates will be emitted during the SRC-II plant operations. Although applicable EPA air quality standards will not be violated under normal operating conditions, this does not guarantee the absence of subtle effects. Unplanned, nonroutine emissions could release greater quantities of SO₂, dust, and hydrocarbons into the atmosphere for a short time than would be released by normal operations. Although plant species vary in their sensitivity to SO₂, NO₂, CO, and particulate matter, vegetation near the site will likely experience little directly observable effects from any of these pollutants (except possibly SO₂) if standards are not violated.

G.2 SULFUR DIOXIDE

At the specific locality at which pollutant concentrations will be maximal, as determined by wind direction (about 2.5 km NE of the facility), the normal operation of the plant is expected to increase ambient ground-level concentrations of SO₂ by 53 µg/m³ for the 3-h maximum, 13 µg/m³ for the 24-h maximum, and 4 µg/m³ for the annual average. These concentrations compare with present ambient levels in the SRC-II area of 705, 239, and 44 µg/m³ respectively. These ambient levels could already adversely affect sensitive plant species.

Various sources indicate that the increased concentrations of SO₂ near the facility would adversely affect only the most sensitive plant species, and such effects could probably not be distinguished from the effects of present ambient levels of SO₂. An EPA study⁵ showed that 4-h SO₂ concentrations that caused leaf injury to 22 different agricultural crops ranged from 629 to 1834 µg/m³. In the presence of ozone or NO₂, 4-h SO₂ concentrations that ranged upward from 262 µg/m³ resulted in foliar injury in 10 agricultural crops.⁶ An EPA study⁷ projected that, for sensitive plants, SO₂ concentrations required to produce threshold injury range from 262 to 2620 µg/m³. For intermediate plants, the SO₂ concentrations required are 1310 to 13,100 µg/m³. For sensitive woody plants in the southeastern United States, an EPA study⁸ estimated that 3-h SO₂ concentrations required to produce threshold injury range from 786 to 1572 µg/m³. These various studies indicate that, at least over short time periods, SO₂ emissions from the proposed facility should not significantly impact most plant species. However, the association of SO₂ with the increasing ambient concentrations of certain pollutants, such as ozone and peroxyacetyl nitrate (PAN),² may result in plant injury from SO₂ concentrations lower than the levels cited above. This speculation is supported by the findings of several studies that SO₂ concentrations below the threshold injury concentrations can cause injury when other pollutants are present.⁵

Effects of chronic, low-level exposures are more difficult to assess than effects of short-term exposures because few long-term studies have been done. Most field studies conducted near polluting industries have not been able to separate the effects of acute and chronic exposures. In one long-term study, white pine (a sensitive species) continued to increase in volume over a 10-year period when concentrations of SO_2 averaged $21 \mu\text{g}/\text{m}^3$ during each 6-month growing season.⁹

Pasture is the predominant land use in the area (480 ha on site) (ER, Volume 1). Other land uses include hay meadow (48 ha) and cropland (12 ha). Most pasture grasses are considered sensitive species,⁵ and those in areas of maximum concentration near the site could experience slightly reduced productivity as a result of plant operation.

During abnormal operating conditions, short term SO_2 concentrations off site could be much higher than during normal operation (Sect. 4.2.3.1) and could seriously affect the growth of very sensitive plant species.

G.3 NITROGEN OXIDES

The NO_2 threshold of injury to vegetation appears to be severalfold higher than the SO_2 threshold.⁴ When NO_2 concentrations are high, other pollutants are usually present; plant injury therefore results most commonly from pollutant combinations rather than from exposure to NO_2 alone.² Although NO_2 can occasionally injure trees and shrubs located adjacent to large point sources, it usually causes very little injury.⁸

Normal plant operation of all the facilities except the thawing shed* is expected to increase the ambient annual average NO_x concentration of $29 \mu\text{g}/\text{m}^3$ by a maximum of $5 \mu\text{g}/\text{m}^3$ (Sect. 4.2.3.1). Because this increase represents only 5% of the national ambient air quality standard and 17% of ambient levels, NO_x emissions should not significantly impact vegetation (except possibly near the site, due to the thawing shed operation).

G.4 CARBON MONOXIDE

Carbon monoxide has a relatively short life or residence time in the atmosphere and is not recognized as a pollutant that has serious effects on vegetation. Because predicted increases in maximum concentrations resulting from facility operation represent less than 0.1% of the air quality standard (Sect. 4.2.3.1), no significant impacts are anticipated.

G.5 HYDROCARBONS

During normal operations, the plant flare or controlled combustor is expected to consume most hydrocarbons. The maximum 3-h concentration of nonmethane hydrocarbons is predicted to be $6 \mu\text{g}/\text{m}^3$, which is much lower than the background level of $2453 \mu\text{g}/\text{m}^3$, and about 4% of the air quality standard.

G.6 PEROXYACETYL NITRATE

Peroxyacetyl nitrate (PAN) is formed almost exclusively from the photochemical reaction of unsaturated hydrocarbons with NO_x and is a regional, rather than a site-specific, problem. PAN is a suspected phytotoxicant on vegetables and has been an important problem in the Los Angeles basin.⁸ Woody plants, however, are apparently very tolerant of PAN. Because of the low predicted concentrations of NO_2 and low emissions of hydrocarbons from plant operation, the region would experience a very small increment to impacts caused by PAN.

G.7 PARTICULATES AND TRACE METALS

Highly concentrated airborne particulates can affect vegetation by clogging stomata and reducing light intensity, thus interfering with plant respiration and photosynthesis. Nonvolatile trace metals contained in particulates, volatile trace metals condensed on the surfaces of particulates,

* Additional information obtained after the DES was published includes emissions of NO_x from a thawing shed, which will emit only 2% (1.21 g/s) of the total NO_x emissions (58.9 g/s) from the SRC-II facility. However, the emissions from the shed will be released near ground level, which will result in a high ground level concentration ($23.4 \mu\text{g}/\text{m}^3$ maximum annual average, located 500 m east of the center of the SRC-II process area) of NO_x from all SRC-II sources. Because the shed represents an anomaly, its emissions were not added to this analysis, which was originally presented in the DES.

and trace metals in vapors can be deposited on the surfaces of vegetation and on the soil, resulting in toxic effects on vegetation and animals. However, two reports have indicated that in the next several years, trace metal emissions will not seriously affect biota.^{10,11} Both reports emphasized that knowledge of source terms and effects on biota is lacking and that further research is needed. Based on data from conventional coal combustion studies for power plants, Turner and Strojani¹² concluded that atmospheric releases of trace elements do not present acute ecological problems. However, the effects of chronic exposure of ecosystems to long-term, low-level releases and accumulation in soils are not that well known. Thus, short-term effects to vegetation and wildlife are not expected to occur, but data are insufficient to predict the long-term effects, if any, that will result from facility operation.

During facility operation, coal handling and storage facilities and coal-conversion-related processes (including coal combustion for steam production) will release particulates containing trace elements. Because coal handling and storage particulates will settle primarily within a few hundred meters of the facility (Sect. 4.2.3.1), they should not significantly affect vegetation near the site. Normal plant operation (excluding coal handling and storage) is expected to increase the ambient annual average particulate concentration of $42 \mu\text{g}/\text{m}^3$ by a maximum of $7 \mu\text{g}/\text{m}^3$ (Sect. 4.2.3.1). This increase in concentration represents 12% of the secondary air quality standard ($60 \mu\text{g}/\text{m}^3$). No significant impacts on vegetation or animals should occur as a result of particulates.

G.8 COOLING TOWER IMPACTS

During operation of the plant, small releases of cooling tower water, called drift, will occur. Numerous studies have shown the amount of salts deposited on vegetation in drifting water droplets from freshwater cooling towers to be inconsequential.¹³ Also, the heavy rainfall in the SRC-II area would readily wash the salts from vegetation. Consequently, salt deposition effects are expected to be inconsequential.

The potential impacts of using process wastewater as makeup water for the cooling tower cannot be accurately assessed at this time, given the uncertain chemical characteristics of the priority organics of this water. A complex set of trace elements, organics, dissolved solids, and other constituents would be present in this water. These constituents, which would be heated during certain plant processes and could form chemical species such as chloroform and chlorophenols, would be emitted during cooling tower operations. The biological effects of these constituents after release from the tower is not known. However, their concentrations would be so low that vegetation and wildlife would probably not be significantly affected. Careful monitoring of the cooling tower makeup water and using some medium other than process water as a cooling tower makeup source would be mitigating measures.

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Appendix H
GEOLOGY

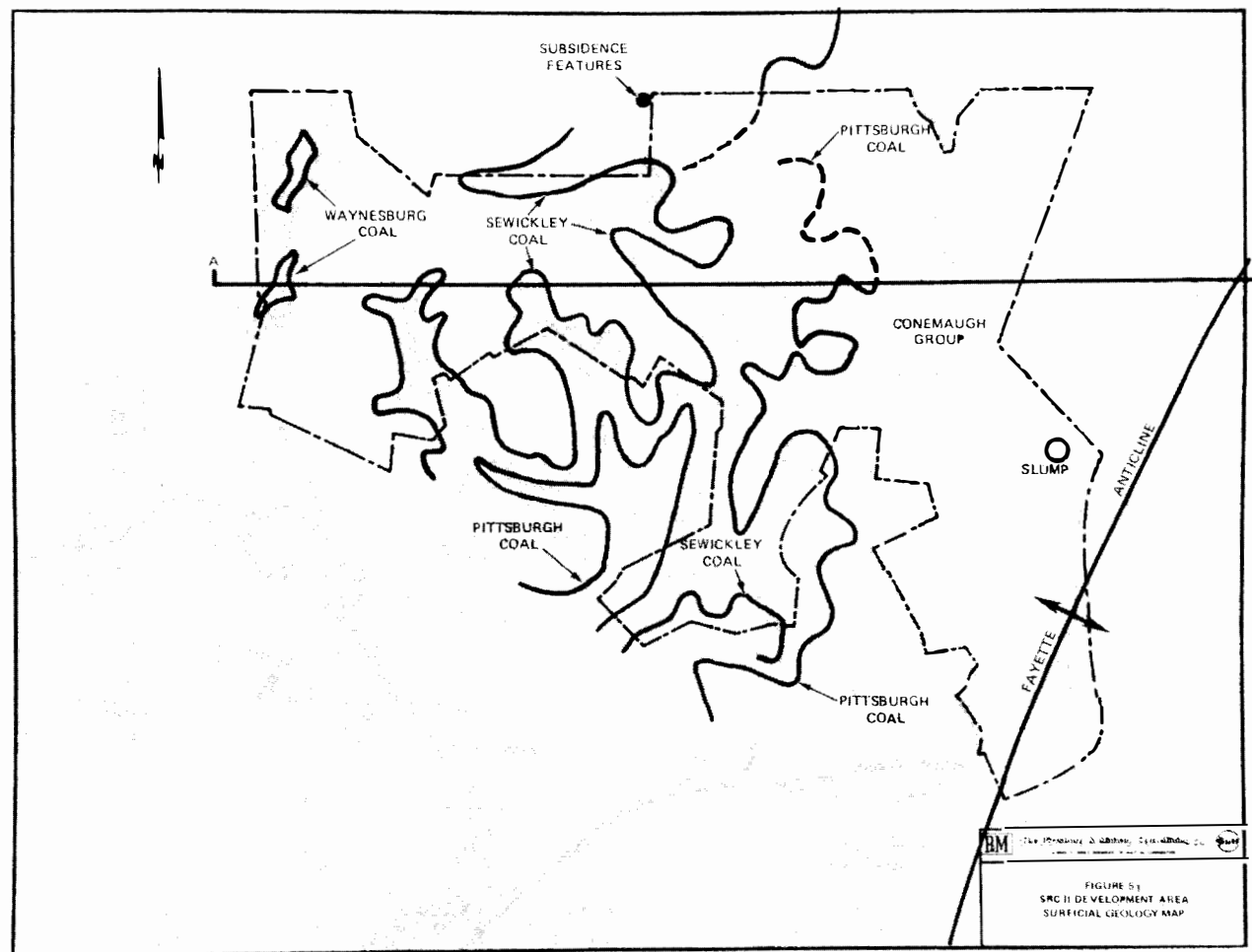


Fig. H.1. SRC-II development area surficial geology map.

ES-5595

WEST VIRGINIA LANDSLIDE STUDY
 West Virginia Geological and Economic Survey
 Robert B. Erwin, Director & State Geologist

WEST VIRGINIA LANDSLIDES AND SLIDE-PRONE AREAS

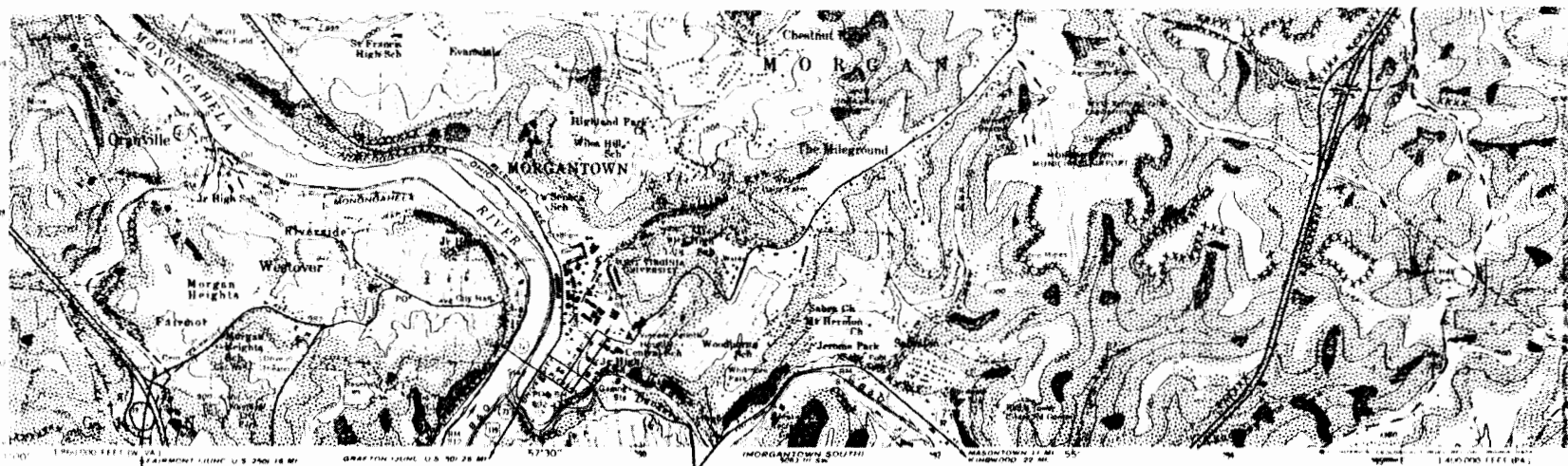
MORGANTOWN NORTH
 7.5' Quadrangle
 1976



Fig. H.2. West Virginia landslides and slide-prone areas.



Fig. H.2. (continued)



EXPLANATION

Information on this map is intended as a general guide and should not be used as a substitute for detailed geological engineering and on site investigations. Slide prone areas are based on evidence of new and old slides. Stable slopes may be susceptible to landslides if they are modified by man. Additional information is contained in the report accompanying this map.

RECENT LANDSLIDES

Areas where landslides have been historically recorded or characterized by fresh scars and obvious recent movement.

OLDER LANDSLIDES

Areas lacking evidence of recent movement, but characterized by hummocky ground, slump blocks, flow structures, water seeps, or evidence from aerial photographs. Previously stable but can be reactivated easily.

ROCKFALLS

Areas where rocks have fallen or are highly likely to fall. Normally confined to very steep, natural or man-made slopes and cliffs.

SLIDEPRONE AREAS

Areas judged to be unstable due to the occurrence of landslides, incompetent rock and soil, steep slope, or other evidence of instability.

RELATIVELY STABLE GROUND

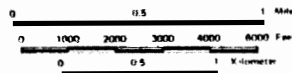
Areas judged to have very low susceptibility to landslides and contain no known evidence of instability.



Contour Interval 20 Feet
Datum is Mean Sea Level

Topographic Base Map
By U. S. Geological Survey
Base Map Complies With
National Map Accuracy Standards

SCALE 1:24,000



Compiled By
Peter Lessing, Byron R. Kulander, Bruce D. Wilson,
Stuart L. Dean, and Stanley Woodring
1976
Appalachian Regional Commission Contract 75-179A

Fig. H.2. (continued)

Table H.1. Partial stratigraphic column--
P&M/SRC-II site

Era	Period	Group	Formation	Important beds
Cenozoic	Quaternary		(Alluvium)	
Mesozoic		Absent		
Paleozoic	Permian Pennsylvanian	Dunkard	Waynesburg	Waynesburg coal
		Monongahela	Uniontown Pittsburgh	Sewickley coal Redstone coal Pittsburgh coal (aquifers drained)
		Conemaugh ^a Allegheny	Casselman	Freshwater sands Upper Freeport coal Freshwater sands
	Mississippian	Pottsville	Kanawha New River Pocahontas	Salt sands
		Mauch Chunk Greenbrier Pocono		Maxton sand Big Lime Big Injun sand (gas sand)

^a None of the rock strata below the middle part of the Conemaugh Group are exposed in the SRC-II site.

Appendix I
GROUNDWATER

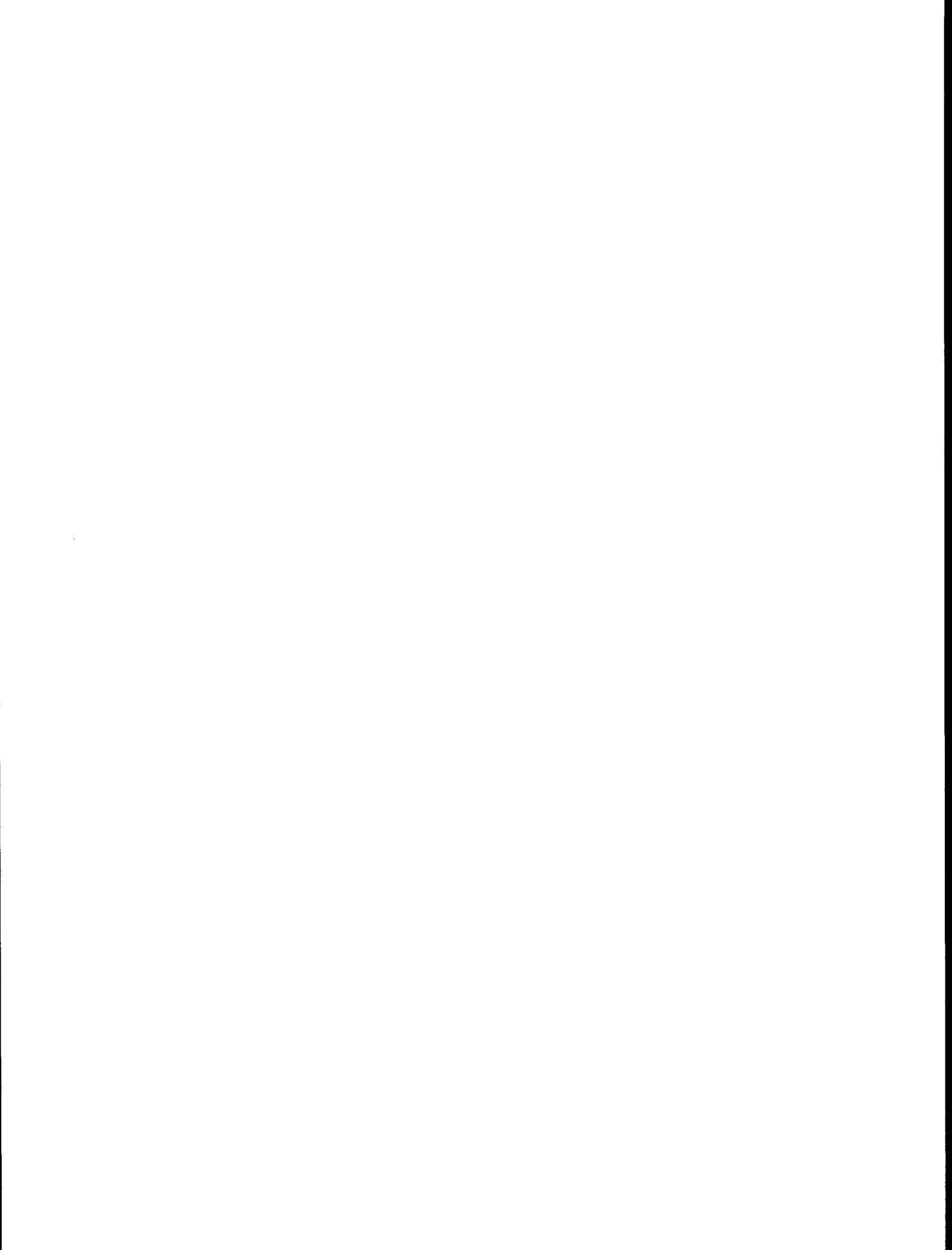




Table I.1. Groundwater quality data--
P&M/SRC-II site, well 1^a

Parameters (mg/liter) ^b	Sampling dates			
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
<u>General</u>				
Water temperature, °C ^c	14	13	10	10.3
Specific conductance, µmhos/cm ^c	360	295	338	232
pH, units ^c	6.8	6.5	7.1	6.5
Dissolved oxygen ^c	8.6	3.9	5.7	7.3
Acidity, free (CaCO ₃)	-	0	0	0
Acidity, total (CaCO ₃)	-	21	5	17
Alkalinity, pht. (CaCO ₃)	-	0	0	0
Alkalinity, total (CaCO ₃)	152	170	149	131
Bicarbonate (CaCO ₃)	-	170	-	131
Calcium	10.5	55	56	49
Carbon, inorganic	-	-	46	-
Carbon, organic	4	<1	<1	5
Carbon, total	-	-	46	43
Carbonate (CO ₃)	-	0	0	0
Color, platinum-cobalt units	<5	-	5-10	-
Fluoride	0.1	0.20	0.10	0.08
Magnesium	50	13	12	11
Potassium	1.4	1.4	1.1	1.8
Silica (as SiO ₂)	10	6.4	4.3	4.5
Sodium	3.7	3.4	2.7	3.4
Solids dissolved, total	230	260	195	193
Solids suspended, total	5	-	3	-
Sulfate (as SO ₄)	35	30	29	13
<u>Nutrients</u>				
Ammonia nitrogen as N	<0.05	<0.1	<0.1	<0.1
Kjeldahl nitrogen as N	0.15	-	<0.1	-
Nitrate nitrogen as N	1.8	0.6	0.6	0.8
Nitrite nitrogen as N	<0.01	<0.01	0.01	<0.01
Phosphate, total as P	0.05	0.03	0.02	0.03
<u>Indicators of industrial and municipal contaminants</u>				
COD	<10	<5	<5	<5
Chloride	2	4	2	2
Cyanide	< 0.01	<0.001	<0.001	<0.001
Oil and grease	< 5	8	<1	3

Table I.1 (continued)

Parameters (mg/liter) ^b	Sampling dates			
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
Phenols, ppb	.002	2.5	6.8	2.0
Sulfide (as S)	<0.1	<0.02	<0.02	<0.02
Thiocyanate	<1	-	<0.4	-
<u>Trace elements (total concentration)</u>				
Aluminum	0.4	<0.1	<0.1	0.5
Antimony	<0.5	-	<0.1	<0.1
Arsenic	<0.01	<0.01	<0.01	<0.01
Barium	-	<0.1	<0.1	<0.1
Beryllium	<0.01	-	<0.02	<0.02
Boron	<0.10	-	<0.5	<0.5
Cadmium	0.03	0.01	<0.01	<0.01
Chromium, hexavalent	-	<0.002	<0.002	0.004
Chromium, total	<0.05	<0.03	<0.03	<0.03
Copper	<0.05	0.02	0.03	<0.02
Iron	0.35	0.06	0.05	0.18
Lead	0.010	<0.05	<0.05	<0.05
Manganese	<0.05	0.03	<0.02	0.02
Mercury	0.009	<0.0002	<0.0002	<0.0002
Molybdenum	<0.1	<0.05	<0.05	<0.05
Nickel	<0.05	<0.02	<0.02	<0.02
Selenium	<0.002	<0.01	<0.01	<0.01
Silver	-	<0.02	<0.02	<0.02
Uranium	-	-	<0.1	-
Vanadium	<0.2	-	<0.1	-
Zinc	0.55	0.02	0.02	<0.02
<u>Trace organics</u>				
Benz(a)anthracene, ppt	0.0	0.0	<40	<40
Benzo(a)pyrene, ppt	<10	0.0	<10	80
Benzo(e)pyrene, ppt	0.0	0.0	<40	44
Benzo(g,h,i)perylene, ppt	0.0	0.0	<10	15
Benzene-soluble fraction, mg/kg	0.086	0.65	0.31	0.83
Pyrene	0.2	-	-	-
<u>Level I analysis for hydrocarbons</u>				
C-1	<1	-	-	-
C-2	<1	-	-	-
C-3	<1	-	-	-
C-4	<1	-	-	-
C-5	<1	-	-	-
C-6	<1	-	-	-

Table I.1 (continued)

Parameters (mg/liter) ^b	Sampling dates			
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
C-7	<0.1	-	-	-
C-8	0.5	-	-	-
C-9	<0.1	-	-	-
C-10	<0.1	-	-	-
C-11	<0.1	-	-	-
C-12	<0.1	-	-	-
Methylene chloride extract, mg/10 liters	1.8	-	-	-
Infrared analysis for functional groups	Trace HC	-	-	-

^aBeach well.

^bExcept as indicated.

^cField measurements.

Table I.2. Groundwater quality data--
P&M/SRC-II site, well 2,^a spring 4^b

Parameters (mg/liter) ^c	Sampling dates			
	Well 2	Spring 4		
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
<u>General</u>				
Water temperature, °C ^d	14	13.9	8	11.5
Specific conductance, µmhos/cm ^d	660	311	220	212
pH, units ^d	7.2	6.9	6.5	7.1
Dissolved oxygen ^d	10.3	7.8	8.2	5.9
Acidity, free (CaCO ₃)	-	0	0	0
Acidity, total (CaCO ₃)	-	17	18	13
Alkalinity, pht. (CaCO ₃)	-	0	0	0
Alkalinity, total (CaCO ₃)	234	154	127	114
Bicarbonate (CaCO ₃)	-	154	-	114
Calcium	150	55	49	65
Carbon, inorganic	-	-	41	-
Carbon, organic	6	<1	2	<1
Carbon, total	-	-	43	62
Carbonate (CO ₃)	-	0	0	0
Color, platinum-cobalt units	<5	-	5 - 10	-
Fluoride	0.3	0.18	0.17	0.16
Magnesium	9.0	0.02	9.2	74
Potassium	5.1	1.1	0.8	0.9
Silica (as SiO ₂)	10	5.2	4.3	3.6
Sodium	8.9	3.3	2.8	3.2
Solids dissolved, total	430	202	167	178
Solids suspended, total	5	-	3	-
Sulfate (as SO ₄)	125	30	32	13
<u>Nutrients</u>				
Ammonia nitrogen as N	<0.05	<0.1	<0.1	<0.1
Kjeldahl nitrogen as N	0.15	-	<0.1	-
Nitrate nitrogen as N	2.4	0.2	<0.2	<0.2
Nitrite nitrogen as N	<0.01	<0.01	<0.01	<0.01
Phosphate, total as P	0.10	<0.02	0.01	<0.01
<u>Indicators of industrial and municipal contaminants</u>				
COD	<10	<5	<5	<5
Chloride	13	<0.2	0.98	2
Cyanide	<0.01	<0.001	<0.001	<0.001
Oil and grease	<5	7	3	2

Table I.2 (continued)

Parameters (mg/liter) ^c	Sampling dates			
	Well 2	Spring 4		
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
Phenols, ppb	2.0	2.8	1.8	1.8
Sulfide (as S)	<0.1	<0.02	<0.02	<0.02
Thiocyanate	<1	-	<0.4	<0.02
<u>Trace elements (total concentration)</u>				
Aluminum	0.8	<0.1	<0.1	<0.1
Antimony	<0.5	-	<0.1	<0.1
Arsenic	<0.01	<0.01	<0.01	<0.01
Barium	-	<0.1	<0.1	<0.1
Beryllium	<0.01	-	<0.02	<0.0 2
Boron	<0.10	-	<0.5	<0.5
Cadmium	0.01	<0.01	<0.01	<0.01
Chromium, hexavalent	-	<0.002	0.003	0.004
Chromium, total	<0.05	<0.03	<0.03	<0.03
Copper	0.05	0.02	<0.02	<0.02
Iron	1.65	0.06	0.08	0.03
Lead	0.016	<0.05	<0.05	<0.05
Manganese	0.15	0.02	<0.02	<0.02
Mercury	0.0045	<0.0002	<0.0002	<0.0002
Molybdenum	<0.1	<0.05	<0.05	<0.05
Nickel	<0.5	<0.02	<0.02	<0.02
Selenium	<0.002	<0.01	<0.01	<0.01
Silver	-	-	<0.02	<0.02
Uranium	-	-	<0.1	-
Vanadium	<0.2	-	<0.1	-
Zinc	1.30	0.02	<0.03	<0.02
<u>Trace organics</u>				
Benz(a)anthracene, ppt	0.0	0.0	<40	<40
Benzo(a)pyrene, ppt	15	0.0	<10	14
Benzo(e)pyrene, ppt	0.0	0.0	<40	<40
Benzo(g,h,i)pyrene, ppt	0.0	0.0	<10	116
Benzene-soluble fraction, mg/kg	0.808	0.26	0.07	0.34
Pyrene	0.0	-	-	-
<u>Level I analysis for hydrocarbons</u>				
C-1	-	-	-	-
C-2	-	-	-	-
C-3	-	-	-	-
C-4	-	-	-	-
C-5	-	-	-	-
C-6	-	-	-	-

Table I.2 (continued)

Parameters (mg/liter) ^c	Sampling dates			
	Well 2	Spring 4		
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
C-7	-	-	-	-
C-8	-	-	-	-
C-9	-	-	-	-
C-10	-	-	-	-
C-11	-	-	-	-
C-12	-	-	-	-
Methylene chloride extract, mg/10 liters	-	-	-	-
Infrared analysis for functional groups	-	-	-	-

^aHunt well.

^bHunt spring (primary water supply).

^cExcept as indicated.

^dField measurements.

TABLE I.3 Groundwater quality data--
P&M/SRC-II site, spring 1

Parameters (mg/liter) ^a	Sampling dates			
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
<u>General</u>				
Water temperature °C ^b	14.7	11.9	6.3	10
Specific conductance, $\mu\text{mhos/cm}^b$	180	159	119	125
pH, units	6.5	6.7	6.9	6.6
Dissolved oxygen ^b	10.2	10.6	12.1	6.9
Acidity, free (CaCO ₃)	-	0	0	0
Acidity, total (CaCO ₃)	-	4	5	4
Alkalinity, pht. (CaCO ₃)	-	0	0	0
Alkalinity, total (CaCO ₃)	60	49	42	36
Bicarbonate (CaCO ₃)	-	49	-	36
Calcium	23	25	22	21
Carbon, inorganic	-	-	10	-
Carbon, organic	6	1	<1	4
Carbon, total	-	-	10	36
Carbonate (CO ₃)	-	0	0	0
Color, platinum-cobalt units	<5	-	0 - 5	-
Fluoride	0.2	0.08	0.07	0.05
Magnesium	4.5	4.9	3.7	18
Potassium	1.2	1.1	1.0	1.1
Silica (as SiO ₂)	12	8.5	6.3	5.1
Sodium	3.8	2.5	2.4	2.7
Solids dissolved, total	120	110	92	101
Solids suspended, total	5	-	<1	-
Sulfate (as SO ₄)	25	27	30	10
<u>Nutrients</u>				
Ammonia nitrogen as N	<0.05	<0.1	<0.1	<0.1
Kjeldahl nitrogen as N	<0.15	-	<0.1	-
Nitrate nitrogen as N	1.8	1.8	1.9	1.5
Nitrite nitrogen as N	<0.01	<0.01	<0.01	<0.01
Phosphate, total as P	<0.05	0.09	0.02	0.02
<u>Indicators of industrial and municipal contaminants</u>				
COD	<10	<5	<5	<5
Chloride	3	4	2	2
Cyanide	<0.01	<0.001	<0.001	<0.001
Oil and grease	<5	7	2	3
Phenols, ppb	2.0	3.0	4.5	1.8
Sulfide (as S)	<0.1	<0.02	<0.02	<0.02
Thiocyanate	1	-	<0.4	-
<u>Trace elements (total concentration)</u>				
Aluminum	0.2	0.2	<0.1	0.1
Antimony	<0.5	-	<0.1	<0.1
Arsenic	<0.01	<0.01	<0.01	<0.01

Table I.3 (continued)

Parameters (mg/liter) ^a	Sampling dates			
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
Barium	-	<0.1	<0.1	<0.1
Beryllium	<0.01	-	<0.02	<0.02
Boron	<0.10	-	<0.5	<0.5
Cadmium	0.02	<0.01	<0.01	<0.01
Chromium, hexavalent	-	<0.002	0.002	0.003
Chromium, total	<0.05	<0.03	<0.03	<0.03
Copper	<0.05	<0.02	<0.02	<0.02
Iron	0.15	0.24	0.07	<0.02
Lead	<0.01	<0.05	<0.05	<0.05
Manganese	<0.05	0.05	<0.02	<0.02
Mercury	0.011	<0.0002	<0.0002	<0.0002
Molybdenum	<0.1	<0.05	<0.05	<0.05
Nickel	<0.05	<0.02	<0.02	<0.02
Selenium	<0.002	<0.01	<0.01	<0.01
Silver	-	<0.02	<0.02	<0.02
Uranium	-	-	<0.1	-
Vanadium	<0.2	-	<0.1	-
Zinc	0.90	<0.02	0.02	<0.02
<u>Trace organics</u>				
Benz(a)anthracene, ppt	0.0	0.0	<40	<40
Benzo(a)pyrene, ppt	<10	0.0	<10	67
Benzo(e)pyrene, ppt	0.0	0.0	<40	40
Benzo(g,h,i)perylene, ppt	0.0	0.0	<10	<12
Benzene-soluble fraction, mg/kg	0.173	7.18	0.10	0.29
Pyrene	0.0	-	-	-
<u>Level I analysis for hydrocarbons</u>				
C-1	-	-	-	-
C-2	-	-	-	-
C-3	-	-	-	-
C-4	-	-	-	-
C-5	-	-	-	-
C-6	-	-	-	-
C-7	-	-	-	-
C-8	-	-	-	-
C-9	-	-	-	-
C-10	-	-	-	-
C-11	-	-	-	-
C-12	-	-	-	-
Methylene chloride extract, mg/10 liters	-	-	-	-
Infrared analysis for functional groups	-	-	-	-

^aExcept as indicated.^bField measurement.

Table I.4 Groundwater quality data-
P&M/SRC-II site spring 2, well 3

Parameters (mg/liter) ^c	Sampling dates			
	Spring 2	Well 3		
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
<u>General</u>				
Water temperature °C ^d	11.8	15.5	10.8	11.1
Specific conductance, $\mu\text{mhos}/\text{cm}^d$	950	430	330	383
pH, units	6.9	7.2	7.2	7.0
Dissolved oxygen ^d	9.2	-	-	-
Acidity, free (CaCO ₃)	-	0	0	0
Acidity, total (CaCO ₃)	-	15	13	7
Alkalinity, pht. (CaCO ₃)	-	0	0	0
Alkalinity, total (CaCO ₃)	315	275	275	255
Bicarbonate (CaCO ₃)	-	298	-	255
Calcium	130	72	59	45
Carbon, inorganic	-	-	56	-
Carbon, organic	4	<1	<1	6
Carbon, total	-	-	56	7
Carbonate (CO ₃)	-	0	0	0
Color, platinum-cobalt units	<5	-	0 - 5	-
Fluoride	0.3	0.12	0.14	0.11
Magnesium	34	36	36	7.8
Potassium	1.6	2.4	2.1	2.2
Silica (as SiO ₂)	11	3.9	3.3	2.7
Sodium	66	27	18	18
Solids dissolved, total	700	390	354	347
Solids suspended, total	10	-	<1	-
Sulfate (as SO ₄)	270	75	58	22
<u>Nutrients</u>				
Ammonia nitrogen as N	<0.05	<0.1	<0.1	<0.1
Kjeldahl nitrogen as N	<0.05	-	0.17	-
Nitrate nitrogen as N	0.25	<0.2	0.2	<0.2
Nitrite nitrogen as N	<0.01	<0.01	<0.01	<0.01
Phosphate, total as P	<0.05	<0.01	<0.01	<0.01
<u>Indicators of industrial and municipal contaminants</u>				
COD	<10	<5	<5	<5
Chloride	4	5	2	1
Cyanide	<0.01	<0.001	<0.001	0.002
Oil and grease	<5	4	1	3
Phenols, ppb	2.0	0.3	2.0	1.8
Sulfide (as S)	<0.1	<0.02	<0.02	<0.02
Thiocyanate	<1	-	<0.4	-
<u>Trace elements (total concentration)</u>				
Aluminum	0.2	0.2	<0.1	<0.1
Antimony	<0.5	-	<0.1	<0.1
Arsenic	<0.01	<0.01	<0.01	<0.01

Table I.4 (continued)

Parameters (mg/liter) ^c	Sampling dates			
	Spring 2	Well 3		
	Aug. 78	Nov. 78	Feb. 79	Apr. 79
Barium	-	<0.1	<0.1	<0.1
Beryllium	<0.01	-	<0.02	<0.02
Boron	<0.10	-	<0.5	<0.5
Cadmium	0.02	<0.01	<0.01	<0.01
Chromium, hexavalent	-	<0.002	<0.002	0.003
Chromium, total	<0.05	<0.03	<0.03	<0.03
Copper	<0.05	<0.02	<0.02	<0.02
Iron	0.35	0.07	0.10	<0.02
Lead	0.01	<0.05	<0.05	<0.05
Manganese	<0.05	0.04	<0.02	<0.02
Mercury	0.008	<0.0002	<0.0002	<0.0002
Molybdenum	<0.1	<0.05	<0.05	<0.05
Nickel	<0.05	<0.02	<0.02	<0.02
Selenium	<0.002	<0.01	<0.01	<0.01
Silver	-	<0.02	<0.02	<0.02
Uranium	-	-	<0.1	-
Vanadium	<0.2	-	<0.1	-
Zinc	0.75	0.03	0.10	<0.02
<u>Trace organics</u>				
Benz(a)anthracene, ppt	0.0	0.0	<40	<40
Benzo(a)pyrene, ppt	13	0.0	<10	47
Benzo(e)pyrene, ppt	0.0	0.0	<40	40
Benzo(g,h,i)perylene, ppt	0.0	0.0	<10	<10
Benzene-soluble fraction, mg/kg	0.093	0.31	0.31	0.51
Pyrene	32	-	-	-
<u>Level I analysis for hydrocarbons</u>				
C-1	<1	-	-	-
C-2	<1	-	-	-
C-3	<1	-	-	-
C-4	<1	-	-	-
C-5	<1	-	-	-
C-6	<1	-	-	-
C-7	<0.1	-	-	-
C-8	0.2	-	-	-
C-9	<0.1	-	-	-
C-10	<0.1	-	-	-
C-11	<0.1	-	-	-
C-12	<0.1	-	-	-
Methylene chloride extract, mg/10 liters	2.7	-	-	-
Infrared analysis for functional groups	Trace HC	-	-	-

^aRauber spring.^bMathew well.^cExcept as indicated.^dField measurement.

Table I.5 Groundwater quality data,
 replicate sample analysis--
 P&M/SRC-II site, spring 1 and well 3

Parameters (mg/liter) ^a	Sampling dates		
	Spring 1	Well 3	
	Nov. 78	Nov. 78	Feb. 79
<u>General</u>			
Water temperature, °C ^e	11.9	15.5	10.8
Specific conductance, $\mu\text{mhos}/\text{cm}^e$	159	430	330
pH, units	6.7	7.2	7.0
Dissolved oxygen ^e	10.6	-	-
Acidity, free (CaCO ₃)	0	0	0
Acidity, total (CaCO ₃)	4	11	13
Alkalinity, pht. (CaCO ₃)	0	0	0
Alkalinity, total (CaCO ₃)	49	297	251
Bicarbonate (CaCO ₃)	49	297	251
Calcium	25	71	65
Carbon, inorganic	-	-	53
Carbon, organic	<1	<1	<1
Carbon, total	-	-	53
Carbonate (CO ₃)	0	0	0
Color, platinum-cobalt units	-	-	0 - 5
Fluoride, soluble	0.11	0.23	0.13
Magnesium	4.8	36	35
Potassium	1.2	2.2	2.1
Silica (as SiO ₂)	12	4.2	3.4
Sodium	2.4	27	18
Solids dissolved, total	100	400	348
Solids suspended, total	-	-	1
Sulfate (as SO ₄)	9	25	68
<u>Nutrients</u>			
Ammonia nitrogen as N	<0.1	<0.1	<0.1
Kjeldahl nitrogen as N	-	-	0.11
Nitrate nitrogen as N	1.6	<0.2	0.2
Nitrite nitrogen as N	<0.01	<0.01	<0.01
Phosphate, total as P	0.03	0.05	<0.01
<u>Indicators of industrial and municipal contaminants</u>			
COD	<5	<5	<5
Chloride	4	5	2
Cyanide	<0.001	<0.001	<0.001
Oil and grease	7	5	2
Phenols, ppb	-	-	-
Sulfide (as S)	<0.02	<0.02	<0.02
Thiocyanate	-	-	<0.4
<u>Trace elements (total concentration)</u>			
Aluminum	0.2	<0.1	<0.1
Antimony	-	-	<0.1
Arsenic	<0.01	<0.01	<0.01

Table I.5 (continued)

Parameters (mg/liter) ^a	Sampling dates		
	<u>Spring 1</u>	<u>Well 3</u>	
	Nov. 78	Nov. 78	Feb. 79
Barium	<0.1	<0.1	<0.1
Beryllium	-	-	<0.02
Boron	-	-	<0.5
Cadmium	<0.01	<0.01	<0.01
Chromium, hexavalent	<0.002	<0.002	<0.002
Chromium, total	<0.03	<0.03	<0.03
Copper	<0.02	<0.02	<0.02
Iron	0.13	0.05	0.11
Lead	<0.05	<0.05	<0.05
Manganese	0.04	0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002
Molybdenum	<0.05	<0.05	<0.02
Nickel	<0.02	<0.02	0.2
Selenium	<0.01	<0.01	<0.01
Silver	<0.02	<0.02	<0.02
Uranium	-	-	<0.1
Vanadium	-	-	<0.1
Zinc	<0.02	0.03	0.1

^aExcept as indicated.

^bRefer to November 1978 column in Table I.3.

^cRefer to November 1978 column in Table I.4.

^dRefer to February 1979 column in Table I.5.

^eField measurements.

Table I.6. Groundwater quality data,
replicate sample analysis--
P&M/SRC-II site, well 1

Parameters (mg/liter) ^a	Sampling dates	
	Apr. 1979	
	Rep. 2 ^b	Rep. 3
<u>General</u>		
Water temperature °C	10.3	10.3
Specific conductance, µmhos/cm ^c	232	232
pH, units	6.5	6.5
Dissolved oxygen ^c	7.3	7.3
Acidity, free (CaCO ₃)	-	-
Acidity, total (CaCO ₃)	-	nil
Alkalinity, pht. (CaCO ₃)	-	-
Alkalinity, total (CaCO ₃)	139	137
Bicarbonate (CaCO ₃)	173	137
Calcium	46	46.5
Carbon, inorganic	-	-
Carbon, organic	4	3
Carbon, total	-	11
Carbonate (CO ₃)	0	0
Color, platinum-cobalt units	-	-
Fluoride, soluble	0.1	0.9
Magnesium	10.5	11.1
Potassium	1.2	1.0
Silica (as SiO ₂)	9.2	9.8
Sodium	2.6	3.1
Solids dissolved, total	220	155
Solids suspended, total	-	-
Sulfate (as SO ₄)	35	39
<u>Nutrients</u>		
Ammonia nitrogen as N	<0.05	<1.0
Kjeldahl nitrogen as N	0.15	-
Nitrate nitrogen as N	0.9	0.01
Nitrite nitrogen as N	<0.01	<0.01
Phosphate, total as P	0.05	7.0
<u>Indicators of industrial and municipal contaminants</u>		
COD	<10	3
Chloride	3.8	7
Cyanide	<0.02	<0.1
Oil and grease	<5	1
Phenols, ppb	-	2.1
Sulfide (as S)	<0.1	<0.1
Thiocyanate	-	-
<u>Trace elements (total concentration)</u>		
Aluminum	0.4	0.15
Antimony	0.6	<0.01
Arsenic	<0.01	<0.001

Table I.6 (continued)

Parameter (mg/liter) ^a	Sampling dates	
	Apr. 1979	
	Rep. 2 ^b	Rep. 3
Barium	0.1	<0.1
Beryllium	<0.1	<0.005
Boron	<0.1	1.6
Cadmium	0.01	<0.005
Chromium, hexavalent	<0.05	nil
Chromium, total	<0.05	<0.05
Copper	<0.05	0.05
Iron	0.60	0.17
Lead	0.014	<0.01
Manganese	10.5	11.1
Mercury	0.0085	0.0015
Molybdenum	<0.1	<0.025
Nickel	<0.05	<0.05
Selenium	<0.01	<0.01
Silver	<0.05	<0.005
Uranium	-	-
Vanadium	-	-
Zinc	0.05	0.016

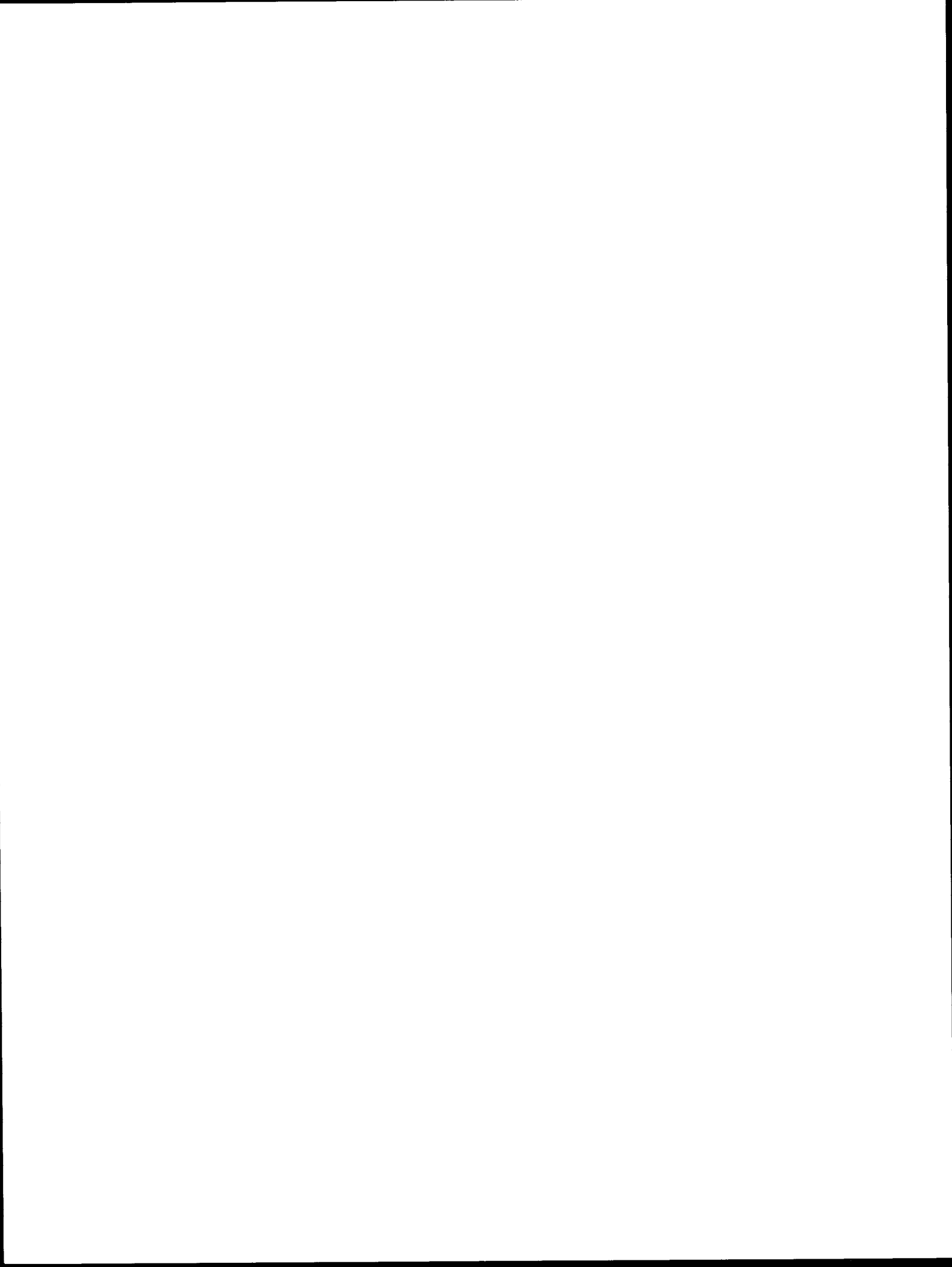
^aExcept as indicated.

^bRefer to April 78 column in Table I.6.

^cField measurements.

Appendix J

EFFECT OF FLOODPLAIN ENCROACHMENT ON FLOOD ELEVATIONS



Appendix J

EFFECT OF FLOODPLAIN ENCROACHMENT ON FLOOD ELEVATIONS

Hydrologic and hydraulic data on the Monongahela River between Lock and Dam 8 at Point Marion, Pennsylvania, and Rosedale, West Virginia, were provided by Department of the Army, Pittsburgh District, Corps of Engineers, Pittsburgh, Pennsylvania as input data for a HEC-2 "Water Surface Profile" computer run. The input was modified to reflect the encroachment of the proposed site on the floodplain, and the program was rerun. The following printouts contain input, output, and summary data for conditions before and after construction. A brief description of the HEC-2 program also follows.

J.1 HEC-2

This program computes the water surface profile for rivers and streams at selected cross sections for specified flow conditions. The effects of various hydraulic structures such as bridges, culverts, weirs, embankments, and dams may be considered in the computations. The principal use of the program is for determining profiles for various frequency floods for both natural and modified conditions.

The model was used for this purpose on the Monongahela River along the proposed SRC-II demonstration plant site. The model for the natural conditions was provided by the Pittsburgh District, Corps of Engineers. Discharges on the Monongahela were determined by analysis of historic flow data. This model was run by Roy F. Weston Company to determine the existing conditions. Cross-section data adjacent to the proposed site were modified to reflect construction of the product storage area in the floodplain. [Site preparation will include filling to raise the storage area above the 500-year flood elevation. This computer run is based on the configuration for product storage in the floodplain proposed in the Draft EIS. This proposal has since been changed (Appendix D) to reduce the amount of floodplain encroachment. This analysis therefore represents a worst-case analysis.] The model was run again with the modified data to compute any changes in the water surface elevations.

The results of this model are only as reliable as the data input to the program. To predict the magnitude of the flooding event, two important sets of parameters must be identified: maximum flows to be conveyed during the flood and the hydraulic characteristics of the stream system to convey the flood.

Maximum flows were determined by analysis of historic flow data for the Monongahela River. Probabilities were assigned through a process of ranking 26 years of historic data at Lock 8 near Pt. Marion, Pennsylvania. The longer the period of record, the more reliable the flow calculations. Results based on 26 years of record should give very reliable data assuming no major changes have occurred in the basin.

The physical characteristics of the Monongahela River were determined by the Corps of Engineers and coded into a computer model in 1973. For the segment of river affecting the proposed SRC-II demonstration plant, no major changes in the characteristics of the river have occurred since the model used a forerunner of the HEC-2 program. The data from the original model was coded into the HEC-2 model to analyze the impact of the demonstration plant's construction in the floodplain. The water surface elevations presented in Table J.1 should be considered reliable and accurate for design purposes.

Table J.1. Hydraulic Data--Monongahela River

	2-Year	10-Year	50-Year	100-Year	500-Year
<u>RM 93.74</u>					
Before Construction					
Elevation, m	793.54	800.72	805.78	807.79	811.27
Discharge, ft ³	36,800	63,700	89,000	100,000	128,000
Velocity, cfs	4.4	5.4	6.2	6.4	7.3
After Construction					
Elevation, m	793.54	800.72	805.78	807.79	811.26
Discharge, ft ³	36,800	63,700	89,000	100,000	128,000
Velocity, cfs	4.4	5.4	6.2	6.4	7.3
<u>RM 94.11</u>					
Before Construction					
Elevation, m	793.62	800.79	805.85	807.85	811.34
Discharge, ft ³	36,800	63,700	89,000	100,000	128,000
Velocity, cfs	5.0	6.1	6.9	7.2	8.1
After Construction					
Elevation, m	793.62	800.78	805.83	807.82	811.28
Discharge, ft ³	36,800	63,700	89,000	100,000	128,000
Velocity, cfs	5.0	6.1	7.0	7.3	8.3
<u>RM 94.63</u>					
Before Construction					
Elevation, m	793.88	801.06	806.10	808.08	811.56
Discharge, ft ³	36,800	63,700	89,000	100,000	128,000
Velocity, cfs	5.3	6.5	7.4	7.7	8.8
After Construction					
Elevation, m	793.88	801.05	806.11	808.10	811.58
Discharge, ft ³	36,800	63,700	89,000	100,000	128,000
Velocity, cfs	5.3	6.5	7.4	7.7	8.8

Appendix K
SLAG AND COAL LEACHING TESTS

Appendix K

SLAG AND COAL LEACHING TESTS*

K.1 ASH-SLAG WASTE SHIPMENT FROM TEXACO (MONTEBELLO)

On Sept. 25, 1978, Oak Ridge National Laboratory (ORNL) received ten fiber drums of vacuum bottoms from the Fort Lewis SRC-II pilot plant. The coal used in the SRC-II unit was described as Kentucky 9/14 coal. Most of the drums contained a mixture of coarse and fine ash added in proportion to that observed during the run, but that had not been mixed. One drum contained ash-slag that had not been fractionated (MRL run 57808); this material was selected for use in the studies conducted to date (Table K.1). Studies on the fine and coarse fractions may be conducted later if these two fractions are to be disposed of in different landfills.

K.2 BATCH LEACHING RESULTS

Five types of batch leaching have been completed [EPA-EP, American Society for Testing and Materials (ASTM) distilled water, ASTM at pH 4.5 using a sodium acetate - acetic acid buffer solution, 0.1 N NH_4OH and 0.1 N HNO_3]. All tests were performed using slag-extractant weight ratios, time intervals, and equipment suggested in the proposed standard leaching tests. Although the last two leaching tests are not "standard," the same techniques and solid-to-liquid ratios were used. All elemental analyses were performed using atomic absorption techniques. Beryllium, sulfate, copper, nickel, and iron and all the elements in the EPA Interim Primary Drinking Water Standards (except cyanide and nitrate) were determined. Because nitric acid is required to preserve samples for later trace element analysis, nitrate analysis has no significance. Cyanide was not determined because no reason was found for it to be in gasifier ash-slugs. The additional analyses were performed because they are of concern to environmentalists and may, in the future, be added to the currently proposed Resource Conservation and Recovery Act (RCRA) list of trace element limitations in leachates. Results of the five types of batch leaching and the RCRA standards, where applicable, are given in Table K.2.

K.3 COLUMN LEACHING STUDIES

Column leaching in laboratory columns (3.75-in.-diam.) has been completed, but analytical results are only partly complete. These columns have a 30-cm (12-in.) depth of slag and are dosed daily with 1 liter of demineralized water (about one column volume). Results for leaches 1, 2, 10, and 20 are given in Table K.3. Generally, column leachate concentrations are less than batch leachates, which may result from shorter contact time between the water and the slag or other factors.

K.4 DISCUSSION OF TENTATIVE RESULTS

At this time, our analysis of this slag indicates that the material is relatively inert, and if landfill is proposed as the most acceptable method of slag disposal, trace element leaching does not appear to be a problem. Using the proposed RCRA draft regulations (Dec. 18, 1978), this slag should not be classified as "hazardous." Subsequent modifications of these regulations or addition of bioassay tests or other trace elements not on the present list could make these conclusions erroneous. However, the 0.1 N HNO_3 leach, which is more severe than would be expected in a landfill environment, does not appear to exceed RCRA criteria.

*Data as of Mar. 28, 1979.

Table K.1. Analysis of selected elements
present in feed coal and ash/slag determined
by neutron activation analysis

Element	Feed coal ^a	Ash/slag
Aluminum, %	1.22	9.83
Antimony, ppm	<i>b</i>	<i>b</i>
Arsenic, ppm	7	46
Barium, ppm	57	310
Calcium, %	0.82	2.26
Cesium, ppm	1	7
Chromium, ppm	21	708
Cobalt, ppm	1.4	36.8
Copper, ppm	≤60	≤300
Iron, %	1.17	15.8
Magnesium, ppm	0.16	1.3
Manganese, ppm	11.0	274
Molybdenum, ppm	10	63
Potassium, %	0.258	1.9
Rubidium, ppm	<i>b</i>	<i>b</i>
Selenium, ppm	3.0	17
Silver, ppm	<i>b</i>	≤10
Sodium, ppm	349	2350
Strontium, ppm	38	170
Thorium, ppm	1.4	14
Titanium, ppm	693	4590
Vanadium, ppm	90	457
Uranium, ppm	1.54	18
Zinc, ppm	<i>b</i>	≤600

^aOak Ridge National Laboratory sample of Western Kentucky No. 9, not necessarily representative of actual feed coal producing the ash/slag.

^bNot analyzed.

Table K.2. Elemental analysis of leachates derived from various batch leaching protocols

Element ^a	EPA EP	ASTM H ₂ O	ASTM pH 5	0.1 N HNO ₃	0.1 N NH ₄ OH	RCRA criteria
Arsenic, ppb	0.53	<5	<5	6.1	2.4	500
Barium, ppm	<0.5	<0.5	<0.5	<0.5	<0.5	10
Cadmium, ppb	3.4	4.0	4.9	25	1.3	100
Chromium, ppb	0.13	3.7	3.9	42	1.9	500
Lead, ppb	1.6	5.2	2.1	8.3	4.4	500
Mercury, ppb	0.191	0.025	0.010	0.04	0.33	20
Nitrate (as N), ppm	--- ^b	<0.05 ^c	<0.05 ^c	---	---	100
Selenium, ppb	<1	0.04	0.04	<1	7	100
Silver, ppb	0.07	0.09	0.23	3.2	0.20	500
Sulfate, ppm	4.89	23.63	22.90	26.79	36.57	None
Iron, ppm	20.5	147	720	2482	0.06	None
Copper, ppb	0.94	---	---	---	---	None
Beryllium, ppb	0.09	---	---	---	---	None
Antimony, ppb	<2	---	---	---	---	None
Nickel, ppb	758	---	---	---	---	None

^aFirst ten elements are in Interim Primary Drinking Water Standards.^b---means not determined.^cSamples not acidified before analysis.

Table K.3. Laboratory columns of Texaco-Montebello ash/slag from SRC-II vacuum bottoms

All values listed are in ppb

Column No.	Element	Leach No.			
		1	2	10	20
1	Arsenic	1.16	0.79	2.0	3.1
2		1.36	1.33	1.53	3.4
1	Barium	<0.5	<0.5	<0.5	<0.5
2		<0.5	<0.5	<0.5	<0.5
1	Cadmium	11	0.13	0.014	0.10
2		16	0.11	0.020	0.091
1	Chromium	7.0	3.5	0.25	0.49
2		6.2	3.2	0.24	0.41
1	Lead	1.4	<0.3	<0.3	<0.43
2		0.93	<0.3	<0.3	<0.3
1	Mercury	0.007	0.024	0.013	0.019
2		0.011	0.012	0.003	<0.001
1	Selenium	120	44	16	<5
2		195	34	<5	<5
1	Silver	0.34	0.17	0.13	0.10
2		0.36	0.17	0.12	0.10

K.5 ORGANIC CONSTITUENTS IN SLAG LEACHATES

In order to explore the question of whether organic constituents remain in the slag, further leaching tests were performed. Vacuum bottoms from the Fort Lewis Pilot Plant were gasified in a Texaco gasifier. At the Gulf Research & Development facility at Harmerville, Pennsylvania, the gasifier slag was subjected to a benzene extraction. This procedure was used to extract organics out of slag and is far more severe than any conditions that would occur in a landfill.

Following the extraction, the benzene leachate was analyzed for the presence of benzene solubles and polynuclear aromatic (PNA) compounds. The results of the extraction under these extreme conditions are shown below and indicate that benzene soluble constituents are present in the slag in very low concentrations. Under actual landfill conditions, organic constituents are not expected to be of environmental concern.

	<u>Coarse Slag</u>	<u>Fine Slag</u>
Total benzene solubles (%by weight)	0.0315	0.0165
Benz-a-anthracene (ppb)	12	10
Benz-a-pyrene (ppb)	17	13
Benz-e-pyrene (ppb)	4	17
Benzo (g,h,i) perylene (ppb)	8	5

K.6 COAL LEACHING

The proposed feed coal for the SRC-II demonstration plant was subjected to water leaching in a field lysimeter to simulate actual storage conditions. The results are presented in Table K.4.

Table K.4. Summary of Leachate Data Collected from Pittsburgh #8 Coal in Field Lysimeter

Parameter	Number of observations	Mean	Standard deviation	Minimum	Maximum
Runoff (% of rainfall)	10	78	24.7	19	100
Percent transmission before filter	20	82.4	22.1	21.7	99.3
Percent transmission after filter	18	98.6	1.1	96.7	100
pH	20	2.9	0.2	2.7	3.4
Acidity (mg/liter as CaCO ₃)	15	990	720	262	2,990
Electrical conductivity (μmhos/cm)	20	1,730	956	758	4,380
Sulfate (mg/liter)	20	1,240	909	369	3940
Iron (mg/liter)	20	296	307	15.1	1,330
Arsenic (μg/liter)	8	16.2	13.2	2.5	42
Barium (mg/liter)	8	< 0.2	a	a	a
Cadmium (μg/liter)	8	9.5	13.3	1.2	42
Chromium (μg/liter)	3	11	7.9	2.1	22
Lead (μg/liter)	8	7.6	6.2	4.5	23
Selenium (μg/liter)	8	< 20	b	b	b
Silver (μg/liter)	8	< 0.05	c	c	c
Mercury (μg/liter)	8	0.08	0.05	0.04	0.18

^aBarium concentration < 0.2 mg/liter for all samples.

^bSelenium concentration < 20 μg/liter for all samples.

^cSilver concentration < 0.05 μg/liter for all samples.

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Appendix L

SOILS

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Appendix L

SOILS

The proposed construction of coal conversion plants in the United States causes concern about safe disposal of the large quantities of solid wastes generated by the technology. Soils are viewed as a possible attenuation mechanism that reduces the hazard of groundwater contamination and as an engineering fill or liner for disposal areas. Analysis of the problem is difficult because of the lack of characterizations of the solid waste stream, the chemical nature of solutions leaching from the disposal areas, and the regulatory requirements that may be imposed on disposal practices for solids. Generally, three routes of possible contamination exist: leachate from coal pile storage areas, solid waste disposal sites, and accidental spills in the plant process area. The first case, coal storage, may involve alternating aerobic and anaerobic conditions, depending on rainfall patterns, depth to the water table, and design of the storage area. The second case, waste disposal, will probably produce anaerobic conditions initially because most waste will be disposed of in slurry form. The third case, spills, will probably involve less disturbed soils under aerobic conditions.

The purposes here are to (1) review current literature on trace element attenuation in soils to identify those elements most likely to remain mobile in the soils and (2) assess the relative importance of various soil properties in attenuating pollutants. The species were chosen for analysis on the sole basis of drinking water standards and toxicity considerations. Efficiency of experimental designs used by the authors was not assessed as such, but was analyzed if two authors did not reach the same conclusions from similar experiments. Material discussed here includes a synopsis of the author's conclusions, an analysis of soil chemical parameters likely to affect attenuation, and descriptions of the individual trace element behavior in soils.

L.1 FACTORS AFFECTING ATTENUATION OF TRACE ELEMENTS IN SOILS

Many factors, internal and external to the soil system, influence movement of trace elements in soils. External factors include climate and related factors such as moisture input and temperature. Soil properties exerting the greatest effect on the chemistry of soil attenuation include

1. surface area and the amounts and types of clays present (related to soil texture);
2. amount of iron, aluminum, and manganese hydroxy oxides;
3. pH;
4. redox conditions;
5. organic matter content; and
6. type and concentration of other ions or gases in the soil.

Such factors as biological activity, hydrology, pore-space geometry, disposal area design, time since disposal, and initial waste chemistry will also influence the final soil solution chemistry, but are not specifically analyzed in this study. Site-specific analysis would be required to assess the importance of these parameters.

L.1.1 Clay content

The clay-size particle content of the soil may be one of the most important properties in attenuating contaminants. Clays retard water movement (allowing more time for chemical reactions to occur), provide large surface areas for reactions, and are often composed of highly reactive components such as layered aluminosilicates, organic matter, and aluminum, iron, or manganese hydroxy oxides. Clay-trace-element interactions may include ion exchange, adsorption, complexation, or precipitation onto the clay substrate. Generally, the higher the clay-size particle content the less the migration of trace elements. Attenuation by clay minerals (i.e., layered aluminosilicates) depends on the type and amount of clay present and has a significant effect on the solution concentration of elements such as Cd, Cr, Cu, Hg, Ni, Se, and Zn. Lesser effects have been noted with As, Fe, Pb, Mn, and PAHs. Ion exchange is the primary mechanism although adsorption onto iron/manganese hydroxy oxide coatings and aluminum hydroxide interlayers may also prove significant. The ability of the clay mineral to retain the element is influenced by (1) the

species of the element present, (2) its activity in solution (which may be reduced by complexation), (3) its pH, and (4) the concentration of other ions in solution. Different clays exhibit different preference orders for various species; Farrah and Pickering¹ found that the following preferences exist:

Montmorillonite: $\text{Ca} > \text{Pb} > \text{Cu} > \text{Mg} > \text{Cd} > \text{Zn}$

Illite: $\text{Pb} > \text{Cu} > \text{Zn} > \text{Ca} > \text{Cd} > \text{Mg}$

Kaolinite: $\text{Pb} > \text{Ca} > \text{Cu} > \text{Mg} > \text{Zn} > \text{Cd}$

Higher-order ions will tend to displace lower-order ions. Large quantities of one species may "swamp" the system and replace other ions that are normally preferred.

Iron, manganese, and aluminum hydroxy oxides and organic matter are often included in the clay-size fraction. Their attenuation properties are discussed below.

L.1.2 Iron, manganese, and aluminum hydroxy oxides

Many investigators consider the hydroxy oxides to be the most important species in attenuating the movement of contaminants in soils. Metals may be adsorbed on the surface or incorporated into the crystal structure as a replacement for manganese, iron, or aluminum. Surface adsorption is increased by the normally large surface area of the hydroxy oxides, which commonly occur as coatings and interlayers within clay structures. Redox, pH, and microbial activity exert a strong influence by affecting the amount of hydroxy oxide precipitation or leaching that occurs. Figures L.1, L.2, and L.3 illustrate the forms of iron, manganese, and aluminum compounds that are stable under various conditions at fixed values of temperature, pressure, and activities of sulfur, carbon dioxide, and aluminum. The pH also affects the charge on the surface of the hydroxy oxide and its reaction chemistry (for reasons that are more fully outlined by Schwertmann and Taylor²). Cations tend to be adsorbed at pHs greater than the zero point of charge whenever the surface carries a negative charge. Complexation, or the formation of unusual bridging structures, may affect this general behavior.³

L.1.3 Soil pH

Changes in the pH of the soil system may solubilize certain solid phases, precipitate new compounds, and shift ion exchange balances or the surface charge on certain hydroxy oxides. Shifts in pH most likely occur in poorly buffered soils, such as sandy soils with no free lime. A particularly acid or alkaline leachate is the most likely mechanism for shifting soil pH. Other factors may include deliberate liming of the soil, shifts in carbon dioxide content caused by microbial action or by decay of organic matter, neutralization of acidity by reaction of the soils with components in the leachate, or the imposition of anaerobic conditions.

The mobilities of most trace elements studied are affected to some degree by the soil pH. Significant changes in soil solution concentration may occur with chromium and selenium (mobility increasing with pH) and with iron and manganese (decreased solubility with increased pH). To a lesser degree, arsenic, zinc, and silver will leach more easily in alkaline soils; Cd, Cu, Co, Hg, and Ni will be more mobile under acid conditions.

L.1.4 Redox conditions

Levels of oxidation potential (Eh) in the soil may affect (1) the stable species in precipitation reactions, (2) the hydroxy oxide stability (therefore, the extent of attenuation of associated trace metals), and (3) the level of microorganism activity (by requiring alternate energy sources for metabolic processes, important in the change of the oxidation state of several metals). Reduction of Eh is generally associated with waterlogged conditions although the actual Eh achieved after flooding depends on the soil and on the time since flooding. Hess and Blanchard⁴ observed Eh values of +300 mV and +400 to +500 mV for two soils that were flooded for 21 d. Addition of organic matter decreased these values to -150 mV after 1 d. Anaerobic conditions caused by waterlogging are likely to occur under waste disposal areas that use slurry application methods. Waterlogged soils are also less likely to lose gaseous components such as certain forms of arsenic⁵ and mercury.⁶

The greatest effect of Eh is on trace elements associated with iron and manganese hydroxy oxides and those trace elements present at concentrations high enough to be affected by solubility equilibrium. Most metals are more mobile under reducing conditions. Metals affected most are As, Cd, Fe, and Mn; those less affected include chromium, cobalt, and mercury.

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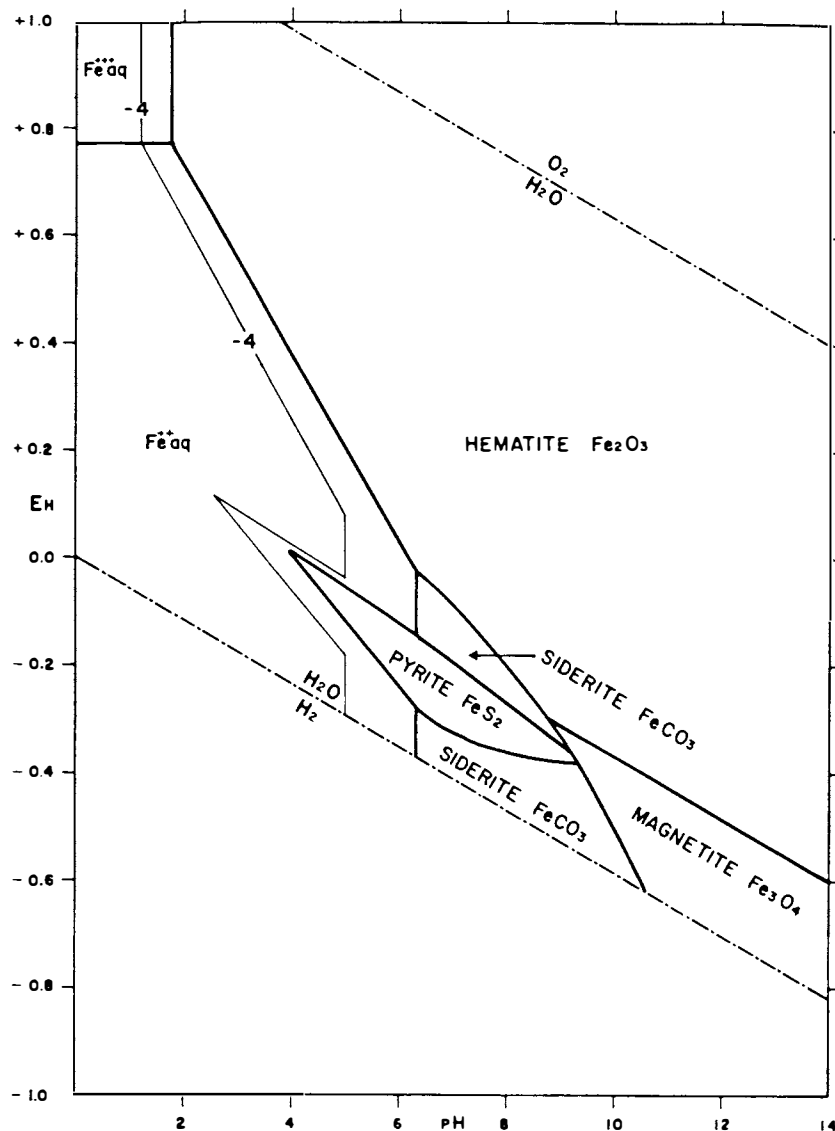


Fig. L.1. Stability relations of iron oxides, sulfides, and carbonate in water at 25°C and 1 atm total pressure. Total dissolved sulfur = 10^{-6} . Total dissolved carbonate = 10^{-3} . Note elimination of FeS field FeCO₃ under strongly reducing conditions, and remarkable stability of pyrite in presence of small amount dissolved sulfur. Reprinted by permission from R. M. Garrels and C. L. Christ, *Solutions, Minerals, and Equilibria*, Harper and Row, New York, 1965, p. 224.

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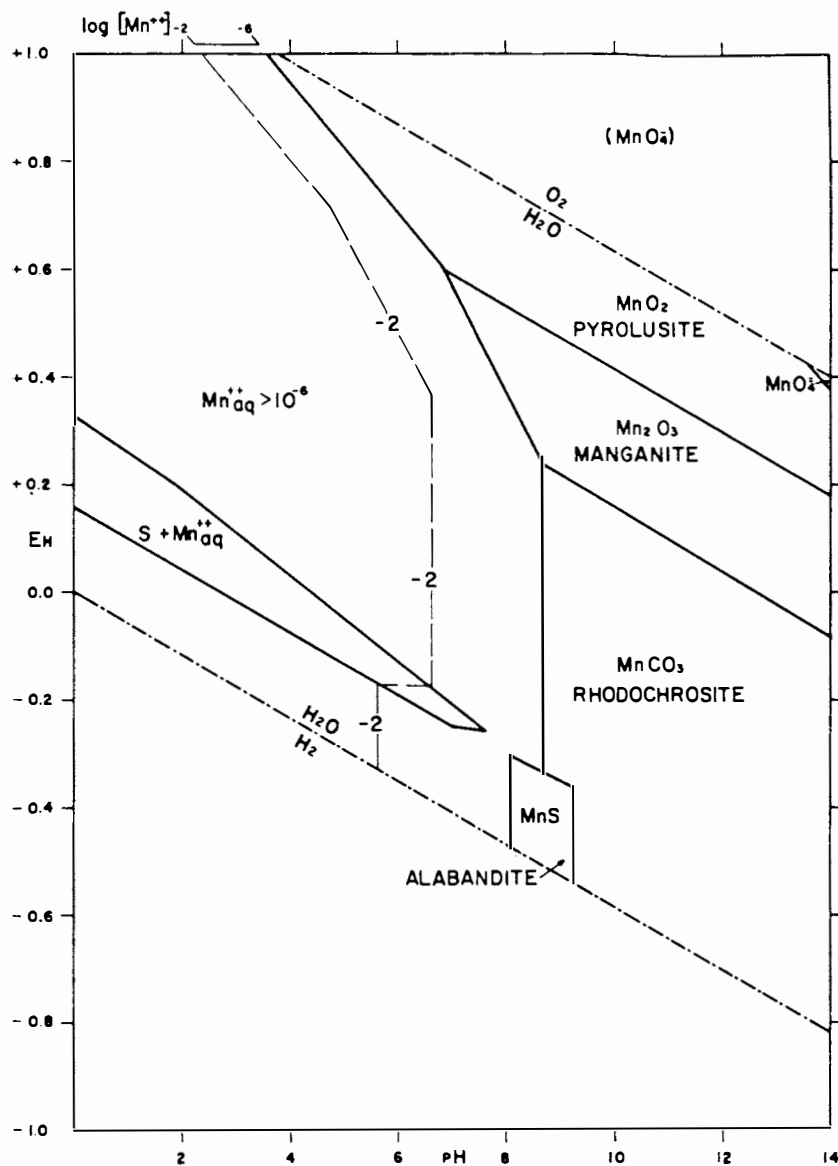


Fig. L.2. Stability relations among some manganese compounds in water at 25°C and 1 atm total pressure. Total dissolved sulfur species = 10^{-1} , $p\text{CO}_2 = 10^{-4}$. [Courtesy E. Gaucher.] Reprinted by permission from R. M. Garrels and C. L. Christ, *Solutions, Minerals, and Equilibria*, Harper and Row, New York, 1965, p. 243.

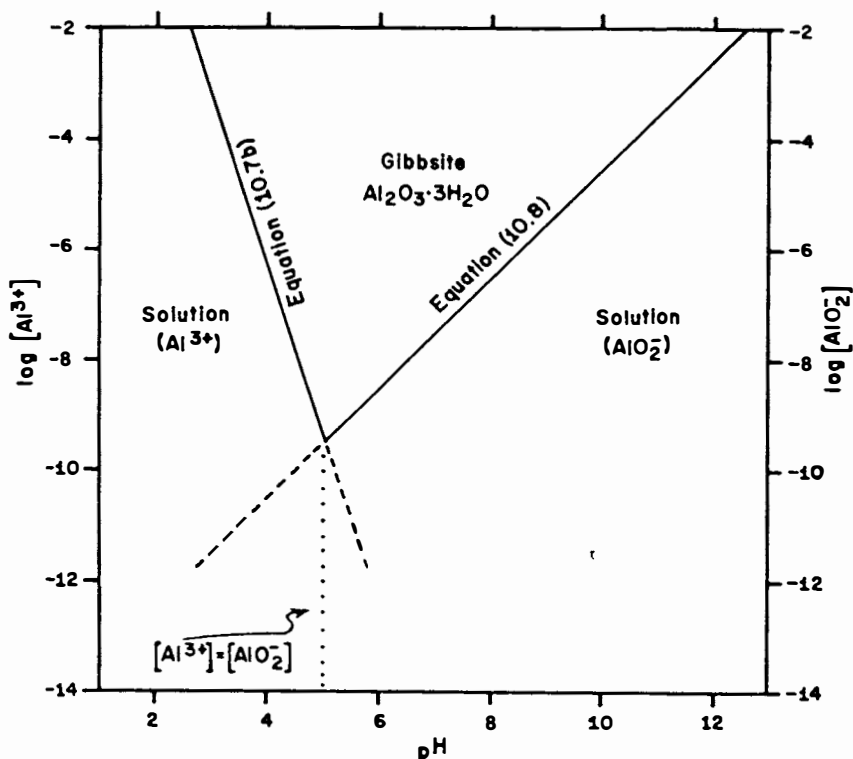


Fig. L.3. Stability of gibbsite expressed in terms of pH, and activities of aluminum ion and aluminate ion, at 25°C and 1 atm. Reprinted by permission from R. M. Garrels and C. L. Christ, *Solutions, Minerals, and Equilibria*, Harper and Row, New York, 1965, p. 354.

L.1.5 Organic matter content

Organic matter tends to decrease mobility of trace metals because of its large cation exchange capacity. However, depending upon the nature of the organic matter present, chelation may also occur and form soluble complexes that reduce the metal's activity and susceptibility to attenuation but maintain a fairly large concentration in solution. Some of these reactions involve covalently bonded hydrogen and are therefore pH dependent.

These competing tendencies often make impact of organic matter on trace metal attenuation difficult to assess. Evidence indicates that cadmium⁷ and silver⁸ mobilities are increased by the presence of organics, and PAHs and lead in solution are usually decreased.^{9,10} Although the solubility relationships are unclear, other metals that appear to react with organic matter include Cr, Cu, Hg, Ni, Fe, Mn, and Zn.

L.1.6. Other reactants in the system

The degree or nature of attenuation of the various trace elements is linked to the type and concentration of other species in the soil. As discussed above, ion exchange reactions are easily shifted. Precipitation reactions are altered by the presence of other elements in the proper form and at adequate concentrations. (Examples are barium precipitation in the presence of sufficient sulfate or carbon dioxide and silver in the presence of halides.) Chloride ions complex with certain metals (cadmium, copper, and nickel) and stabilize these metals in solution by reducing their reactivity. Phosphate ions or carbon dioxide may alter adsorption onto some hydroxy oxides by assisting in bonding, by altering the solubility of the substrate, or by shifting the zero point of charge.¹¹

L.2 COMPARATIVE AND CASE STUDIES

Several studies that compare the mobility of various trace elements and the behavior of soil types have been performed. Fuller¹² presented an extensive analysis of element mobilities under various soil conditions and the ability of several soils of differing orders to attenuate contaminants. The results are summarized in Tables L.1, L.2, and L.3.

Sims and Patrick¹³ compared the behavior of Fe, Mn, Zn, and Cu under various Eh and pH values by measuring the distribution in various soil fractions (Tables L.4 and L.5). Several conclusions, discussed elsewhere, are evident from the data: (1) the relative ease of manganese transformations in soils during changes in Eh as compared with iron; (2) the effect of Eh on the fraction of various species occupying exchange positions; and (3) the comparative stability of iron in the system (occurring in the residual fraction).

Korte et al.¹⁴ ranked 10 soils from 7 of the most prominent orders according to their abilities to attenuate 11 different trace elements under aerobic conditions. Results are summarized in Fig. L.4. Correlation coefficients were calculated for each of the elements according to clay content, pH, cation exchange capacity (CEC), surface area, free iron oxide, manganese, and combinations of components (Tables L.6 and L.7).

Several case studies have been performed on the leaching of trace elements in sewage disposal ponds and fly ash disposal areas. Lund et al.¹⁵ measured the distribution of Zn, Cd, Cu, Cr, and Ni in soil profiles at two treatment plants. Figure L.5 gives some of the results. All concentrations measured in the site soil were above background levels that were measured in nearby locations. Disposal was over a 20-year period in sludge ponds used as drying beds (probably alternating between anaerobic and aerobic conditions) and in effluent ponds (probably maintained under anaerobic conditions). Because waste behavior would be influenced by the high organic-matter content, the wastes studied probably differ from coal conversion wastes.

Two studies on the effect of fly ash disposal on soil systems were available. Phung et al.¹⁶ studied a fly ash leachate of very high alkalinity (pH 12.3) and found pH changes to be the major short-term impact on the soils. As the pH was reduced, concentrations of certain elements (B, Pb, Co, Cr, and Ni) were increased significantly. Theis¹⁷ analyzed contamination problems by measuring groundwater concentrations of ten elements from wells near a fly ash disposal site. The greatest concentrations were measured for iron, zinc, arsenic, and copper. Amorphous oxides of iron and manganese were present in the soils and were postulated to be the major mechanism of trace metal attenuation.

L.3 SOIL CHARACTERISTICS AT THE PROPOSED SITE

See Fig. L-6 for the distribution of soils on the proposed site.

L.3.1 Proposed solid waste disposal area

The soils in this area are generally composed of strip-mine soils and naturally occurring soils. Disposal for the demonstration phase will start on the undisturbed portion. These soils have moderate clay content, high percentages of silt, low to average pH, and average ranges of iron and magnesium (Table L.8). Soil profiles are generally deep (greater than 100 cm). Species that are more likely to be mobile in such soils (but are not necessarily present in the solid waste leachate) include:

<u>Aerobic</u>	<u>Anaerobic</u>	
cadmium	arsenic	iron (at low pH)
cobalt	cadmium	mercury
iron (at low pH)	chromium	nickel
zinc	cobalt	zinc

The depth and slow percolation rates of these soils should, however, reduce the possibility of significant contamination.

L.3.2 Proposed coal storage area

Soils at this location were tested for trace elements and organics, but not for general soil characteristics. Results from the same soil series elsewhere on the site indicate that textures range from loam to silty clay, moderately low pH, low to normal levels of iron and manganese, and soil depths of less than 90 cm. PAH levels were higher than levels at other areas of the site, but were still within normal forested area ranges. The species that are more likely to be mobile

Table L.1. Mobility of selected elements
in 11 soil series of varying pH

Soil series	Element in leachate
Acid Soils	
Ava	
Kalkaska	
Wagram	Zn, Cd, As, Cr, Se, Cu
Davidson	Be Pb
Molokai	In order of decreasing mobility →
Chalmers	
Neutral-to-alkaline soils	
Anthony	
Fanno	
Mohave, limy	Cr, As, Se, Cd, Be, Cu
Mohave	Zn Pb
Nicholson	In order of decreasing mobility →

Source: W. H. Fuller, *Movement of Selected Metals, Asbestos, and Cyanide in Soil: Applications to Waste Disposal Problems*, Report EPA-600/2-77-020, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1977.

Table L.2. Overall ability of 11 soil series in
attenuating contaminants

Mobility class	Texture	Soil series	Order
I. Strongly immobilizing	Clay	Molokai	Oxisol
	Silty clay	Nicholson	Alfisol
II. Usually strongly immobilizing	Silty clay	Chalmers	Molisol
	Loam		
	Clay	Davidson	Ultisol
	Clay	Fanno	Alfisol
	Sandy clay	Mohave	Aridisol
	Loam	(Limy)	
III. Moderately immobilizing	Silty clay	Ava	Alfisol
	Loam		
	Sandy loam	Mohave (lime free)	Aridisol
IV. Weakly immobilizing	Sandy loam	Anthony	Entisol
	Sand	Kalkaska	Spodosol
	Loamy sand	Wagram	Ultisol

Source: W. H. Fuller, *Movement of Selected Metals, Asbestos, and Cyanide in Soil: Applications to Waste Disposal Problems*, Report EPA-600/2-77-020, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1977.

Table L.3. General mobility of selected elements under aerobic and anaerobic conditions

Mobility in leachate	Aerobic conditions	Anaerobic, acid	Anaerobic, neutral to alkaline
High	Se	Cd, Ni, Hg, Zn	As, Cr
Medium	Fe, Zn, Pb, Cu	As, Be, Cr	Cd, Hg, Se, Zn
Low	As, Cd, Cr, Hg	Cu, Pb, Se	Cu, Pb, Ni

Source: Adapted from W. H. Fuller, *Movement of Selected Metals, Asbestos, and Cyanide in Soil: Applications to Waste Disposal Problems*, Report EPA-600/2-77-020, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1977.

Table L.4. The distribution of Fe, Mn, Zn, and Cu among soil fractions as influenced by redox potential (Eh), averaged across pH

Micro-nutrient	Eh (mV)	Soil fraction								
		(1) Water soluble	(2) Exchangeable	(3) Organic sites	(2 + 3)	(4) NH ₂ OH·HCl (μg/g soil)	(5) Oxalate	(6) NaOH	(7) Residual	Sum of 4,5,6,7
Fe	-150	681	1,226	899	2,125	1,264	6,250	271	9,952	17,737
	0	628	687	999	1,686	1,096	7,936	314	10,576	19,922
	+150	1,021	<1	464	464	684	8,157	286	11,252	20,379
	+300	145	54	690	744	481	9,906	316	12,530	23,233
	+500	846	<1	558	558	314	8,358	319	11,028	20,019
Mn	-150	92	169	<1	169	28	42	<1	63	133
	0	73	147	<1	147	32	59	<1	62	153
	+150	90	116	<1	116	28	84	<1	67	179
	+300	16	126	<1	126	35	131	<1	68	234
	+500	32	22	<1	22	89	133	<1	59	281
Zn	-150	4.5	<1	13	13	4.1	26	15	123	168
	0	5.1	1.3	25	26	3.3	28	16	101	148
	+150	10.5	<1	16	16	2.4	25	10	131	168
	+300	4.2	2.3	13	15	5.0	35	11	124	175
	+500	10.9	<1	17	17	2.7	24	10	128	165
Cu	-150	2.6	0.3	4.5	4.8	<0.1	4.6	<0.1	12.9	17.5
	0	5.0	0.6	2.0	2.6	<0.1	5.6	<0.1	8.5	14.1
	+150	5.1	0.3	1.1	4.1	<0.1	7.4	<0.1	10.9	18.3
	+300	3.1	0.2	0.6	0.8	<0.1	9.9	<0.1	11.2	21.1
	+500	1.8	0.3	0.7	1.0	<0.1	8.3	<0.1	11.2	19.5

Source: Reprinted by permission from J. L. Sims and W. H. Patrick, Jr., "The Distribution of Micronutrient Cations in Soil Under Conditions of Varying Redox Potential and pH," *Soil Sci. Soc. Am. J.* 42: 258-62 (1978).

Table L.5. The influence of redox potential on the distribution of Fe, Mn, Zn, and Cu among soil fractions expressed as a percentage of total Fe, Mn, Zn, or Cu

Micro-nutrient	Eh (mV)	Soil fraction							(7) Residual	Sum of 4,5,6,7
		(1) Water soluble	(2) Exchange- able	(3) Organic sites	Sum of 1,2,3	(4) NH ₂ OH·HCl (%)	(5) Oxalate	(6) NaOH		
Fe	-150	2.9	5.1	3.8	12	5.3	26.3	1.1	41.8	75
	0	2.6	2.9	4.2	10	4.6	33.3	1.3	44.4	84
	+150	4.3	<0.1	1.9	6	2.9	34.3	1.2	47.3	86
	+300	0.6	0.2	2.9	4	2.0	41.6	1.3	52.6	98
	+500	3.6	<0.1	2.3	6	1.3	35.1	1.3	46.3	84
Mn	-150	24.6	45.8	<0.3	71	7.6	11.4	<0.3	17.1	36
	0	19.8	39.8	<0.3	60	8.7	16.0	<0.3	16.8	42
	+150	24.4	31.4	<0.3	56	7.6	22.8	<0.3	18.2	49
	+300	4.3	34.1	<0.3	38	9.5	35.5	<0.3	18.4	63
	+500	8.7	6.0	<0.3	15	24.1	36.0	<0.3	16.0	76
Zn	-150	2.4	<0.5	6.8	9	2.2	13.7	7.9	64.7	89
	0	2.7	0.7	13.2	17	1.7	14.7	8.4	53.2	78
	+150	5.5	<0.5	8.4	14	1.3	13.2	5.3	68.9	89
	+300	2.2	1.2	6.8	10	2.6	18.4	5.8	65.3	92
	+500	5.7	<0.5	8.9	15	1.4	12.6	5.3	67.4	87
Cu	-150	10.8	1.3	18.8	31	<0.4	19.2	<0.4	53.8	73
	0	20.8	2.5	8.3	32	<0.4	23.3	<0.4	35.4	59
	+150	21.3	1.3	4.6	27	<0.4	30.8	<0.4	45.4	76
	+300	12.9	0.8	2.5	16	<0.4	41.3	<0.4	46.7	88
	+500	7.5	1.3	2.9	12	<0.4	34.6	<0.4	46.7	81

Source: Reprinted by permission from J. L. Sims and W. H. Patrick, Jr., "The Distribution of Micronutrient Cations in Soil Under Conditions of Varying Redox Potential and pH," *Soil Sci. Soc. Am. J.* 42: 258-62 (1978).

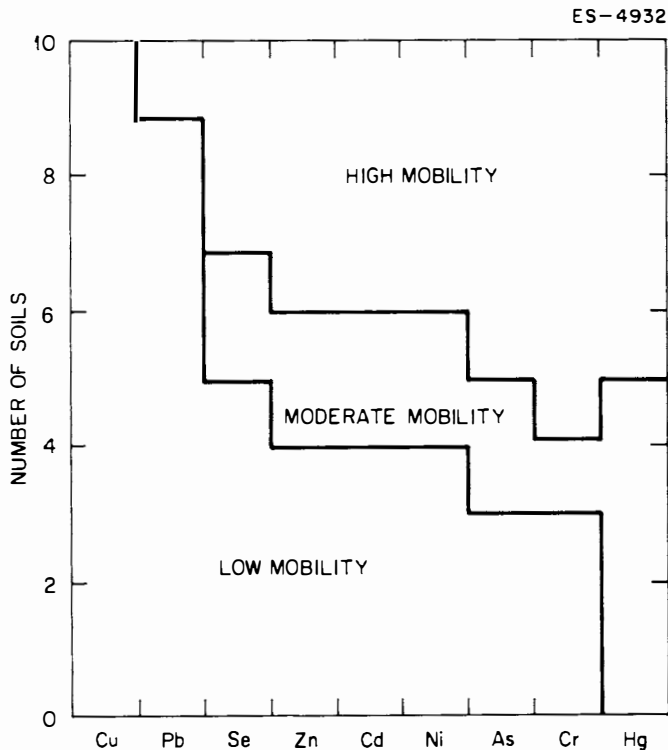


Fig. L.4. Mobility of selected trace elements in ten soils. Source: Adapted from N. E. Korte et al., "Trace Element Movement in Soils: Influence of Soil Physical and Chemical Properties," *Soil Sci.* 122: 350-59 (1976).

in this soil are similar to those described in Sect. 1. Percolation rates may be somewhat higher because of the slightly coarser texture, and soil depths may be shallower. Analyses of the coal storage area soils for these parameters would determine the significance of these factors.

L.3.3 Proposed process area

Soils in this area are characterized by deep profiles, very low to moderate pH, normal levels of iron and manganese, and high organic matter content in the surface layers. The dominant particle size in the soil is silt. Unpaved areas are likely to remain aerobic (oxygen present). Under such conditions, most elements are likely to be retained in the soil and would not leach into groundwater. The acidic conditions in some areas could increase the mobilities of iron, zinc, and possibly cadmium, but the deep profile and slow rate of seepage should substantially reduce the likelihood of groundwater impacts unless very large quantities of the substances are spilled. The ability of the soil to absorb or convert organic chemicals would depend upon the substance spilled and the extent to which soil microorganisms have reestablished themselves and can digest the organic compound. Spill prevention and drainage collection techniques should, however, reduce the hazard of such spills.

L.4 SOIL TESTING PROCEDURES

Results obtained from laboratory chemical analyses may vary widely and should be used with caution when applying the results without calibration to the field. This variability in results is largely due to the nature of the soil material. Soil chemical species may exist in the soil water, in a solid but readily "available" form (i.e., removable from the solid phase under normal soil conditions), or tightly bound with the solid soil material. The boundaries between these forms are indistinct and depend upon the soil conditions, the time frame under consideration, and the application of the test (plant nutrient requirements, and leachate reactions).

Table L.6. Correlation coefficients of mass adsorbed per gram of soil with soil properties

Element	Clay	pH	CEC ^a	Surface area	Fe ₂ O ₃	Mn
Arsenic	0.83 ^b	0.22	0.42	0.66 ^c	0.60	0.52
Beryllium	0.78 ^c	0.47	0.62 ^c	0.81 ^d	0.52	0.52
Cadmium	0.67 ^c	0.48	0.60	0.71 ^d	0.46	0.45
Chromium	0.56	-0.43	0.21	0.10	0.75 ^d	0.65 ^c
Nickel	0.69 ^c	0.51	0.79 ^d	0.88 ^b	0.27	0.24
Selenium	0.71 ^c	-0.30	0.44	0.39	0.68 ^c	0.57
Vanadium	0.84 ^b	0.16	0.55	0.61 ^c	0.59	0.49
Zinc	0.83 ^d	0.52	0.71 ^c	0.84 ^d	0.50	0.48

^aCation exchange coefficient.^bSignificant at 0.001 level.^cSignificant at 0.05 level.^dSignificant at 0.01 level.

Source: Reprinted by permission from N. E. Korte et al., "Trace Element Movement in Soils: Influence of Soil Physical and Chemical Properties," *Soil Sci.* 122: 350-59 (1976).

Table L.7. Coefficients of determination (R²) for each element on data from all soils

	Ions							
	Cd	Be	Zn	Ni	Cr	As	Se	V
Clay, surface area, free iron oxides ^a	0.93 ^b	0.87 ^b	0.88 ^b	0.82 ^b	0.56	0.78 ^c	0.57	0.75 ^c
Clay, surface area, free iron oxides, pH	0.94 ^b	0.91 ^b	0.93 ^b	0.86 ^c	0.83 ^c	0.78	0.84 ^c	0.75

^aOrder does not imply level of significance.^bSignificant at 0.01 level.^cSignificant at 0.05 level.

Source: Reprinted by permission from N. E. Korte et al., "Trace Element Movement in Soils: Influence of Soil Physical and Chemical Properties," *Soil Sci.* 122: 350-59 (1976).

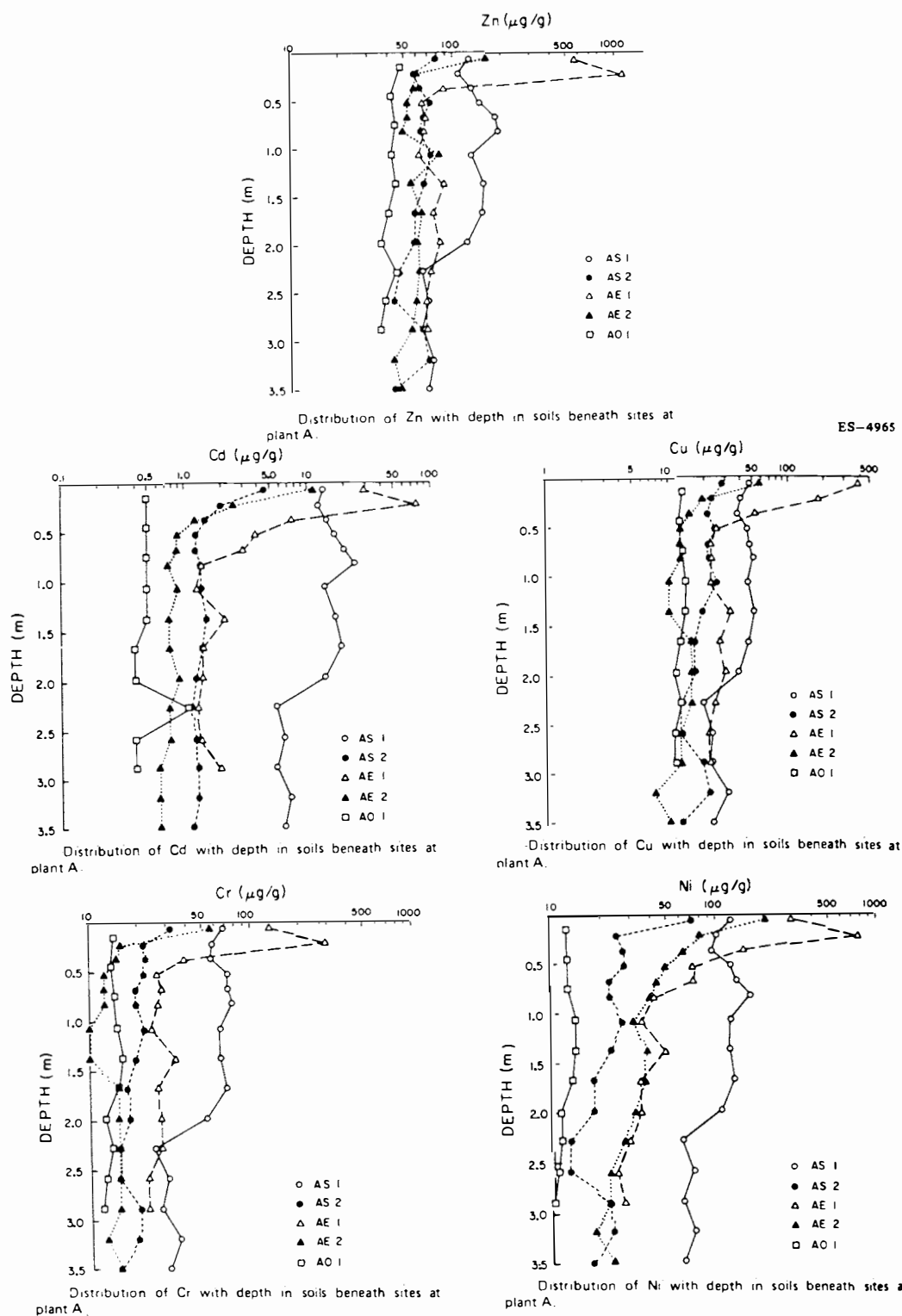


Fig. L.5. Mobility of selected metals below sludge disposal areas. Reprinted by permission from J. A. Lund, A. L. Page, and C. O. Nelson, "Movement of Heavy Metals Below Sewage Disposal Ponds," *J. Environ. Qual.* 5: 331-32 (1976).

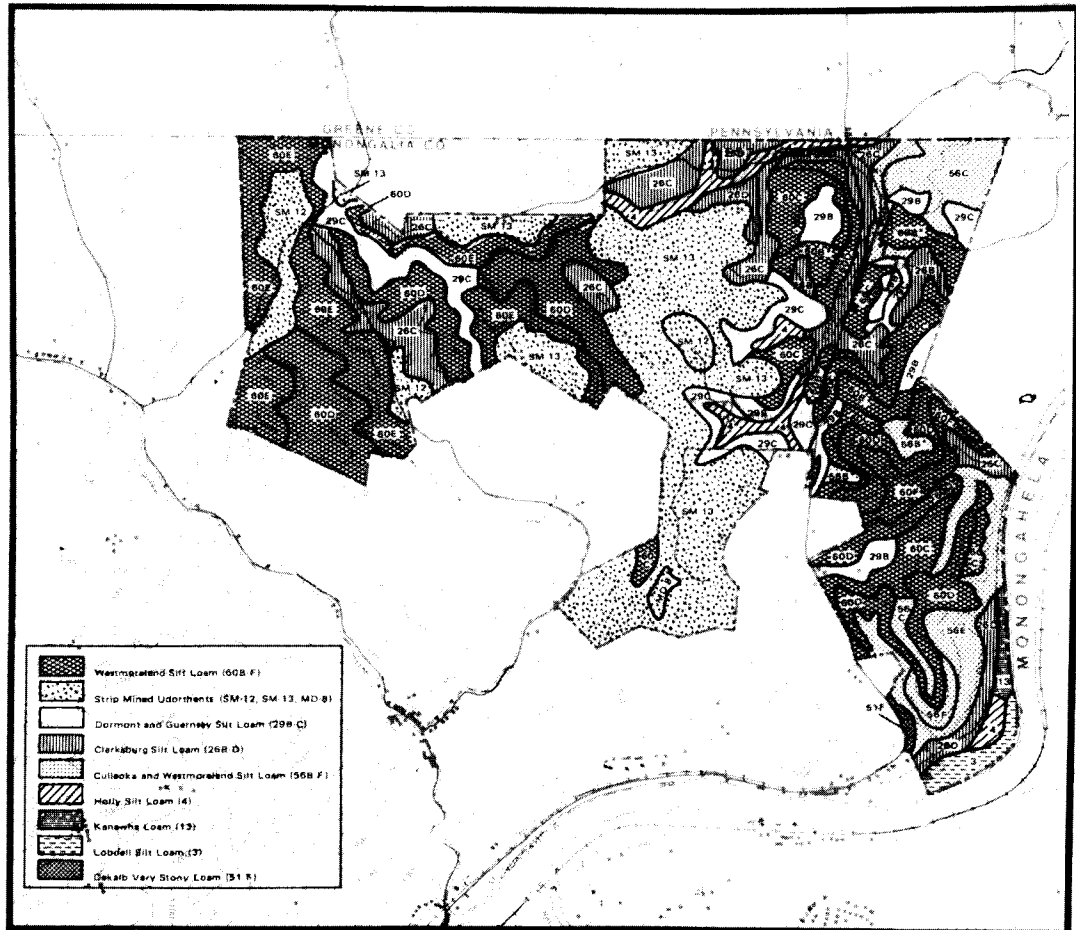


Fig. L.6. Distribution of soils at the proposed site. Source: ER, Vol.1.

Mapping Unit Descriptions for Fig. L.6

The following pages contain brief descriptions of the soil mapping units located on the project site. Important soil characteristics such as depth of soil, drainage class, and inclusions of other soils are summarized.

Mapping Unit 3 - Lobdell silt loam. This is a nearly level, moderately well-drained soil on floodplains and in drainageways. Depth to bedrock is greater than 6 ft. Surface texture is silt loam, and subsoil textures are loam and sandy loam. Permeability is moderate. Inclusions of Kanawha, Holly, and other soils make up about 15% of the mapping unit.

Mapping Unit 4 - Holly silt loam. This is a nearly level, poorly drained soil on floodplains and in drainageways. Depth to bedrock is greater than 6 ft. Surface texture is silt loam, and subsoil textures are loam and sandy loam. Permeability is moderate. Inclusions of Kanawha, Lobdell, and other soils make up about 20% of this mapping unit.

Mapping Unit 5 - Lobdell soils, 30% Holly soils, and 20% other soils. This mapping unit has characteristics similar to those described for Mapping Units 3 and 4.

Mapping Unit 13 - Kanawha loam. This is a nearly level, well-drained soil on terraces. Depth to bedrock is greater than 6 ft. Surface texture is silt loam and subsoil textures are loam and sandy loam. Permeability is moderate. Lobdell, Holly, and other soils make up about 15% of this mapping unit.

Mapping Unit 26B - Clarksburg silt loam, 3 to 8% slopes. This is a gently sloping, moderately well-drained soil on footslopes and in drainageways and formed in colluvial materials moved downslope by solifluction processes. Depth to bedrock is from 5 to 15 ft. Surface texture is silt loam, and subsoil textures are loam, clay loam, or silty clay loam. This soil contains a dense, slowly permeable fragipan about 2-ft thick. Inclusions of Dormont, Guernsey, Culleoka, Westmoreland, and other soils make up 20% of this mapping unit.

Mapping Unit 26C - Clarksburg silt loam, 8 to 15% slopes. This soil is similar to Mapping Unit 26B except for steeper slopes.

Mapping Unit 26D - Clarksburg silt loam, 15 to 25% slopes. This soil is similar to Mapping Unit 26B except for the steeper slopes.

Mapping Unit 29B - Dormont and Guernsey silt loams, 3 to 8% slopes. This undifferentiated unit consists of deep, moderately well-drained Dormont soils, Guernsey soils, or both. Depth to bedrock, which consists of shale, mudstone, or limestone, averages 5 ft. Surface textures are silt loam, and subsoil textures are silty clay loam or silty clay. Permeability is moderately slow to slow. Inclusions of Culleoka, Westmoreland, Clarksburg, and other soils make up about 15% of this unit.

Mapping Unit 29C - Dormont and Guernsey silt loams, 8 to 15% slopes. These soils are like Mapping Unit 29B except for the steeper slopes.

Mapping Unit 29D - Dormont and Guernsey silt loams, 15 to 25% slopes. These soils are like Mapping Unit 29B except for steeper slopes.

Mapping Unit 56B - Culleoka-Westmoreland silt loams, 3 to 8% slopes. This complex consists of moderately deep and deep, well-drained soils. Bedrock, which consists of shale, sandstone, and limestone, occurs at about 35 in. in Culleoka soils and 60 in. in Westmoreland soils. Surface textures are silt loam, and subsoil textures are silty clay loam. Permeability is moderate. This unit consists of 40% Culleoka soils, 35% Westmoreland soils, and 25% other soils.

Mapping Unit 56C - Culleoka-Westmoreland silt loams, 8 to 15% slopes. These soils are similar to Mapping Unit 56B except for steeper slopes.

Mapping Unit 56D - Culleoka-Westmoreland silt loams, 15 to 25% slopes. These soils are similar to Mapping Unit 56C except for steeper slopes.

Mapping Unit 56E - Culleoka-Westmoreland silt loams, 25 to 35% slopes. These soils are similar to Mapping Unit 56C except for steeper slopes. Additionally, Culleoka soils make up about 50% of the unit, Westmoreland soils 30%, and other soils 20%.

Mapping Unit 56F - Culleoka-Westmoreland silt loams, 35 to 65% slopes. These soils are similar to Mapping Unit 56C except for steeper slopes. Additionally, Culleoka soils make up about 55% of the unit, Westmoreland soils 25%, and other soils 20%.

Mapping Unit 60B - Westmoreland silt loam, 3 to 8% slopes. This is a gently sloping, deep well-drained soil on hillsides and ridge-tops. Depth to bedrock, which consists of shale, sandstone, or limestone, averages 60 in. Surface texture is silt loam, and subsoil texture is silty clay loam. Permeability is moderate. Inclusions of Dormont, Guernsey, Culleoka, and other soils make up 20% of the mapping unit.

Mapping Unit 60C - Westmoreland silt loam, 8 to 15% slopes. These soils are similar to Mapping Unit 60B except for steeper slopes. Additionally, inclusions of other soils make up 25% of the mapping unit.

Mapping Unit 60D - Westmoreland silt loam, 15 to 25% slopes. These soils are similar to Mapping Unit 60B except for steeper slopes.

Mapping Unit 60D3 - Westmoreland silt loam, 15 to 25% slopes, severely eroded. This soil is similar to Mapping Unit 60D except for severe erosion.

Mapping Unit 60E - Westmoreland silt loam, 25 to 35% slopes. This soil is similar to Mapping Unit 60B except for the steeper slopes.

Mapping Unit 60F - Westmoreland silt loam, 35 to 65% slopes. This soil is similar to Mapping Unit 60B except for the steeper slopes.

Mapping Unit SM-12 - Udorthents, mudstone, and sandstone, low base. This soil consists of a mixture of sandstone, mudstone, shale, and soil materials on areas surface mined for coal. These units usually consist of a vertical highwall up to 60 ft. in height, a gently sloping bench, and a steep outslope. Rock fragment content ranges from 10 to 70%. Textures are loam, clay loam, or silty clay loam. Permeability is variable. Inclusions of other mine soils, Culleoka, Westmoreland, and other soils make up about 30% of this unit.

Mapping Unit SM-13 - Udorthents, mudstone, and sandstone, high base. These soils are similar to Mapping Unit SM-12 except for higher pH and base saturation.

Mapping Unit 51F - Dekalb very stony loam, 35 to 65% slopes. This is a very steep, very stony soil on ridgetops and hillsides. Depth to sandstone bedrock is 25 in. Inclusions of Lily and other soils comprise 20% of this unit.

Mapping Unit 150C - Lily loam, 8 to 15% slopes. This is a strongly sloping well-drained soil on ridgetops and benches. Bedrock consists of siltstone, shale, or sandstone and occurs at a depth of 31 in. Inclusions of Dekalb and other soils comprise about 20% of this unit.

Mapping Unit ML - Udorthents, cut and fill. This unit consists of mixed soil and rock material in areas that have been excavated, graded, or filled. Rock fragment content ranges from 10 to 70%. Size of rock fragments range from less than 1 in. to 2 ft.

Mapping Unit MD8 - Udorthents, dumps, very low base. This unit consists of waste from processing and cleaning of coal. Slopes range from nearly level to very steep. Rock fragment content ranges from 10 to 80%. Texture is sandy loam. Permeability is variable. Inclusions of other soils make up about 20% of this unit.

Table L.8. Summary of laboratory analyses of soil series that occur near the proposed process, coal storage, and waste disposal areas^a

Sample	Soil	Depth (cm)	Location	pH ^b		% Clay	% Silt	Exchangeable cations (meq/100 g)				Base saturation (%)	Organic matter (%)
				A	B			K	Ca	Mg	CEC		
SA7	Udorthents (SM13)	0-15	Solid waste disposal area	6.5	7.0	20	45	0.11	17.5	1.00	28	64	4.4
		15-31		6.4	6.6	22	40	0.06	20.2	1.02	25	100	2.4
		31-61		6.3	6.7	21	26	0.11	14.8	1.33	23	100	1.8
		61-91		4.5	5.2	18	27	0.08	8.2	0.70	27	100	5.1
		91-122		5.4	5.4	20	29	0.08	22.8	0.35	26	100	3.8
SA14	Udorthents (SM13)	0-15	Solid waste disposal area	4.6	4.8	10	41	0.18	4.2	0.93	29	27	3.9
		15-31		4.9	5.0	9	40	0.11	5.8	1.23	31	31	4.0
		31-61		4.8	5.1	10	38	0.10	5.2	2.48	21	50	0.6
		61-91		5.2	5.4	10	35	0.11	5.5	2.31	20	58	0.4
		91-122		5.4	5.6	12	30	0.11	6.5	2.57	22	35	0.3
SA5	Holly (4)	0-15	Solid waste disposal area	4.6	4.9	32	47	0.09	6.2	0.82	40	38	5.4
		15-31		5.0	5.4	28	50	0.06	7.8	0.94	36	36	4.7
		31-61		5.3	5.5	31	46	0.04	7.0	0.75	35	36	3.3
		61-91		5.5	5.7	27	39	0.05	7.0	0.75	35	39	1.9
		91-122		5.8	5.8	30	27	0.06	7.0	0.84	27	47	2.3
SA10	Clarksburg (26B)	0-15	Solid waste disposal and main process areas	4.2	4.8	10	41	0.13	1.0	0.20	27	15	5.7
		15-31		4.4	5.0	15	35	0.08	0.8	0.10	23	17	2.3
		31-61		5.0	5.2	20	31	0.08	1.2	0.27	23	10	1.4
		61-91		5.2	5.8	10	46	0.19	5.0	0.99	21	40	1.5
		91-122		4.4	-	15	41	-	-	-	11	35	-
SA8	Westmoreland (60C)	0-15	Solid waste disposal, main process, and coal storage areas	4.6	5.4	32	47	0.07	6.0	0.71	33	33	4.5
		15-31		5.0	5.4	28	50	0.05	4.2	0.45	27	31	1.8
		31-61		5.3	4.8	31	46	0.04	3.5	0.56	24	32	0.6
		61-91		5.5	4.7	27	39	0.04	2.8	1.22	24	33	0.4
		91-122		5.8	4.8	30	27	0.08	2.5	1.42	15	81	0.3

Table L.8. (continued)

Sample	Soil	Depth (cm)	Location	pH ^b		% Clay	% Silt	Exchangeable cations (meq/100 g)				Base saturation (%)	Organic matter (%)
				A	B			K	Ca	Mg	CEC		
SA17	Westmoreland (60B)	0-15	Solid waste disposal, main pro- cess, and coal storage areas	5.5	6.1	20	59	0.10	7.8	0.73	23	63	4.3
		15-31		5.8	5.9	25	53	0.06	6.5	0.68	17	68	1.4
		31-61		4.8	5.0	25	53	0.06	4.8	0.81	18	57	0.6
		61-91		5.0	5.2	27	50	0.06	4.5	1.11	20	54	0.4
		91-122		5.6	5.8	28	39	0.06	6.0	1.95	20	64	0.2
SA9	Dortmont- Guernsey (29C)	0-15	Main process and coal storage areas	3.8	4.8	20	61	0.11	1.5	0.23	30	56	5.1
		15-31		3.7	4.7	38	48	0.09	1.5	0.22	23	83	1.0
		31-61		3.6	4.5	46	44	0.06	1.8	0.45	18	100	0.4
		61-91		3.4	4.5	53	43	0.09	1.0	0.56	15	100	0.3
		91-122		-	-	-	-	-	-	-	-	-	-
SA12	Culleoka- Westmoreland (56D)	0-15	Coal storage area	4.0	4.8	20	36	0.15	2.0	0.26	18	13	3.0
		15-31		4.0	4.5	24	48	0.11	0.5	0.10	18	12	0.4
		31-61		3.8	4.6	28	34	0.15	1.2	0.56	22	13	0.3
		61-91		4.2	4.7	22	37	0.14	2.8	1.69	37	10	0.2
		91-122		4.4	5.1	22	42	0.10	8.5	3.15	31	33	0.4

^aDerived from data presented in the SRC-II Demonstration Project Environmental Analysis Report, Appendix, Vol. II, West Virginia Air Pollution Control Commission, *Annual Report*, 1978.

^bA: pH as determined by CDM/Accu Labs. B: pH as determined by WVU Soil Testing.

General agronomic soil tests of nutrient parameters are attempts to measure the readily available and soil soluble concentrations of the nutrients. The values obtained depend on the ability of the extracting procedure to separate the available and tightly bound forms. The accuracy of the soil test chosen depends upon the plants using the nutrient because different crops extract different amounts of nutrients from the soil. Generally, laboratory analyses are calibrated with field tests of fertilizer to yield relationships to overcome this difficulty and to allow extrapolation of laboratory results to other cases.

Trace element determinations were made by measuring the total element composition of the soil. This process allows more accurate and repeatable results that can be compared to concentrations during and after operation of the facility. It does not, however, distinguish fractions that are water soluble and that could affect aquifer water quality.

L.5 UNIVERSAL SOIL LOSS EQUATION

The Universal Soil Loss Equation (USLE) was originally developed by the Agricultural Research Service (USDA) to predict soil losses due to sheet erosion of agricultural watersheds.¹⁸ The basic form of the equation is:

$$A = RKLSCP,$$

where

- A = average annual soil loss,
- R = rainfall factor,
- LS = slope length and steepness factor,
- C = cropping and management factor, and
- P = supporting conservation practice.

Values of these factors are estimated by soil survey personnel based on field measurements, rainfall statistics, and soil characteristics.

The equation has also been used to estimate soil losses from ungaged watersheds and construction sites.¹⁹ Several modifications of the equation have been proposed, such as the Williams-Berndt model incorporating peak runoff rates and storm water volumes.²⁰ This modification allows estimation of sediment yield during individual flood events. The accuracy of the models vary. In an unpublished study of four Tennessee watersheds, the Williams-Berndt model was found to (1) overestimate the cumulative sediment yield on one watershed by 30%, (2) predict the sediment yield within 10% for two watersheds, and (3) underestimate the yield by 58% on the remaining watershed. Sediment yields from individual rainfall events were more poorly modeled.

Inaccuracies in the results are due to a number of factors. Estimation of values for the equation parameters is difficult and subject to interpretation. Additionally, seasonal variations, antecedent moisture conditions, gully erosion, and stream transport of sediment are not modeled by the equation. Other methods provide more accurate modeling of the hydrology, soil, and transport processes.²¹⁻²³ However, these models require extensive data collection and field verification and may not accurately model future watershed conditions (i.e., during construction). In ungaged watersheds, such as occur on the proposed site, the optimum procedure is to (1) estimate the sediment yield during construction by the use of the USLE, (2) design mitigating measures based on this estimate, incorporating an adequate margin of safety, and (3) monitor the site during construction to allow modification of sediment control practices to compensate for inadequacies in the original sediment yield estimates. The use of more complex modeling would require the acquisition of several years of reliable stream flow data, field verification of predicted yields, and extensive testing of the site soils and runoff patterns before design of the mitigating measures. It is questionable whether such methods would improve the results obtained by the combination of USLE-mitigation-monitoring, proposed above.

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Appendix M

CORPS OF ENGINEERS, ADEQUACY OF BARGE NAVIGATION SYSTEMS

DEPARTMENT OF THE ARMY
Pittsburgh District, Corps of Engineers
Federal Building, 1000 Liberty Avenue
Pittsburgh, Pennsylvania 15222

ORPED-PR

25 March 1980

Mr. John F. Pearson Jr.
Asst. Manager for SRC Projects
U.S. Dept. of Energy
P.O. Box E
Oak Ridge, Tn. 37830

Dear Mr. Pearson:

Pittsburgh District Navigation
System Capabilities

On 13 March 1980 we provided information relative to the existing use and estimated capacity of the navigation system here in the Pittsburgh District, to Mr. D. P. Lessig, Vice President, SRC-II, Demonstration Project, with the Pittsburgh and Midway Coal Mining Co.

In addition, in conjunction with the above letter, we met with Ray Moxley, Ray Hinterliter and Tom Smith of Gulf Minerals Research Inc. and discussed at length the significance of the letter data.

Subsequently, in review of the material furnished Mr. Lessig and the GMR Inc. group, it appeared desirable to furnish additional clarification/documentation on system capabilities. Since your Messrs Martin and DeVault and Mr. Moxley of GMR Inc. were in this office on 20 March regarding a water availability analysis for the SRC-II proposal, we discussed the matter with them. They endorsed our suggestion, but in turn proposed that our letter be directed to you with a copy to Mr. Lessig.

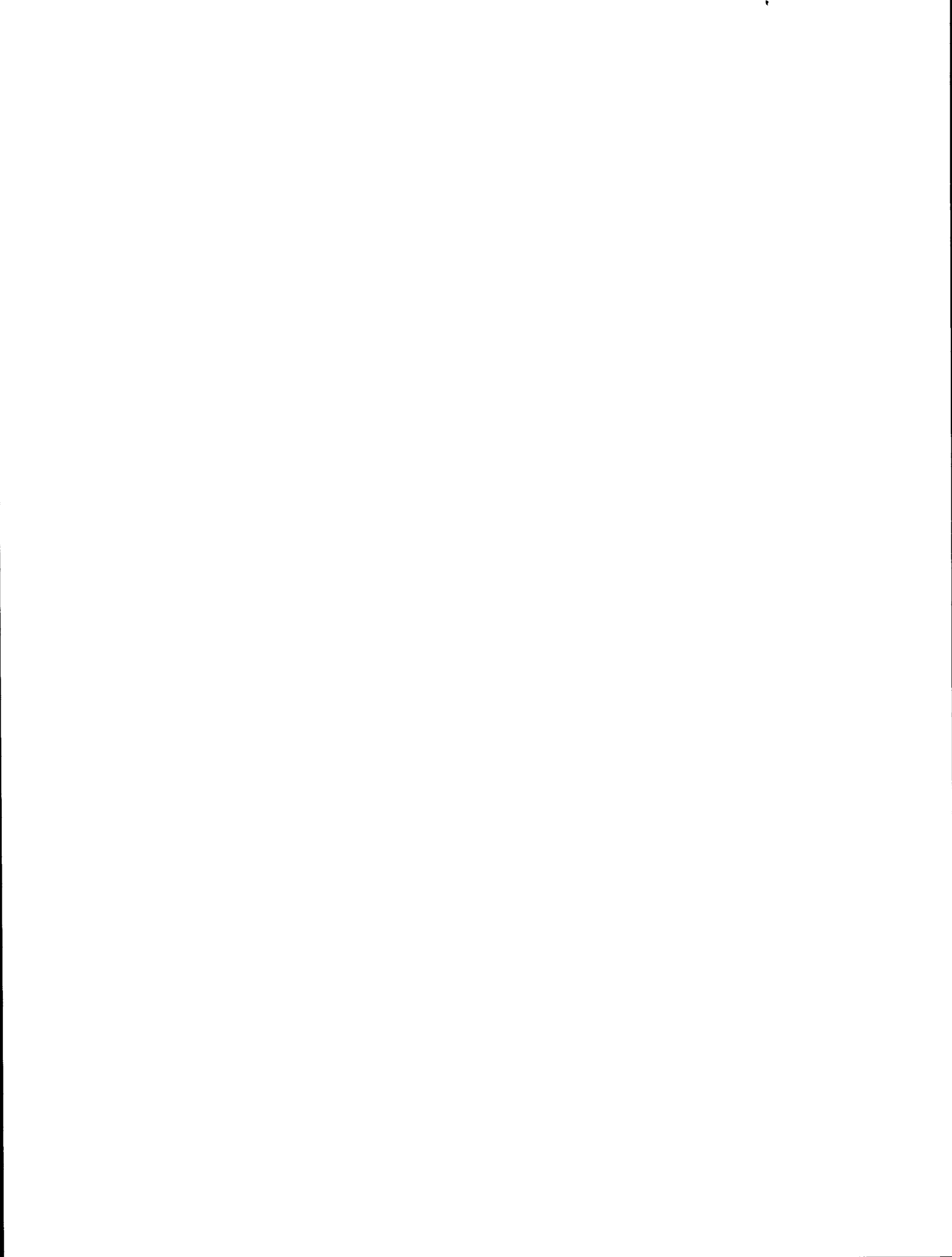
In this regard, we want to re-emphasize to avoid any possible confusion, that, in our opinion, the existing navigation system to be impacted upon by the added traffic to the SRC-II facility is adequate to accommodate the movement of the volume of coal required for the demonstration plant.

Sincerely,

JOSEPH A. YORE
Colonel, Corps of Engineers
District Engineer

Appendix N

CORPS OF ENGINEERS, LOW FLOW IN THE MONONGAHELA RIVER



Appendix N

CORPS OF ENGINEERS, LOW FLOW IN THE MONONGAHELA RIVER

Flow data for the Monongahela River was obtained from the U.S. Army Corps of Engineers, Pittsburgh District Office (letter enclosed). The flow of the Monongahela at Morgantown can be estimated from that of the river at Hault, West Virginia, and that of Buffalo Creek at Barrackville, West Virginia, according to the following formula:

$$\text{HOULT} + (2.5 \times \text{BARRACKVILLE}) = \text{MORGANTOWN}.$$

Average monthly flows from these two locations were used in the calculations for data from water-years 1951 through 1967. These dates encompass a span of dry years and are representative of worst-case conditions from the standpoint of water intake effects. As shown in Table N.1, the average monthly flows are generally lowest in September or October, months in which the ichthyoplankton densities are not the highest.

Table N.1. Estimate flows for lowest-flow months for Monongahela River at Morgantown, West Virginia¹

Water year ²	Month in which lowest average flow occurred	Average flow for month ³ (m ³ /min)
1951	September	1125
1952	October	833
1953	October	865
1954	October	721
1955	September	1125
1956	October	1569
1957	September	880
1958	October	1978
1959	July ⁴	996
1960	July ⁴	1170
1961	September	1696
1962	September	1055
1963	July ⁴	1365
1964	October	806
1965	August	694
1966	July ⁴	617
1967	July ⁴	1396

¹USGS data provided by the U.S. Army Corps of Engineers, Pittsburgh District Office.

²Extends from Oct. 1 of previous year to Sept. 30 of the particular year.

³Mean daily flows may have been less than the mean monthly flow.

⁴Months in which ichthyoplankton most numerous.



DEPARTMENT OF THE ARMY
PITTSBURGH DISTRICT, CORPS OF ENGINEERS
FEDERAL BUILDING, 1000 LIBERTY AVENUE
PITTSBURGH, PENNSYLVANIA 15222

ORPED-H

23 January 1980

Ms. Susan Turbak
Staff Scientist
Science Applications, Inc.
Building C, Suite 100
800 Oak Ridge Turnpike
Oak Ridge, TN 37830

Low Flow in the Monongahela
River at Morgantown, West Virginia

Dear Ms. Turbak:

This is in response to your letter of 11 January 1980 requesting information on monthly low flow values for the Monongahela River at Morgantown, West Virginia. We have reviewed our files and find that none of the data you requested has been compiled. However, the United States Geological Survey (USGS) has been recording streamflows in the Monongahela River and tributaries for many years.

The drainage area for the Morgantown Lock & Dam is 2,648 square miles (sq.mi.). Of this area, 1,184 sq. mi. are controlled by Tygart Lake which began operation in 1938. Additionally, the Stonewall Jackson Lake project on the West Fork River will control another 102 sq. mi. upon completion. Its current scheduled date of completion is 1987. The low flows at the head of the Monongahela River at Fairmont, W. Va. are maintained at a minimum of 340 cfs by Tygart Lake. Upon completion of Stonewall Jackson Dam, the minimum flow value will be raised to 420 cfs. During extreme low flow periods, the minimum flows at Morgantown will be approximately equal to those at the head of the river.

In order to determine historical flows at Morgantown, the USGS flow records for the Monongahela River at Hoult, W. Va. and Buffalo Creek at Barrackville, W. Va. can be used. These records span the dry years during the period of time that Tygart Lake has been regulating streamflow. The record at Hoult, W. Va. ended in 1967, but streamflow from that date until now has been high and would not be considered "worst-case" conditions. Copies of the monthly records for the two stations (1938-1967) are inclosed so that you can make your own assessment of how often minimum flows occurred during times of important biological activity. Monthly flows at Morgantown can be computed using the following equation: $\text{HOULT} + (2.5 \times \text{BARRACKVILLE}) = \text{MORGANTOWN}$

Sincerely,

GEORGE CINGLE, JR.
Acting Assistant Chief,
Engineering Division

Inclosures
As stated

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the transparency and accountability of the organization. The document then outlines the specific procedures for recording transactions, including the use of standardized forms and the requirement for double-checking entries. It also addresses the importance of regular audits to ensure the integrity of the records.

The second part of the document focuses on the financial management of the organization. It provides a detailed overview of the budgeting process, from the initial planning stage to the final approval. The document also discusses the various methods for tracking expenses and income, and the importance of staying within the allocated budget. It includes a section on the handling of unexpected financial challenges and the need for flexibility in the budgeting process.

The third part of the document deals with the human resources aspect of the organization. It outlines the recruitment process, from the identification of job openings to the selection of the most qualified candidate. The document also discusses the importance of providing ongoing training and development opportunities for employees to ensure they remain up-to-date in their skills. It also addresses the issue of employee compensation and the need for a fair and competitive salary structure.

The final part of the document provides a summary of the key points discussed and offers some concluding thoughts on the overall management of the organization. It emphasizes the importance of continuous improvement and the need for the organization to adapt to changing circumstances. The document concludes with a statement of commitment to the organization's mission and vision.

Appendix 0

EPA, APPLICATION OF NEW-SOURCE PERFORMANCE STANDARDS FOR PETROLEUM REFINERIES
TO SULFUR RECOVERY

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION III

6TH AND WALNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

Mr. Robert C. Martin
U.S. Department of Energy
Environmental Protection Branch
Oak Ridge Operations
P.O. Box 3
Oak Ridge, TN 37830

Dear Mr. Martin:

This is in response to your request for a determination regarding the applicability of the standards of performance for new stationary sources (NSPS) to the proposed solvent refined coal demonstration plant (SRC-II) near Morgantown, W.Va. The main points of discussion center on the definition of petroleum refinery, affected facilities, and petroleum under 40 CFR part 60, subpart J.

Petroleum refinery in 40 CFR 60.101(a) is defined as:

"any facility engaging in producing gasoline, kerosene, distillate fuel oils, residual fuel oils, lubricants, or other products through distillation of petroleum or through redistillation cracking or reforming of unfinished petroleum derivatives."

The affected facilities of the petroleum refinery to which the standards apply are listed under 60.100(a) as:

"fluid catalytic cracking unit catalyst regenerators, fuel gas combustion devices, and all claus sulfur recovery plants, except claus plants of 20 long tons per day or less associated with a small petroleum refinery."

The standard goes on to define petroleum in 60.101(b) as "the crude oil removed from the earth and the oils derived from tar sands, shale, and coal."

The SRC-II process utilizes a typical refining process to convert high sulfur coal into a low sulfur distillate fuel oil. This product would fall under the definition of petroleum in 60.101(b). Therefore, if any of the affected facilities mentioned in section 60.100(a) are used in this process, the NSPS for petroleum refineries would be applicable.

2

The preliminary draft environmental impact statement for the proposed SRC-II plant includes two methods of coal drying options for the coal preparation unit of the facility: Conventional Technology, where wet coal is simultaneously ground and dried in a system heated by combustion flue gases, and flash drying where wet coal is ground separately. Both options would fall under the definitions of coal preparation plant in 60.251(a), and the standards contained in 40 CFR part 60 Subpart Y would be applicable.

If you have any questions, please contact me at 215/597-2711.

Sincerely,

Vernon Butler
Project Officer

cc: C. Raymond Moxley
Abe Ferdas

Appendix P
CARBON DIOXIDE ISSUE

APPENDIX P

THE CARBON DIOXIDE ISSUE

P.1 CARBON DIOXIDE RELEASE TO THE ATMOSPHERE

All methods of large-scale energy production have environmental consequences. Release of carbon dioxide (CO_2) to the atmosphere is a major concern associated with the use (burning) of fossil fuel as an energy source.¹⁻³ Of all liquid and gaseous emissions from fossil fuel energy production (coal, petroleum, and natural gas), only CO_2 is retained in significant quantities in the atmosphere.⁴ Atmospheric CO_2 permits incoming short-wave radiation to reach the earth, but absorbs long-wave, infrared radiation.⁵ Infrared radiation is the principal outgoing radiation from the earth's surface. As atmospheric CO_2 levels increase, the amount of terrestrial radiation that is absorbed increases accordingly.⁶

Part of the terrestrial radiation absorbed by the atmospheric CO_2 is reradiated back to the earth, resulting in elevated global temperatures, known as the greenhouse effect.⁷ Theoretically, the trapping and reradiation of energy back to earth, with the ensuing increase in global temperatures, will alter climatic patterns.⁸⁻¹⁰ Although the relationship between atmospheric CO_2 levels and global temperature changes has never been empirically proven, many researchers believe that CO_2 -induced climatic change will cause elevated sea levels as polar ice caps melt, and northward and southward latitudinal shifting of agricultural zones.^{11,12} Whether these changes actually occur, when they may occur, and to what degree they will occur is a matter of debate.

Atmospheric CO_2 levels are undoubtedly increasing and have been increasing for a considerable length of time. Since 1958, several monitoring programs most notably the Mauna Loa, Hawaii monitoring program, have documented the atmospheric CO_2 increase.¹³ Atmospheric CO_2 levels are now estimated to be increasing at an annual rate of about 1.5 ppm with a present background of about 333 ppm.¹⁴ The increase in atmospheric CO_2 since 1860 is estimated to be 40 to 70 ppm.¹⁵ If the current increase in fossil fuel use continues at 4.3%/year, with the present distribution of CO_2 between the atmosphere, biosphere, and oceans, the atmospheric concentration of CO_2 can be expected to double by the year 2035. Annual growth rates for fossil fuel use of 1.0 to 3.0% delay the projected doubling time of atmospheric CO_2 levels by 5 to 25 years.¹⁶

The significance of the synthetic fuel contribution to the already increasing levels of atmospheric CO_2 is an important issue in the ongoing debate concerning future fossil fuel usage. The central issue of the argument revolves around the higher CO_2 emissions from synfuels than from directly burning fossil fuels (Table P.1).¹⁷ When the Btu's of all products and by-products are compared with the Btu's of the feed coal, the efficiency of coal liquefaction generally ranges from 60 to 70%. Many of the Btu's absent in the final products are discarded from the plant as carbon bound with oxygen, forming CO_2 gas. Although the CO_2 emissions from synfuels production and use exceed those from other fossil fuels, during the demonstration phase of the project these emissions will represent a very small fraction of U.S. and world CO_2 emissions.

As illustrated in Table P.1, CO_2 emissions from the production and use of synfuels are significantly higher than emissions from any other energy source. Synfuel production emits high levels of CO_2 because energy from fossil fuel is required to convert coal to synthetic fuel. Estimates of the excess amount of CO_2 that synfuel production will emit varies slightly from source to source, but the range is generally two to three times greater than that for natural gas, slightly less than two times the amount for petroleum, and less than 50% more than coal.^{18,19}

P.2 SIGNIFICANCE OF THE CARBON DIOXIDE ISSUE

Regardless of whether synfuels become a major contributor to our energy needs, world CO_2 levels are predicted to double during the next century. The doubling of CO_2 levels by the

year 2035 assumes a continued high growth rate of energy demand and fossil fuel use. If synthetic fuels are substituted for petroleum and natural gas, the doubling time for atmospheric CO₂ concentrations is shortened, but not significantly. It is important to realize that as synfuels begin contributing to the nation's energy ends, the use of other fossil fuels will decline, reducing CO₂ emissions from conventional sources.

TABLE P.1

RELATIVE AMOUNTS OF CARBON RELEASED IN CARBON DIOXIDE FOR VARIOUS FOSSIL FUELS

Fuel	Carbon in Carbon Dioxide (in 10 ¹⁵ g) ^a
OIL	2.0
GAS	1.45
COAL	2.5
COAL: converted to gas or oil (synthetic fuels)	3.4

^aCarbon released in CO₂ per 100 quads of energy released as heat.
(One quad = 10¹⁵ Btu.)

SOURCE: Woodwell, et. al., "The Carbon Dioxide Problem: Implications for Policy in the Management of Energy and Other Resources," Council on Environmental Quality (July, 1979), p. 6.

The actual share the United States will contribute to world-wide CO₂ emissions is dependent on the fossil fuel mixture used, development of nonfossil energy sources, and the growth of fossil fuel use by other countries. Based on the scenario proposed by President Carter, baseline calculations from synfuel CO₂ releases have been calculated assuming a production rate of 1 million barrels a day by 1985, 2 million barrels a day by 1990, and 5 million barrels a day in the year 2000. This rate of production was then projected to the year 2050 with an anticipated rate of 60 million barrels of synfuel per day.²⁰ By 1990, synfuels will be contributing a small percentage to man-made CO₂ emissions. Preliminary studies indicate a two million bbl/day synfuels program will represent a 3% increase in CO₂ emissions from U.S. fossil-fuel combustion and production. These emissions will represent less than 1% of global man-made emissions in 1990. Using the current projections for synthetic fuel development, the U.S. emissions of CO₂ from synfuels will represent 1.9% of the world total in 2025 and 3% in 2050.²¹ These baseline calculations are believed, by the Institute of Energy Analysis, to be based on an unrealistically high energy use scenario. This rate of energy production is equal to 125 quads which is approximately twice the amount of present production. In addition, all energy projections of a few years ago were much higher and, every year, the projections for the future are getting lower. The fraction of the U.S. total energy which will come from this scenario in the year 2050 is 37½ percent.²²

The United States currently contributes approximately 28% of the world's man-made CO₂ emissions.²³ If current projections regarding a shift in the reliance on petroleum to coal comes true, at the national and world scales, total U.S. and world emissions of CO₂ will dramatically increase. An interesting sidelight of this projection is that the U.S. share of world CO₂ emissions will decrease in relative terms while increasing in absolute terms. This argument has been seized upon by proponents of the synthetic fuels and coal development advocates in the nation as a rationale for adopting coal and coal conversion technologies as a major part of our energy program. As the world moves away from petroleum reliance to coal reliance total CO₂ emissions will increase. It is projected that the U.S. contribution to total CO₂ emissions will decrease to 8% in 2025 as developing countries increase their use of fossil fuels.²⁴

Justifying synthetic fuels and coal usage based on total projected world emissions of CO₂ tends to obfuscate the significance of the amount the U.S. contributes to the atmosphere. In a recent presentation to the U.S. Senate Committee on Energy and National Resources, Professor David Rose (MIT) attempted to put all of the issues regarding fossil fuel use, technologies, and CO₂ emissions into perspective.²⁵ The thrust of Rose's argument was that more thought should be given to the logic of developing a large scale synthetic fuels program given the uncertainty of the climatological consequences that may ensue from increasing atmospheric CO₂ concentrations. The shift to a national and world-wide reliance on coal as a primary energy source, as a result of this problem, needs to be reassessed. The inertia which such a technological shift may build up over several decades will be difficult to reverse should global warming, resulting from increase CO₂ concentrations, prove to be a major world problem.²⁶

Because of the small scale which is employed by the synthetic fuel demonstration projects, the global impact of their CO₂ emissions will be minimal. The above discussions assumed high daily outputs of synthetic fuels in commercial-scale plants in predicting the impact of CO₂ emissions. The demonstration plants will produce small quantities of synthetic fuels and thereby small quantities of CO₂. The ultimate purpose of the demonstration projects, however, is to demonstrate the feasibility of a large scale commercial synthetic fuels industry. This should be kept in mind when comparing synfuels' impacts to the potential environmental impacts of other energy alternatives.

REFERENCES FOR APPENDIX P

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3. Wilfrid Bach, "Impact of World Fossil Fuel Use on Global Climate: Policy Implications and Recommendations," Symposium on CO₂ and Synthetic Fuels, U.S. Senate, Washington, D.C., July 30, 1979, p. 122.
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9. Ref. 4, p. 9, footnote 4.
10. Ref. 3, p. 122, footnote 3.
11. C. F. Baes, H. E. Olson, and R. M. Rotty, "Carbon Dioxide and Climate: The Uncontrolled Experiment," *Am. Sci.* 65 (3): 317 May (1977).
12. Ref. 4, p. 27, footnote 4.
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14. George M. Woodwell et al., "The Carbon Dioxide Problem: Implications for Policy in the Management of Energy and Other Resources," A Report to the Council on Environmental Quality, July 1979, p. 1.
15. Ref. 14, p. 1, footnote 14.
16. Ref. 13, p. 19, footnote 3.
17. U.S. Department of Energy, *Carbon Dioxide Emissions from Synthetic Fuels Sources*, Washington, D.C., August 8, 1979, p. 2.
18. Ref. 17, p. 2, footnote 17.
19. Committee on Governmental Affairs, U.S. Senate, *Carbon Dioxide Accumulation in the Atmosphere, Synthetic Fuels and Energy Policy, Comment by Roger Reselle (July 30, 1979)*, U.S. Government Printing Office, Washington, D.C., 1979, p. 32.
20. Ref. 19, p. 9, footnote 17.
21. Ref. 19, p. 16, footnote 19.

- 22. Ref. 19, p. 16, footnote 19 (comments by Dr. Ralph Rotty).
- 23. Ref. 19, p. 21, footnote 19.
- 24. Ref. 17, p. 2, footnote 17.
- 25. Professor David J. Rose, "*On the Global CO₂ Problem*," a presentation prepared for the U.S. Committee on Energy and Natural Resources, April 3, 1980.
- 26. Ref. 25, p. 14, footnote 25.

Appendix Q
AIR QUALITY

Appendix Q

AIR QUALITY

Q.1 DATA

The analysis of the air quality impact of operating the SRC-II facility required information on the various emission sources associated with the plant, including emissions during start-up, normal operation, shutdown, and upset conditions. These emission data, as well as stack parameter data, were supplied by Pittsburgh and Midway Coal Mining Company and are detailed in Appendix C, Sect. C.4.

Hourly surface meteorological data needed as input to the air quality models used were taken from a data tape supplied by Stearns-Roger Services, Inc. This tape contained data collected from the field monitoring program initiated in June 1978 (see Sect. 3.2.3). The monitoring station is located approximately 1.5 km northeast of the facility site. Meteorological parameters measured include wind speed, wind direction, and temperature at both the 10- and the 60-m heights of a 60-m tower, as well as relative humidity and the change in temperature between 10 and 60 m. The measured temperature change with height was used to calculate atmospheric stability according to Table Q.1. One year of surface data (September 1, 1978 through August 31, 1979) was extracted from the tape and preprocessed to serve as input to the air quality models used. Upper-air data containing mixing heights were taken from a National Climatic Center data tape. The data from Pittsburgh were used because Pittsburgh is the nearest upper-air station to Morgantown.

Q.2 AIR QUALITY MODELING

The air quality modeling effort was accomplished in two different steps. The first step was to apply the Environmental Protection Agency's (EPA's) CRSTER model, using the one year of site meteorological data, to each of the individual emission sources comprised in the SRC-II facility. The assumptions and a description of this model appear in the CRSTER User's Manual.¹ The purpose of using the CRSTER model was to define the worst-case meteorological conditions for dispersion in the year of record considered. Additionally, the model runs indicated the relative magnitude of the impact of each individual source. The elevation of the SRC-II facility was assumed to be 1160 m. Receptor elevations were extracted from U.S. Geological Survey topographical maps of the area. The polar receptor grid used in CRSTER was centered on the proposed SRC-II plant site. The receptors were located every 10° radially around the site at distances of 0.6, 1.2, 1.8, 2.5, and 3.6 km from the site. These relatively small distances were chosen so that the maximum short-term concentrations, which tend to occur close to the source, could be calculated.

The results of the CRSTER runs enabled identification of the worst-case 24-h, 3-h, and 1-h meteorological conditions. These conditions were then used as input to the Industrial Source Complex (ISC) model.² Several 24-h cases were run to ensure that the worst meteorological conditions were indeed chosen. The ISC model was not run for the entire year of data because this would have been extremely expensive; hence the use of CRSTER as a screening tool.

The ISC model is a steady-state Gaussian dispersion model that is capable of handling point sources, area sources, and volume sources. Because of the nature of the SRC-II facility, which contains numerous separate point sources and area sources such as the coal piles and fugitive nonmethane hydrocarbon (NMHC) emissions, the ISC model was ideal for this application. In addition, the model accounts at each point for the contribution of each pollutant source as well as for the total contribution of all of the sources to pollutant concentration at that point.

In addition to the 24-h, 3-h, and 1-h estimates of maximum pollutant concentrations, the long-term mode of the ISC model (ISCLT) was used to calculate annual concentrations. The ISCLT model requires meteorological input in the form of relative frequency distributions of wind direction, wind speed class, and atmospheric stability. The relative frequency distribution used for input to ISCLT was developed from the site meteorological data produced in the monitoring program.

Concentrations were calculated at receptors located on a Cartesian grid system, with the origin placed at the location of the largest emitter, the SCOT burner and incinerator. Receptors were

located every 500 m in the x and y directions out to a distance of 5 km. The CRSTER runs indicated that the major impacts will occur within this distance. A total of 400 receptor points was used in the model calculations.

Q.3 RESULTS

The results of the ISC concentration calculations for the five criteria pollutants appear in Tables Q.2 through Q.6. These tables contain the maximum concentration and its location for each averaging period of interest. They include the maximum concentrations due to each of the individual sources as well as the cumulative impact of all sources in the SRC-II complex. It should be noted that the maximum concentrations of the individual sources cannot be summed to obtain the cumulative maximum concentration. This is because the maximum impacts of the individual sources are not all in the same location, because of the physical separation of the sources and the differences in stack parameters.

The results of SO_2 calculations (Table Q.2) indicate that the SCOT burner and incinerator is the major contributor to the maximum 3-h and 24-h concentrations, with the dissolver charge heaters, the power boiler, and the coal dryer also contributing somewhat. The maximum concentration occurs close (less than 1 km) to the SCOT burner and incinerator. The annual maximum concentration, however, occurs extremely close to the thawing shed even though this source is not one of the larger emitters of SO_2 . This occurs primarily because of the low emission height (6.1 m) and low effluent exit velocity from the thawing shed.

As is the case for SO_2 , the maximum annual average concentration of NO_2 (Table Q.3) is located in proximity to the thawing shed. It is also apparent from Table Q.3 that the maximum annual impacts tend to occur to the northeast of the SRC-II facility. This is a result of the prevailing southwest winds in the area.

Table Q.4 indicates that the maximum 1-h CO concentrations are extremely low for the entire facility, particularly in light of the 1-h standard of 40,000 $\mu\text{g}/\text{m}^3$. Table Q.5 shows that the coal dryer, the dissolver charge heater, and the various fugitive sources around the facility are the major contributors to NMHC concentrations. The fugitive NMHC emissions were modeled as an area source since these emissions escape at numerous valves, flanges, and seals and in many locations around the SRC-II facility. Although the fugitive NMHC emissions are the greatest source, the impact of these emissions on maximum concentrations is not much greater than the impact of the coal dryer or the dissolver charge heaters. This is because of the dispersed nature of the fugitive NMHC emissions, which occur at many scattered points instead of being concentrated at one point.

The results of the model calculations for total suspended particulates (TSP) appear in Table Q.6. In addition to the 11 point sources, two area sources were modeled. These included TSP emissions from coal handling, unloading, and conveying as well as fugitive dust emissions from the coal storage pile. Table Q.6 shows these two sources along with the coal dryer as the major contributors to 24-h maximum TSP concentrations. This is a result of both the higher emission rates and the lower emission heights of these sources compared with the other sources.

The maximum annual TSP concentration estimates show similar results. However, at many receptors the ISCLT model calculated higher concentrations for an annual average than the ISCST model calculated for 24-h maximum concentrations. Receptors located too close to sources for a meaningful concentration to be calculated and receptors located within the area sources themselves were ignored.

Table Q.1. Classification of atmospheric stability
by temperature change with height

Stability classification	Pasquill category	Temperature change (ΔT) with height (Δz) ($^{\circ}\text{C}/100\text{ m}$)
Extremely unstable	A	$\Delta T/\Delta z \leq -1.9$
Moderately unstable	B	$-1.9 < \Delta T/\Delta z \leq -1.7$
Slightly unstable	C	$-1.7 < \Delta T/\Delta z \leq -1.5$
Neutral	D	$-1.5 < \Delta T/\Delta z \leq -0.5$
Slightly stable	E	$-0.5 < \Delta T/\Delta z \leq 1.5$
Moderately stable	F	$1.5 < \Delta T/\Delta z \leq 4.0$
Extremely stable	G	$4.0 < \Delta T/\Delta z$

Table Q.2. Maximum concentration of SO₂ for individual sources and all sources for the SRC-II demonstration plant

Source No.	Source	Source location ^a	Concentration					
			3-h		24-h		Annual	
			µg/m ³	Receptor location ^a	µg/m ³	Receptor location ^a	µg/m ³	Receptor location ^a
1	Dissolver charge heaters	85, -256	4.9	-500, 0	1.5	-500, 0	0.12	1500, 3000
2	Fractionator reboiler	329, -457	1.0	0, 0	0.4	0, 0	0.11	1000, 1000
3	Power boiler	305, -122	5.7	-500, 500	1.4	-500, 500	0.15	2000, 4000
4	Superheater	305, -116	1.3	0, 0	0.6	0, 0	0.08	1000, 1500
5	Wastewater incinerator	91, -122	0.4	-500, 500	0.3	-500, 0	0.11	1000, 2000
6	Oxygen-plant heater	0, -152	0.5	-500, 0	0.3	-500, 0	0.06	1000, 2000
7	Heavy-oil product gas	0, -609	0.1	-500, -500	0.1	-500, -500	0.06	500, 500
8	Mineral residue heater	91, -329	0.2	-500, 0	0.1	-500, 0	0.07	500, 500
9	Thawing shed	396, -329	1.3	0, 0	0.9	0, -1500	3.47	500, 0
10	Coal dryer	396, -274	10.0	0, 0	3.9	0, 0	0.12	1500, 2500
11	SCOT burner and incinerator	0, 0	41.0	-500, 500	8.8	-500, 500	1.00	1500, 3500
	All Sources		52.9	-500, 500	12.1	-500, 500	3.71	500, 0

^aExpressed in meters as x, y coordinates on a Cartesian grid having its origin at the SCOT burner and incinerator.

Table Q.3. Maximum annual concentration of NO₂ for individual sources and all sources for the SRC-II demonstration plant

Source No.	Source	Source location ^a	Concentration	
			$\mu\text{g}/\text{m}^3$	Receptor location ^a
1	Dissolver charge heaters	85, -256	0.34	1500, 3000
2	Fractionator reboiler	329, -457	0.91	1000, 1000
3	Power boiler	305, -122	0.68	2000, 4000
4	Superheater	305, -116	0.52	1000, 1500
5	Wastewater incinerator	91, -122	0.71	1000, 2000
6	Oxygen-plant heater	0, -152	0.57	1000, 2000
7	Heavy-oil product gas	0, -609	0.43	500, 500
8	Mineral residue heater	91, -329	0.48	500, 500
9	Thawing shed	396, -329	22.09	500, 0
10	Coal dryer	396, -274	0.93	1500, 2500
11	SCOT burner and incinerator	0, 0	0.06	1500, 3500
	All sources		23.41	500, 500

^aExpressed in meters as x, y coordinates on a Cartesian grid having its origin at the SCOT burner and incinerator.

Table Q.4. Maximum 1-h concentration of CO for individual sources and all sources for the SRC-II demonstration plant

Source No.	Source	Source location ^a	Concentration	
			$\mu\text{g}/\text{m}^3$	Receptor location ^a
1	Dissolver charge heaters	85, -256	0.4	1000, 0
2	Fractionator reboiler	329, -457	0.1	1000, -500
3	Power Boiler	305, -122	0.1	500, 0
4	Superheater	305, -116	0.1	1000, 0
5	Wastewater incinerator	91, -122	0.3	500, 0
6	Oxygen-plant heater	0, -152	0.3	500, 0
7	Heavy-oil product gas	0, -609	0.1	500, -500
8	Mineral residue heater	91, -329	0.1	1000, 0
9	Thawing shed	396, -329	0.1	1500, 0
10	Coal dryer	396, -274	0.2	1500, 0
11	SCOT burner and incinerator	0, 0	0.1	500, 0
	All sources		1.1	1000, 0

^aExpressed in meters as x, y coordinates on a Cartesian grid having its origin at the SCOT burner and incinerator.

Table Q.5. Maximum 3-h concentration of nonmethane hydrocarbons for individual sources and all sources for the SRC-II demonstration plant

Source No.	Source	Source location ^a	Concentration	
			$\mu\text{g}/\text{m}^3$	Receptor location ^a
1	Dissolver charge heaters	85, -256	1.2	-500, 0
2	Fractionator reboiler	329, -457	0.7	0, 0
3	Power boiler	305, -122	0.8	-500, 500
4	Superheater	305, -116	0.9	0, 0
5	Wastewater incinerator	91, -122	0.1	-500, 500
6	Oxygen-plant heater	0, -152	0.6	-500, 0
7	Heavy-oil product gas	0, -609	0.1	-500, -500
8	Mineral residue heater	91, -329	0.1	-500, 0
9	Thawing shed	396, -329	1.0	0, 0
10	Coal dryer	396, -274	2.1	0, 0
11	SCOT burner and incinerator	0, 0	0.1	-500, 500
12	Fugitive sources	-609, -457 ^b	2.4	-1000, 500
	All sources		5.4	-1000, 500

^aExpressed in meters as x, y coordinates on a Cartesian grid having its origin at the SCOT burner and incinerator.

^bSouthwest corner of a square area source assumed to be 1200 m on a side.

Table Q.6. Maximum average concentration of total suspended particulates for individual sources and all sources for the SRC-II demonstration plant

Source No.	Source	Source location ^a	Average concentration			
			24-h		Annual	
			$\mu\text{g}/\text{m}^3$	Receptor location ^a	$\mu\text{g}/\text{m}^3$	Receptor location ^a
1	Dissolver charge heaters	85, -256	2.0	-500, 0	0.17	1500, 3000
2	Fractionator reboiler	329, -457	0.6	0, 0	0.16	1000, 1000
3	Power boiler	305, -122	0.7	-500, 500	0.08	2000, 4000
4	Superheater	305, -116	0.7	0, 0	0.11	1000, 1500
5	Wastewater incinerator	91, -122	0.2	-500, 0	0.08	1000, 2000
6	Oxygen-plant heater	0, -152	0.5	-500, 0	0.08	1000, 2000
7	Heavy-oil product gas	0, -609	0.1	-500, -500	0.07	500, 500
8	Mineral residue heater	91, -329	0.2	-500, 0	0.11	500, 500
9	Thawing shed	396, -329	1.2	0, -1500	4.56	500, 0
10	Coal dryer	396, -274	6.9	0, 0	0.21	1500, 2500
11	SCOT burner and incinerator	0, 0	0.1	-500, 500	0.01	1500, 3500
12	Coal unloading	457, -1523 ^b	9.5	3500, 0	5.19	3500, 500
13	Coal storage piles	-153, -2040 ^c	7.4	1000, -1500	1.71	-1000, -1000
	All sources		12.9	1500, -2000	6.29	3500, 0

^aExpressed in meters as x, y coordinates on a Cartesian grid having its origin at the SCOT burner and incinerator.

^bSouthwest corner of a square area source assumed to be 2500 m on a side.

^cSouthwest corner of a square area source assumed to be 700 m on a side.

REFERENCES FOR APPENDIX Q

1. U.S. Environmental Protection Agency, *User's Manual for Single-Source (CRSTER) Model*, Report EPA-450/2-77-013, Research Triangle Park, N.C., July 1977.
2. U.S. Environmental Protection Agency, *Industrial Source Complex (ISC) Dispersion Model User's Guide*, NTIS PB80-133044, 1980.

Appendix R

SCHEDULE FOR PROCUREMENT OF ENVIRONMENTAL PERMITS

1. The first part of the document is a letter from the President of the United States to the Congress, dated January 3, 1862. It is a very important document, as it contains the President's annual message to Congress, which is a key document in the history of the United States.

2. The second part of the document is a report from the Secretary of the Treasury, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

3. The third part of the document is a report from the Secretary of the Interior, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

4. The fourth part of the document is a report from the Secretary of the War, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

5. The fifth part of the document is a report from the Secretary of the Navy, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

6. The sixth part of the document is a report from the Secretary of the State, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

7. The seventh part of the document is a report from the Secretary of the War, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

8. The eighth part of the document is a report from the Secretary of the Navy, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

9. The ninth part of the document is a report from the Secretary of the State, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

10. The tenth part of the document is a report from the Secretary of the War, dated January 3, 1862. It is a very important document, as it contains the Secretary's annual report to Congress, which is a key document in the history of the United States.

Table R.1. Status of demonstration project permits

Agency, permit	Date permit required	Date application is scheduled
Federal Agencies		
<i>Environmental Protection Agency (EPA)</i>		
1. Prevention of Significant Deterioration (PSD) permit	9/81	5/80
2. National Pollutant Discharge Elimination System (NPDES) permit for construction runoff water	3/81	1/81
3. NPDES permit for discharge from sewage treatment plant	6/81	4/81
4. NPDES permit for water intake back-flushing and any other plant operating discharge	4/82	2/82
5. Resource Conservation and Recovery Act (RCRA) permit	9/81	1/82
6. Spill Prevention Control & Counter-Measure (SPCC) Plan	4/82	4/82
<i>Corps of Engineers (COE)</i>		
1. Section 10 and 404 permits for construction in a navigable river	6/81	1/81
<i>Federal Aviation Administration (FAA)</i>		
1. Notice of Proposed Construction permit	6/81	6/81
West Virginia State Agencies		
<i>Air Pollution Control Commission</i>		
1. Permit to construct, modify, or relocate an air pollution source	9/81	5/80
<i>Department of Natural Resources (DNR)</i>		
1. Water Pollution Control permit for construction runoff	3/81	1/81
2. Water Pollution Control permit for sewage treatment plant discharge	6/81	4/81
3. Water Pollution Control permit for plant discharge operations	4/82	2/82
4. Water Pollution Control permit for a landfill	12/81	10/81
5. Dam Certificates of Approval	12/81	10/81
<i>Department of Health</i>		
1. Permit to construct sewage treatment plant	6/81	4/81
2. Permit to operate sewage treatment plant	11/81	11/81
3. Permit to construct potable water supply system	12/81	9/81
4. Permit to operate potable water supply system	6/82	6/82
5. Permit to construct a Class III land fill for construction wastes	2/1/81	1/81
<i>Department of Highways</i>		
1. Permission to enter highway	2/81	2/81
<i>Department of Mines</i>		
1. Permit to plug a gas well	3/1/81	2/81
Local Agencies		
No county or city permits required		

Appendix S
WATER QUALITY CRITERIA

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the transparency and accountability of the organization. The document outlines the various methods used to collect and analyze data, ensuring that the information is reliable and valid. It also highlights the need for regular audits and reviews to identify any discrepancies or errors in the data.

The second part of the document focuses on the implementation of the proposed changes. It details the steps involved in the process, from the initial planning and design to the final execution and evaluation. The document provides a clear timeline and budget for the project, ensuring that all stakeholders are aware of the expected costs and benefits. It also discusses the potential risks and challenges that may arise during the implementation process and offers strategies to mitigate them.

The third part of the document discusses the long-term impact of the proposed changes. It analyzes the potential benefits to the organization, such as increased efficiency, improved customer satisfaction, and enhanced financial performance. It also considers the potential drawbacks and challenges that may arise in the long run and offers strategies to address them. The document concludes by emphasizing the importance of ongoing monitoring and evaluation to ensure that the changes continue to deliver the desired results.

Appendix S

WATER QUALITY CRITERIA

Table S.1 presents the existing water quality criteria applicable to the Monongahela River. However, these standards and criteria do not include all water quality constituents and are subject to periodic revision. This appendix provides additional information and discussion regarding water quality constituents, particularly organic compounds such as polynuclear aromatic hydrocarbons (PNAs).

These are multiple regulations and standards, which apply to toxic substances. Under existing West Virginia standards (Table S.1), a general water quality standard for toxic substances is defined on the basis of a substance's toxicity as determined by a bioassay test. The bioassay determines the median tolerance limit (TL_{50}), the concentration of a substance that is lethal to 50% of a population of test organisms within 96 h. In the case of trace elements and compounds for which no other standard exists, West Virginia defines the standard as 0.1 of the TL_{50} . Table S.2 presents some standards based on bioassay data. The organisms used to derive these standards were predominantly fish embryo-larvae, the life stage thought to be most vulnerable to toxic substances.

Water quality criteria for 65 toxic pollutants have been issued as draft criteria by the Environmental Protection Agency (EPA), but no final criteria have yet been adopted. Once finalized, these criteria (summarized in Table S.3) will serve as a basis for setting standards. Among the list of 65 toxic pollutants for which EPA is developing criteria are PNAs. However, except for the three individual PNAs in Table S.3, EPA has found its data insufficient for estimating PNA criteria for the protection of freshwater aquatic life.

Although no draft criteria have been established for PNAs, basic compounds, or individual phenolic compounds, Table S.4 indicates the estimated permissible concentrations (EPCs) established for some of these compounds. Concern over the release of PNAs into the aquatic environment stems primarily from the demonstrated carcinogenic and cocarcinogenic activity of several PNA compounds.¹ Given the lack of water quality criteria for PNAs, this appendix presents information useful in evaluating the impacts of PNAs on aquatic environments.

Polynuclear aromatic hydrocarbons (Fig. S.1) are a series of fused-ring aromatic compounds produced both in the natural environment and in high-temperature industrial processes such as petroleum refining, coal coking, and coal liquefaction. The characteristics of a PNA are very much influenced by the compound's molecular weight and the number of rings in its structure. The solubility of PNAs is generally very low and decreases with increasing molecular weight. This low solubility limits the concentrations of PNAs in aqueous solution, but it also results in a tendency of PNAs to adsorb to suspended particulate matter and become concentrated in bottom sediments and the fatty tissues of organisms.

Herbes et al.² reviewed the fate of PNAs in aquatic environments. The persistence of these compounds in surface waters is controlled by such mechanisms as volatilization, photolysis, sorption, sedimentation, bioaccumulation, and metabolism by aquatic organisms. A large number of bacteria commonly found in aquatic ecosystems actively metabolize aromatic hydrocarbons into organic acids as their food source.³ The half-life (time in which concentrations are reduced by 1/2) of PNA compounds is largely a function of their specific chemical structure.² Volatilization is relatively more important for PNAs of lower molecular weight (two- and three-ringed compounds, such as naphthalene), but photolysis and sediment sorption are more important for larger PNAs (those with three or more rings, such as anthracene and pyrene). As is true of the water solubility of PNAs, transport and transformation processes for PNAs will change as a function of environmental parameters such as temperature, turbidity, water velocity, depth, sunlight, and wind speed (Table S.5). Estimates of the half-life of benzantracene (a four-ringed PNA) vary from 10 h in a clear, fast-flowing river to about 10 days in a turbid, slow-moving river.² Southworth⁴ estimated the half-life for anthracene in fast, clear streams to be about 1.4 h. In microcosm studies to measure the fate of ^{14}C -labeled anthracene (a three-ringed PNA), in simulated pond ecosystems, Giddings et al.⁵ found that after six days, about 10% of an initial single dosage remained in the water column. After 84 days of this microcosm experiment, 32% of the original anthracene was present in the sediments, and none was detectable in the water column.

Table S.1. Summary of the most stringent water quality criteria applicable to the Monongahela River and its tributaries

Parameter	Criterion	Agency
Alkalinity	Greater than 20 mg/liter	EPA, ^a PA ^b
Ammonia	Not to exceed 0.02 mg/liter as unionized ammonia	EPA
Arsenic	Not to exceed 0.01 mg/liter	WV ^c
Barium	Not to exceed 0.5 mg/liter	WV
Beryllium	Not to exceed 1.1 mg/liter in hard fresh water	EPA
Cadmium	Not to exceed 1.2 µg/liter in hard fresh water	EPA
Chloride	Not to exceed 100 mg/liter	WV
Chromium, hexavalent	Not to exceed 0.05 mg/liter	WV, ORSANCO, ^d PA ^b
Chromium, total	Not to exceed 0.05 mg/liter	EPA
Copper	Not to exceed 1.0 mg/liter	EPA
Cyanide	Not to exceed 5.0 µg/liter	EPA, PA ^b
Fluoride	Not to exceed 1.0 mg/liter	WV, ORSANCO
Iron	Not to exceed 0.3 mg/liter	EPA
Lead, dissolved	Not to exceed 0.05 mg/liter	ORSANCO
Lead, total	Not to exceed 0.05 mg/liter	EPA, WV
Manganese	Not to exceed 0.05 mg/liter	EPA
Mercury	Not to exceed 0.05 µg/liter	EPA
Nitrate-nitrogen plus nitrite-nitrogen	Not to exceed 10 mg/liter	ORSANCO, PA; ^b EPA similar
Nitrite-nitrogen	Not to exceed 1.0 mg/liter	ORSANCO
Oil and grease	Virtually free from all oil and grease, particularly from associated tastes and odors	EPA
Oxygen, dissolved	Not less than 5 mg/liter at any time	WV; EPA similar
pH value	Generally held between 6.0 and 8.5 In the range 6.5 to 9.0	WV EPA
Phenol	Not to exceed 1 µg/liter	EPA
Parameter	Criterion	Agency
Phosphorus, soluble	Not to exceed 0.03 mg/liter	PA
Selenium	Not to exceed 0.01 mg/liter	WV, ORSANCO, EPA
Silver	Not to exceed 0.05 mg/liter	WV, ORSANCO, EPA
Solids, dissolved	Not to exceed 500 mg/liter as a monthly average or 750 mg/liter at any time (specific conductance values of 800 and 1200 micromhos/cm at 25°C considered equivalent to 500 and 750 mg/liter respectively)	ORSANCO, PA ^b
Solids, suspended and settleable	Should not reduce the depth of the compensation point for photosynthetic activity more than 10% from the seasonably established norm	EPA
Sulfate	Not to exceed 250 mg/liter	ORSANCO, PA; ^b EPA similar
Sulfide	Not to exceed 2 µg/liter as undissociated hydrogen sulfide	EPA
Temperature	Not to exceed 2.8°C (5°F) above natural; not to exceed 30.5°C (87°F) at any time during the months May through November, and not to exceed 22.8°C (73°F) at any time during the months December through April	WV
Toxic substances	Not to exceed 0.1 of the 96-h median tolerance limit	WV, PA similar
Zinc	Not to exceed 5.0 mg/liter	EPA

^aU.S. Environmental Protection Agency, *Quality Criteria for Water*, Report 440/9-76-023, Washington, D.C., July 1976.

^bBureau of National Affairs, "Pennsylvania Water Quality Standards," *Environ. Rep.* 891: 1001-8 (1979).

^cBureau of National Affairs, "West Virginia Water Quality Regulations," *Environ. Rep.* 946: 0512-13 (1978).

^dOhio River Valley Water Sanitation Commission, *Ohio River Main Stem, Assessment of 1977 and Future Water Quality Conditions*, Cincinnati, Ohio, March 1978, pp. 145-48.

Table S.2. West Virginia standards for toxic substances

Based on bioassay data

Chemical constituent	Bioassay organism	0.1 of the bioassay TL ₅₀ (mg/liter)
Arsenic	Bass embryo-larvae ^a	4.2
Cadmium	Bass embryo-larvae	0.16
Chlorine, residual	Golden shiner ^b	0.19
Chromium	Bass embryo-larvae	0.12
Copper	Bass embryo-larvae	0.66
Cyanide	Bluegill ^b	0.10
Lead	Bass embryo-larvae	0.02
Manganese	Goldfish embryo-larvae ^c	0.82
Mercury	Bass embryo-larvae	0.01
Nickel	Bass embryo-larvae	0.20
Selenium	Goldfish embryo-larvae	0.88
Zinc	Bass embryo-larvae	0.52

^aSource of bioassay data: W. J. Birge, et al., "Embryo-Larval Bioassays on Inorganic Coal Elements and In Situ Biomonitoring of Coal Waste Effluents," pp. 97-104 in *Surface Mining and Fish and Wildlife Needs in the Eastern United States*, D. E. Samuel et al., Ed., FWS/OBS-78/81. U.S. Fish and Wildlife Service, 1978.

^bSource of bioassay data: U.S. Environmental Protection Agency. "Quality Criteria for Water." EPA-440/9-76-023, Washington, D.C., July 1978.

^cWhen bass data not available, source of goldfish bioassay data used: W. J. Birge, "Aquatic Toxicology of Trace Elements of Coal and Fly Ash," pp. 219-240 in *Energy and Environmental Stress in Aquatic Systems*, J. H. Thorp and J. W. Gibbons, Eds., Technical Information Center, U.S. Department of Energy, 1978.

Table S.3. Draft water quality criteria for potentially toxic pollutants from the SRC processes^a

Constituent	Freshwater aquatic life ^b		Human health
	24-h average	Not to exceed	
Trace elements			
Arsenic	57	130	0
Cadmium	$\exp[0.87 \ln(h) - 4.38]$	$\exp[1.30 \ln(h) - 3.92]$	10
Chromium, trivalent	$\exp[0.83 \ln(h) + 2.94]$	$\exp[0.83 \ln(h) + 3.72]$	50
Chromium, hexavalent	10	110	0
Copper	$\exp[0.65 \ln(h) - 1.94]$	$\exp[0.88 \ln(h) - 1.03]$	1000
Lead	$\exp[1.51 \ln(h) - 3.37]$	$\exp[1.51 \ln(h) - 1.39]$	50
Mercury	0.064	3.2	0.2
Nickel	$\exp[1.01 \ln(h) - 1.02]$	$\exp[0.47 \ln(h) - 4.19]$	50
Selenium	9.7	22	10
Zinc	$\exp[0.67 \ln(h) + 0.87]$	$\exp[0.64 \ln(h) + 2.46]$	5000
Industrial wastes			
Cyanide	1.4	38	200
Phenol	600	3400	3400
2-4 Dimethylphenol	38	86	c
Polynuclear aromatic hydrocarbons			
Naphthalene	c	ND	143
Fluoranthene	250	560	200
Acenaphthene	110	240	20

^aPollutants measured in $\mu\text{g/liter}$.

^bHardness given as h.

^cNot derived because of insufficient data.

Source: U.S. Environmental Protection Agency, "Water Quality Criteria" *Fed. Regist.* **44**(52): 15926-15981, (1979); **44**(144): 43660-43697, 1979; and **44**(191): 56628-56657 (1979).

Table S.4. Estimated permissible concentrations (EPCs) for polynuclear aromatic hydrocarbon compounds, basic compounds, and phenolic compounds in the SRC fluid or wastewater

Constituent	EPC ($\mu\text{g/liter}$)	Basis
PNAs		
Naphthalene	50	a
Acenaphthene	None	
Fluorene	None	
Phenanthrene	280	b
Anthracene	2000	c
Fluoranthene	800	b
Pyrene	8333	c
Benz[a]anthracene	4	b
Chrysene	79.4	c
Benzo[b]fluoranthene	31.5	c
Benzo[k]fluoranthene	58	c
Benzo[a]pyrene	20	b
Benzo[e]pyrene	109	c
Dibenz[a,h]anthracene	4	b
Benzo[gh,i]perylene	None	
Indeno[1,2,3-cd]pyrene	58.5	c
Biphenyl	13.8	b
Tetralin (tetrahydronaphthalene)	500	a
Basic Compounds		
Aniline	262	b
Methyl aniline	304	b
Dimethyl aniline	345	b
-Naphthylamine	20	c
-Naphthylamine	6	c
Pyridine	207	b
Methyl pyridine	310	b
Quinoline and isoquinoline	140	b
Methylquinoline	492	b
Acridine	800	b
Phenolics		
Cresols	50	a
Phenylphenols	810	c
Alkyl cresols	212	b
Catechol	280	b
Indanols	1300	b

^aEPC, based ecological effects.

^bEPC, based on health effects.

^cEPC for zero threshold pollutants (suspected or potential carcinogens), based on health effects.

Source: J. G. Cleland, and G. L. Kingsbury, "Multi-media Environmental Goals for Environmental Assessment," EPA-600/7-77-136b, U.S. Environmental Protection Agency, Research Triangle Park, N.C., 1977.

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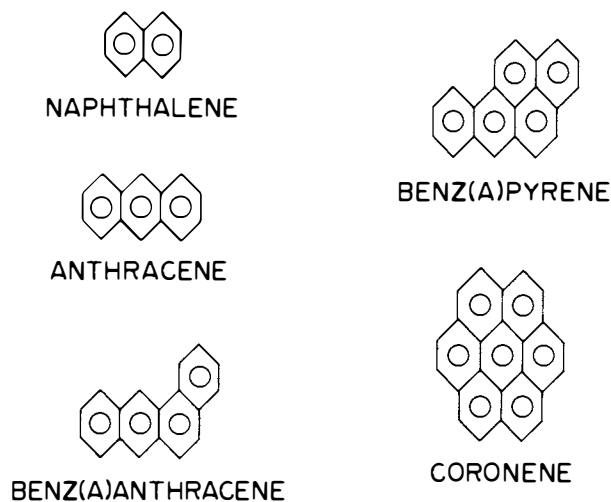


Fig. S.1. Representative PNA compounds. Source: Figure 4, Herbes, S. E., G. R. Southworth, D. L. Shaeffer, W. H. Griest, M. P. Maskarinec. 1980. Critical pathways of polycyclic aromatic hydrocarbons in aquatic environments, pp. 113-128 in: H. Witschi (ed), *The Scientific Basis of Toxicity Assessment*. Elsevier/North Holland Biomedical Press.

Table S.5. Qualitative effects of environmental parameters on rates of transport processes

Parameter	Change resulting from increase in parameter ^a			
	Photolysis	Volatilization	Sedimentation	Microbial degradation
Temperature	<i>b</i>	+ or -	-	+
Turbidity	-	-	+	<i>b</i>
Water velocity	<i>b</i>	+	-	<i>b</i>
Depth	-	-	-	-
Sunlight	+	<i>b</i>	<i>b</i>	<i>b</i>
Wind speed	<i>b</i>	+	<i>b</i>	<i>b</i>

^a+ indicates an increase; - indicates a decrease.

^bNo significant effect.

Source: Herbes, S. E., G. R. Southworth, D. L. Shaeffer, W. H. Griest, and M. P. Maskarinec, 1980. Table 6 from "Critical Pathways of Polycyclic Aromatic Hydrocarbons in Aquatic Environments," pp. 113-128 in H. Witschi (ed), *The Scientific Basis of Toxicity Assessment*, Elsevier/North-Holland Biomedical Press.

The acute toxicity of PNAs is limited by their water solubility. Gehrs⁶ presented theoretical data which suggest that for a PNA with a molecular weight greater than 150, water solubility would be less than the acute toxicity levels for fish (Fig. S.2). Only a limited amount of data are available for specific PNAs.

The trends that have been observed in bioconcentration of PNAs are opposite to those observed for acute toxicity. As Fig. S.3 shows bioconcentration increases as PNAs increase in size and nonpolarity, as measured by the n-octanol/water partition coefficient.⁷ The ranges of bioconcentration of PNAs in *Daphnia* are 10,000x for benzo[a]anthracene (4-ring PNAs) to 100x for naphthalene (2-ring PNAs). Bioaccumulation of PNAs by *Pimephales promelas* (fathead minnows) occurs to a generally lesser degree (George Southworth, ORNL, personal communication to Michael Sale, ORNL, November 1980). For instance, the equilibrium concentrations of anthracene in the tissues of *Pimephales* and *Daphnia* were, respectively, 500x and 1200x aqueous concentrations.⁴

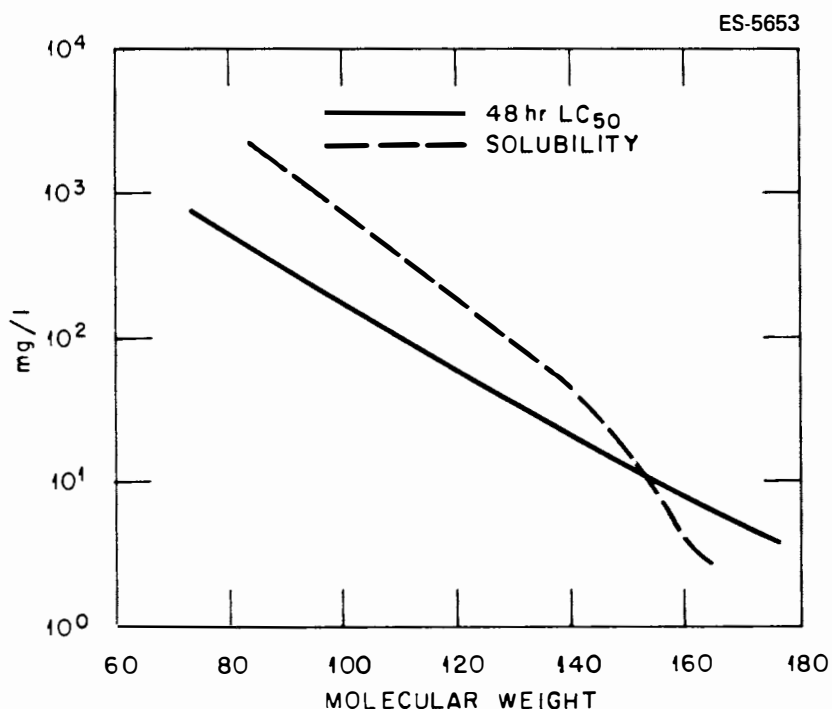


Fig. S.2. Theoretical solubility and LC₅₀ values plotted against molecular weights for a series of aromatic hydrocarbons. Source: Figure 5, Gehrs, C. W. 1977. Environmental implications of coal conversion technologies: organic contaminants, __: 157-175, in: Thorp and Gibbon (eds). Energy and Environmental Stress in Aquatic Systems, CONF-77114, U.S. Department of Energy, Oak Ridge, TN.

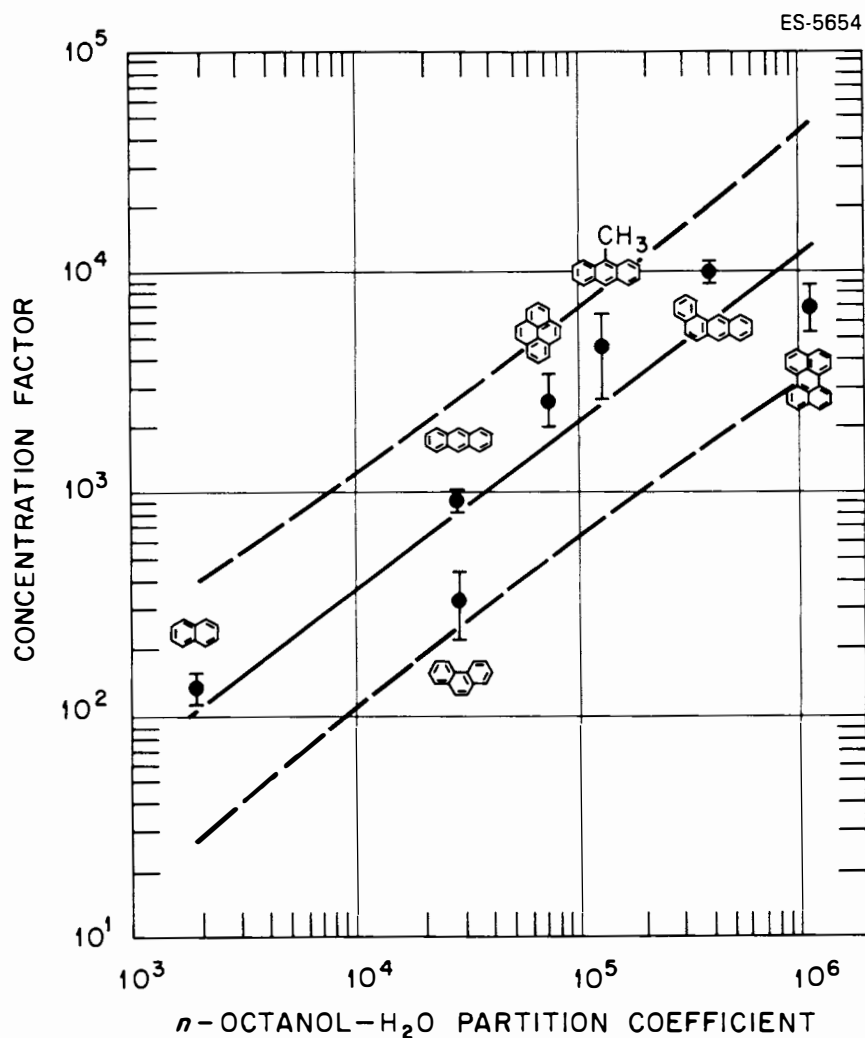


Fig. S.3. Log concentration factor (24 h) vs log *n*-octanol-water partition coefficient (calculated from Leo, 1975) for several PAH in *Daphnia pulex* at 25°C. Dashed lines delineate 95% prediction interval. Source: Figure 2, Southworth, G. R., J. J. Beauchamp, and P. K. Schnieder. 1978. Bioaccumulation potential of polycyclic aromatic hydrocarbons in *Daphnia Pulex*, *Water Res.* 12: 973-977.

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Appendix T

IMPLICATIONS OF THE TOXIC SUBSTANCES CONTROL ACT FOR
SOLVENT REFINED COAL PROCESSES



Appendix T

IMPLICATIONS OF THE TOXIC SUBSTANCES CONTROL ACT FOR SOLVENT REFINED COAL PROCESSES

T.1 TOXIC SUBSTANCES CONTROL ACT

T.1.1 Description

The Toxic Substances Control Act (TSCA), enacted in 1976, protects human health and the environment by authorizing the Administrator of EPA to obtain information from industry on the production, use, disposal, and health effects of chemical substances and mixtures.¹ Under TSCA, EPA's authority centers around four activities:

1. collecting basic information on chemical substances from manufacturers and processors, including importers;
2. identifying potentially harmful substances and requiring that industry test them for adverse health and environmental effects;
3. reviewing all new chemicals for potential health and environmental risks before they are manufactured for chemical use; and
4. controlling unreasonable risks stemming from the manufacturing, processing, distribution, use, or disposal of a chemical substance.¹

The law divides chemicals into "existing" chemicals and "new" chemicals. "Existing" chemicals are those listed in the Chemical Substances Inventory. This inventory is not a list of hazardous or toxic chemicals; rather, it is a list of all chemicals that were manufactured, imported, or processed for a commercial purpose before January 1, 1975. EPA has also collected information on these chemicals to determine which chemicals pose an unreasonable risk to human health or the environment. Testing of these chemicals may be required to further define their persistence, environmental fate, ecological effects, and such health effects as carcinogenicity, mutagenicity, teratogenicity, or behavioral toxicity.

TSCA established in Interagency Testing Committee (ITC) to identify and recommend to EPA chemicals for priority testing. Within 12 months of an ITC recommendation, EPA must either initiate rulemaking proceedings to require testing or publish reasons for not doing so.

A "new" chemical substance is a chemical not listed in the inventory or an existing chemical for which a significant new use has been proposed. These chemicals are subject to a 90-day premanufacturing notification review by EPA. Manufacturers and importers of "new" chemicals must submit a premanufacturing notice (PMN) to EPA. The PMN requires the following information:

- common or trade name,
- chemical identity and molecular structure or the general composition of a mixture of variable composition,
- estimated production amounts,
- proposed use categories,
- methods of disposal,
- workplace exposure levels,
- description of by-products, impurities, and other related products, and
- all test data on health and environmental effects of the substance.

If during the review period EPA feels that additional testing is needed, it may refer the matter to the ITC. If there is insufficient data to make a risk assessment or if the ITC recommends further study, EPA may require testing and extend the review period 90 days.

After review of the PMN and all available data, EPA may prohibit or limit the manufacture, processing, distribution, use, or disposal of a chemical or mixture. Action under TSCA can range from a complete ban to a simple labeling requirement. If the manufacturer objects to the order, EPA can go to a Federal District Court and seek an injunction.

T.1.2 General DOE compliance

DOE projects that result in the production of a new chemical or mixture are impacted by the requirement for submitting a PMN. The PMN must undergo a 90-day review by EPA. If EPA requires additional testing or studies, DOE will have to perform the additional studies. In addition, DOE will have to comply with testing standards developed by EPA.

TSCA will also impact DOE projects that might require the use of chemicals or mixtures that are or will be limited by TSCA. If a chemical essential for a DOE project is limited by EPA, the size or productivity of the project may be limited.

T.2 REGULATIONS IMPLEMENTING TSCA

Almost all the regulations (40 CFR Part 720) implementing TSCA are in draft form at this time.² EPA estimates that most of its draft rules and guidelines will be finalized soon.² Because TSCA is so complex, there are numerous draft regulations published in the *Federal Register* (FR). The regulations may be divided into the following categories:

- premanufacturing notification,
- information gathering/inventory reporting, and
- testing.

T.2.1 Premanufacture notification

The PMN program officially began July 1, 1979. Proposed rules and notice forms for the PMN program were published in the January 10, 1979 FR. A statement of interim policy on PMN requirements and review procedures was published in the May 15, 1979 FR. Revised PMN forms were repropounded on October 16, 1979 (45-day comment period). Industries submitting PMN forms at this time should use the form published in the October 16, 1979 FR.

T.2.2 Information gathering/inventory reporting

Regulations governing the reporting and compilation of chemical substances, as required by TSCA Section 8(b), were promulgated in December 1977. The official publication date for the initial chemical inventory was June 1, 1979. A special 210-day reporting period has been added to the June 1 deadline to permit processors to review and add to the inventory.

EPA is developing a comprehensive plan for reporting and recordkeeping on chemical production, use, by-products, exposure, and disposal. These rules must first be coordinated with other EPA rules to avoid duplicating requirements. These rules are expected to be published in draft form.

By the end of 1979 or in early 1980, EPA planned to propose a model rule for requiring industries to submit relevant health and safety studies.

In July 1978, a security procedures manual was published so that contractors and federal agencies could submit confidential information to EPA.

T.2.3 Testing

Testing standards will be directed at specific characteristics and effects including oncogenicity, teratogenicity, mutagenicity, as well as environmental fate, persistence, and ecological effects. EPA plans to make these consistent with standards being established under its pesticide program.

The first standards, oncogenicity and other chronic effects, were proposed in the May 9, 1979 FR. Additional standards for acute and subchronic toxicity, mutagenicity, teratogenicity, reproductive effects, and metabolism studies were proposed on July 26, 1979. Additional health effects testing standards, as well as the first environmental testing standards, were to be proposed in early 1980.

T.2.4 Summary

During 1980, all aspects of the TSCA program were to be in operation, although not at full capacity.

Initially, more emphasis will be placed on obtaining and analyzing information than on writing specific regulations. Activities in 1980 concentrated on:

- premanufacturing notification system,
- developing testing standards and rules,
- making information systems operational,
- conducting risk assessments, and
- promulgating reporting and recordkeeping requirements.

T.3 THE SRC PROCESS AND DOE TOXICITY STUDIES

T.3.1 SRC processes (SRC-I and SRC-II)

Solvent refined coal (SRC) processes convert high sulfur and ash coal into cleaner burning gaseous, liquid, and/or solid fuels by noncatalytic hydrogenation. Hydrogenation involves direct conversion of coal to improved fuels through the addition of hydrogen to coal at elevated temperatures and pressures, with the amount of hydrogen determining the final form of the fuel — liquid (SRC-II) or solid (SRC-I). SRC-II utilizes about twice the amount of hydrogen as the SRC-I process.

SRC-I primarily produces a solid, coal-like product of less than 1% sulfur and 0.2% ash. SRC-II primarily produces a low-sulfur (0.2-0.5% by weight) fuel oil and naphtha. Both SRC-I and SRC-II also produce significant quantities of gaseous hydrocarbons that are further processed to synthetic natural gas (SNG) and liquefied petroleum gas (LPG) products.

Except for the last stages in production, the processes are essentially the same. SRC-I relies on solvent recovery and solidification functions to produce a solid fuel; SRC-II uses a fractionation function to produce a liquid fuel. Because the processes are very similar, most of the potential toxicants and carcinogens should be common.³ The SRC-II products (light, middle, and heavy distillate) are similar to the SRC-I products of light oil, wash solvent, and process solvent.⁴

At present, there is a lack of definitive data on the chemical constituents in synfuel products, including SRC. Several known or suspected carcinogens are present in products, by-products, and waste streams of synthetic fuel conversion processes. These include polynuclear aromatic hydrocarbons (PAH), naphthalenes, aromatic amines, and inorganic trace elements (selenium, boron, cadmium, lead, and antimony).¹

T.3.2 DOE toxic substances research on SRC materials

Pacific Northwest Laboratory published a report entitled *Biomedical Studies on Solvent Refined Coal (SRC-II) Liquefaction Materials: A Status Report*.⁴ This report, published in October 1979, is the most complete and reliable DOE source of information on toxicity of SRC products.

Studies on toxicity of the SRC-II products — heavy distillate (HD), middle distillate (MD), and light distillate (LD) — indicate that HD is the most toxic. Of the SRC-I products, the process solvent appears to be the most toxic. In general, results of all tests show SRC products to have variable toxicity. The results are summarized below.

1. Microbial mutagenicity appears to be caused primarily by aromatic amines. HD is mutagenically active; LD is not mutagenic.
2. Toxicity studies on monkey kidney cells indicate that both the HD of SRC-II and the process solvent of SRC-I are highly toxic and are similar in degree of toxicity.
3. Mice were used for studies of epidermal carcinogenesis. HD and LD SRC-II products were compared. High doses [approximately 20 mg per application (3 times per week)] and medium doses (2 mg per application) resulted in 100% of the mice treated with HD developing tumors within several months. A light dose of HD (0.2 mg per application) resulted in tumor growth in 6 of 48 mice. High and medium doses of LD resulted in tumors in 1 of 44 and 1 of 46 mice respectively. Light doses of LD did not cause tumor growth in any of 41 mice after 465 days. These dose studies are continuing. The majority of tumors were malignant.
4. Initial oral toxicity studies on rats indicate that SRC-I wash solvent is highly toxic, with an LD₅₀* of 0.57. The other fractions of SRC-I and SRC-II had LD₅₀ values from 2.30-3.75. (To compare, LD₅₀ of crude petroleum is >12.)
5. Developmental toxicity studies indicate that risk for a fetus is only slightly greater than for the mother.

Studies on the ecology/transport effects of SRC-II materials indicate that SRC water soluble components are 450 times more toxic than similar components in No. 6 fuel oil; phenols are the major toxic compounds of untreated wastewater; ammonia is the major toxic compound in treated wastewater.⁵

T.3.3 DOE toxicity studies planned

The following are planned to more fully define the toxic nature of SRC materials:

1. continue generation of analytical characterization data for SRC liquefaction;
2. continue comparisons of environmental effects of liquid effluents and solid wastes from SRC-II;
3. continue biomedical evaluation program;
4. provide information on chemical methods for eliminating the mutagenic hydrocarbons in SRC product;
5. validate carcinogenic activity of aromatic amines;
6. evaluate effectiveness of serum enzyme tests for early detection of health effects in workers; and
7. continue inhalation studies on animals to determine adverse health effects in worker populations.

The studies performed thus far by DOE are essential for making the risk assessment required by TSCA. Because EPA has not yet published standards and rules for testing, the studies proposed by DOE should be initiated or continued. At the time EPA publishes standards, these standards should be examined in light of the studies already done or anticipated by DOE.

T.4 SPECIFIC REQUIREMENTS FOR SRC UNDER TSCA

EPA officials indicate that the specific TSCA requirements for SRC projects can not be established completely. EPA has not decided officially if synfuels will be subject to PMN review. EPA must decide if synfuels, SRC included, are to be classed as "existing" or "new" chemicals. The issue is whether or not synfuels were manufactured and processed prior to January 1, 1975 for "commercial" purposes. The definition of commercial is vague at this time, and feelings are mixed on the issue of synfuels. EPA has formed a committee, separate from the ITC, to determine whether or not synfuels may be considered as "existing" chemicals.

* LD₅₀ is defined as the dose in grams per kilograms of body weight required to kill 50% of the animals.

TSCA also regulates waste products, by-products, and disposal of toxic substances. EPA realizes that the potential for overlap and conflict with other agency regulations, particularly RCRA, NPDES, and Clean Air, is great. The committee discussed previously may also provide EPA with guidance on how TSCA should regulate synfuels throughout the life-cycle of the materials.

If a PMN is required, the SRC-II product may be classed as a mixture of variable composition so that specific identification and analysis of each chemical component may not be necessary. DOE would be required to submit results of all tests so that EPA could make a reasonable risk assessment.

T.5 CONCLUSIONS

1. SRC-II products are generally toxic; they are definitely more toxic than conventional fuel oils as tested in microbial and cellular systems.
2. Specific TSCA requirements for SRC-II remain unknown. EPA intends to resolve the issue of how synfuels should be controlled under TSCA.
3. Studies concerning the toxic nature of SRC-II materials should continue so that a reasonable risk assessment may be made if a PMN is required.
4. No permit is required; however, after review of a PMN, EPA may limit production or require labeling of the materials. Review should be limited to 90 days.
5. The PMN review must be completed before operation begins.
6. Regarding the SRC-II Environmental Compliance Schedule, a time line reflecting compliance with TSCA need not be added at this time because the relationship of TSCA regulations to alternate fuels in general has not yet been defined by EPA. Because EPA can extend its review period by 90 days, a PMN should be submitted at least 6 months before operation begins. EPA regulations do state that early submission of a PMN is acceptable if accompanied by a statement of the fact that commercial processing of the material is a certainty.

REFERENCES FOR APPENDIX T

1. EPA, *Toxic Substances Control Act: An Overview of Its Authorities and Major Activities*, September 1979.
2. EPA, *Implementing the Toxic Substances Control Act: Where We Stand*, Nov. 1, 1979.
3. J. R. Simons, The Aerospace Corporation, *Coal Conversion and Toxic Substances*, November 1978.
4. Pacific Northwest Laboratory, *Biomedical Studies on Solvent Refined Coal (SRC-II) Liquefaction Materials: A Status Report*, October 1979.
5. OHER Program Plan for 1980 (unpublished).

Appendix U
ARCHAEOLOGY AND HISTORY





Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

DEC 1 0 1980

Heritage Conservation and
Recreation Service
U. S. Department of Interior
ATTN: Ms. Carol D. Shull
Acting Keeper of the National Register
440 G Street, N. W.
Washington, D. C. 20243

Gentlemen:

REQUESTS FOR DETERMINATIONS OF ELIGIBILITY; HISTORICAL RESOURCES AT
DOE'S SRC-II SITE, MORGANTOWN, W VA

Reference Letter: September 10, 1980, Clarence E. Moran, AIA, West
Virginia State Historic Preservation Officer to
Carol D. Shull, Acting Keeper of the National
Register(enclosed).

With reference to our earlier correspondence with you on this subject and recent discussions with members of your staff, enclosed is a report prepared by Stearns-Roger Environmental Sciences Division on behalf of the project that should address all pertinent factors to be considered in determining the eligibility of the Gingrich House and Fort Martin "One-Room" School (Community Center) for National Register listing. The Department of Energy believes that this report generally substantiates the position that both structures are eligible for listing, in concurrence with the referenced letter and opinion of the West Virginia State Historic Preservation Officer.

This letter should complete the process of our requesting determinations of eligibility initiated with my letter to you of August 12, 1980 and partially concluded with your letter of November 5, Case No. 436. Please contact us if you believe any additional information is needed for the register determinations.

I would also like to set forth DOE's proposed mitigation plans for the two properties believed to be eligible for listing, pending your determination.

1. Gingrich House

The Gingrich House and surrounding buildings will be maintained by the DOE for the life of the Demonstration Project. It is proposed that the Gingrich House be utilized as a public information center for the SRC-II Project. Such a center would provide data and media-type presentations regarding the Project and would also serve as a Visitor's Center for the plant. Some of the functions of such a center would be:

- Provide information kits about the project;
- Location of displays for the history, process, and project development of SRC-II;
- Location of artifacts or historical articles of the Fort Martin area;
- Provide orientations for tours of the plant facility;
- Space for meetings related to the Project and its future.

In addition to these public functions, the Gingrich House may be used for gatherings of research scientists, engineers, or foreign visitors. This productive use should prevent alteration of the structures and/or grounds of the Gingrich House.

In the event of successful demonstration, the SRC-II Demonstration Plant may be expanded to a commercial plant, owned and operated by a private company. As a condition of transfer of title to the property, DOE will require that the new owner continue mitigation as described above.

2. Fort Martin School

The Fort Martin School is currently used as a community center by the residents of Fort Martin. It is proposed that this function continue and also that the building be used as a meeting place for Project-related gatherings. In order to assist Project layout and reduce the maintenance expenses, the Fort Martin School would be moved from its current location onto the Gingrich property.

A parking lot would be provided for visitors to the plant and the community.

Attached is a legal description of an area that would be set aside to provide a buffer zone for the Gingrich House and Fort Martin School.

Heritage Conservation and
Recreation Service

3

Also enclosed are four documents which provide final reports of investigations into the significant archaeological sites which are within the boundaries of the proposed SRC-II Morgantown site:

1. Fort Martin, a report by Mid-Atlantic Archaeological Research, Inc.
2. Belldina's Bottom, a report by GAI Consultants, Inc.
3. Van Voorhis Farm Site, a report by Mid-Atlantic Archaeological Research, Inc.
4. The "Stone Circle" and the Garlow Farm and Mounded Area, a report by WAPORA, which concludes that Site 46-Mg-8 is indeed not a "Stone Circle".

The cordial and cooperative support provided by your staff in the development of both the historical and archaeological resource study efforts is greatly appreciated. We look forward to the formal resolution of all eligibility rulings for the properties that have been submitted for your consideration. Please contact me or Mr. James A. Reafsnnyder, Research and Development Manager for the SRC Projects, if you have any questions. He may be reached at FTS 626-2429 or Commercial 615/576-2429. Alternatively, Gabriel Marcianti may be contacted at FTS 626-0850 or Commercial 615/576-0850.

Sincerely,



John F. Pearson, Jr.
Assistant Manager for Solvent
Refined Coal Projects

MS-331:GJM

Enclosures:
As stated

Heritage Conservation and
Recreation Service

4

CC w/encs:

Mr. Clarence E. Moran, AIA
State Historic Preservation Officer
W VA Department of Culture & History
Capital Complex
Charleston, W VA 26505

Mr. Jordan Tannenbaum
Advisory Council on Historic Preservation
1522 K Street, N.W.
Washington, D. C. 20005

Mr. Ray M. Kesler, Asst. Supt.
Monongalia County Public Schools
263 Prairie Avenue
Morgantown, W VA 26505



United States Department of the Interior

HERITAGE CONSERVATION AND RECREATION SERVICE
WASHINGTON, D. C. 20243

IN REPLY REFER TO: 436

Mr. John F. Pearson, Jr.
Assistant Manager for
Solvent Refined Coal Projects
Department of Energy
P. O. Box E
Oak Ridge, Tennessee 37830

NOV 5

Dear Mr. Pearson:

Thank you for your letter requesting a determination of eligibility for inclusion in the National Register pursuant to Executive Order 11593 or the National Historic Preservation Act of 1966, as amended. Our determination appears on the enclosed material.

As you understand, your request for our professional judgment constitutes a part of the Federal planning process. We urge that this information be integrated into the National Environmental Policy Act analysis in order to bring about the best possible program decisions. This determination does not serve in any manner as a veto to uses of property, with or without Federal participation or assistance. Any decision on the property in question and the responsibility for program planning concerning such properties lie with the agency or block grant recipient after the Advisory Council on Historic Preservation has had an opportunity to comment.

We are pleased to be of assistance in the consideration of historic resources in the planning process.

Sincerely yours,

Jerry L. Rogers
Acting Keeper of the
National Register

Enclosure

07838

EO. 11593

DETERMINATION OF ELIGIBILITY NOTIFICATION
National Register of Historic Places
Heritage Conservation and Recreation Service

Project Name: Solvent Refined Coal-II, Demonstration Project

Location: Monongalia County

State: WVA

Request submitted by: DOE/John F. Pearson, Jr.

Date received: 7/28/80
8/18/80

Additional information received: 9/16/80; 9/22/80
10/30/80

36 CFR Part 13.0
Determination

Name of property	SHPO opinion	Eligibility Secretary of the Interior's opinion	Criteria
Belldina's Bottom Archeological site.	eligible	eligible	D
Van Voorhis Farm Archeological site.	"	"	D
Fort Martin Archeological site.	"	"	D

for Ray L. Bush
 Keeper of the National Register

Date: 11/5/80



Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

AUG 12 1980

Keeper of the National Register
Heritage Conservation & Recreation Service
Department of the Interior
440 G Street NW
Washington, D.C. 20243

Gentlemen:

REQUESTS FOR DETERMINATIONS OF ELIGIBILITY; HISTORICAL AND
ARCHAEOLOGICAL RESOURCES AT DOE'S SRC II SITE; MORGANTOWN,
WEST VIRGINIA

Enclosed you will find several reports describing the following
cultural resources at DOE's proposed SRC II Plant Site:

1. Belldina's Bottom Archaeological Site

Draft Report on Phase I and II Investigations by GAI
Consultants (Enclosure 1.)

2. Van Voorhis Farm Archaeological Site

Draft Report by Mid-Atlantic Archaeological Research, Inc.
(Enclosure 2)

3. Fort Martin Church, Fort Martin School and Gingrich House
Historical Sites

Draft Report of Additional Historical Data by Stearns-Roger
(Enclosure 3 -- includes photographs of Gingrich House
interior)

This letter and information supplements our submittal of July 22,
1980 relative to the Fort Martin Historical/Archaeological site and
other resources. Although these reports are considered drafts, we
believe they contain accurate information in sufficient detail for
eligibility determinations. Please note GAI's most recent weekly
report inserted in their draft report for the Belldina's Lower
Terrace.

COPY

Keeper of the Register

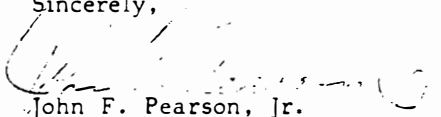
- 2 -

AUG 12 1980

Please contact us promptly if you believe any additional information is needed for the required determinations. We have provided a complete copy of this submittal to the West Virginia State Historical Preservation Officer, along with a request that he provide formal written concurrence to you as soon as possible. This should allow the Department of Interior to exercise the 10-day determination option specified under Title 36, Section 63.3.

Jake Alexander, with ORO's Environmental Protection Branch, should be contacted if you have questions or need additional information regarding these matters, at FTS 626-0849, or commercial: Area Code 615/576-0849. We appreciate your cooperation in helping us to resolve any potential conflicts between the SRC 11 project and these important cultural resources.

Sincerely,

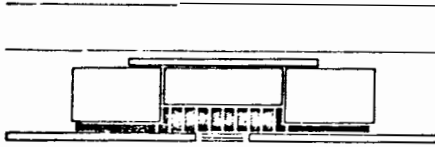


John F. Pearson, Jr.
Assistant Manager for
Solvent Refined Coal Projects

MS-331:JKA

Enclosures

CC:
Clarence Moran, WV/SHPO, Charleston
Mr. Tannebaum, Advisory Council
on Historical Preservation, DC



DEPARTMENT OF CULTURE AND HISTORY

STATE OF WEST VIRGINIA

JOHN D. ROCKEFELLER IV, GOVERNOR

Norman L. Fagan, Commissioner

HISTORIC PRESERVATION UNIT Clarence E. Moran, AIA, Director

August 8, 1980

Ms. Carol D. Shull
Acting Keeper of the National Register
HCRS, Dept. of the Interior
440 G. St., N.W.
Washington, D.C. 20243

Re: Determination of Eligibility
Fort Martin site
Monongalia County, WV

Dear Ms. Shull:

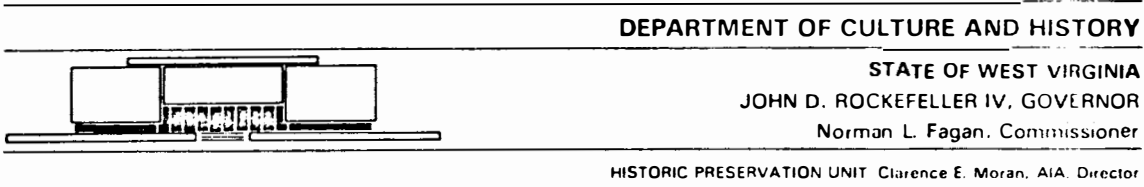
Please refer to the letter dated July 22, 1980 from J. F. Pearson, Jr., Oak Ridge Operations, Department of Energy, to you, and the report "Archaeological Investigations at Fort Martin" by Payne and Cogar, July 1980. In my opinion the Fort Martin property reported on is eligible for inclusion in the National Register.

Sincerely,

Clarence E. Moran, AIA
State Historic Preservation Officer

cc: James K. Alexander

CEM/jfk;rw



September 10, 1980

Mrs. Carol D. Shull
Acting Keeper of the National Register
HCRS, Department of the Interior
440 G Street, N.W.
Washington, D.C. 20243

RE: Determination of Eligibility
Van Voorhis Farm (46 Mg 77),
Belldina's Bottom (46 Mg 75),
Gingrich House, Fort Martin School
and Fort Martin Church

Dear Ms. Carol:

Please refer to the letter dated August 12, 1980 from J.F. Pearson, Jr., Oak Ridge Operations, Department of Energy, to you, and the reports "Draft Reports on Phase I and Phase II Archeological Investigation at Site 46 Mg 75 (Belldina's Bottom)", "Van Voorhis Farm Site (46 Mg 77) Archeological Investigation", and "Additional Historical Data". In our opinion, Van Voorhis Farm, Belldina's Bottom, and the Gingrich House as described are eligible for inclusion in the National Register; we do not believe the Fort Martin Church is eligible. In regard to the Fort Martin School, we have no opinion at this time, pending more data on other one-room schools, in Monongalia County that are extant.

Sincerely,

Clarence E. Moran, AIA
State Historic Preservation Officer

CEM/kfs;rw



Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

JUL 22 1980

Keeper of the National Register
Heritage Conservation and Recreation Service
Department of the Interior
440 G Street N.W.
Washington, D.C. 20243

Gentlemen:

REQUEST FOR DETERMINATION OF ELIGIBILITY; FORT MARTIN
HISTORICAL AND ARCHAEOLOGICAL SITE AT DOE'S SRC II PLANT;
MORGANTOWN, WEST VIRGINIA

Enclosed is a relatively thorough report on the archaeological investigations recently concluded at the historic Fort Martin Site located on DOE's proposed SRC II Plant reservation near Morgantown, West Virginia (Enclosure 1.).

DOE has concluded that several determinations of eligibility, and other considerations as may be determined, prescribed by the National Historic Preservation Act of 1966 and Executive Order 11593 will be necessary for the SRC II project to proceed at the Morgantown site. We believe the Mid-Atlantic report provides adequate documentation for the eligibility determination for Fort Martin. By providing a copy of this letter and enclosures to the West Virginia State Historical Preservation Officer, we are requesting his formal concurrence that the Fort Martin site is eligible. We are hopeful that the Department of Interior can exercise the 10-day determination option under Section 63.3 of Title 36, allowed when the project agency and the SHPO are in substantive agreement relative to eligibility.

Although complete information to support other eligibility determinations is not available at this time, DOE expects to submit requests for rulings on two other significant archaeological sites, and at least three buildings that may have some cultural or historical

R. Fide

Keeper of the
National Register/DOE-DC

- 2 -

JUL 22 1980

significance. A preliminary plant layout map is Enclosure 2. to this letter; pointing out the locations of all the potentially eligible properties that were identified by the Environmental Impact Statement reconnaissance surveys. These preliminary findings were as follows:

Historical Properties

1. The Maple Place
2. Fort Martin Church
3. John Garlow Farm House
4. Gingrich House
5. Fort Martin School

Archaeological Properties

1. Belldina's Bottoms (upper and lower terrace)
2. Fort Martin
3. Fort Harrison
4. Garlow Farm
5. Ridgetop Mound
6. Van Voorhis Farm
7. Stone Circle

The Maple Place, Fort Harrison, and the Ridgetop Mound appear to be so remote from any planned project activity in the near-term that these properties should not be significantly affected. Hence,

Keeper of the
National Register/DOE-DC

- 3 -

JUL 22 1980

a determination of eligibility is not needed at this time. Consultation with the State Historical Preservation Officer concluded that, unless additional information might indicate some significant historic import, the Garlow Farm House probably is not a significant property from the architectural standpoint alone. We are not aware of any additional historic records not already considered that might yield any further information about the Garlow Farm complex. The preliminary archaeological surveys of the Garlow Farm and the Stone Circle sites did not result in any significant findings.

Within a week or so, we hope to submit the preliminary archaeological survey reports for the very important discoveries at the Belldina lower terrace location, and for several prehistoric activity sites found on the Van Voorhis Farm. Based on our discussions with our archaeological consultants, there is little doubt that both these sites will be eligible for the National Register.

The three buildings that we anticipate will need eligibility determinations are highly uncertain relative to the Department of Interior's criteria and guidelines. Your attention is directed to Enclosure 3. of this letter, that provides some preliminary information and photographs of the Gingrich House, the Fort Martin School and the Fort Martin Church; and to the Draft Environmental Impact Statement for SRC II, Section 3.2.4.5. and Appendix U. (Enclosure 4.). We have been advised that a more detailed historical investigation is needed to properly document an eligibility determination for these properties; and we are currently seeking the services of an historical consultant familiar with this area of West Virginia to accomplish this task. However, we request that you review the information we have provided on these properties to determine if enough information might be available to support a determination, particularly a finding that the properties are not eligible.

Based on recent discussions with members of your staff, the staff to the Advisory Council on Historic Preservation, and personnel with the West Virginia Department of Culture and History; we have concluded that, despite some relatively complex matters to be resolved regarding mitigation of potential adverse impacts, there do not appear to be any serious impediments to the substantive

Keeper of the
National Register/DOT -DC

- 4 -

JUL 22 1980

resolution of all issues of concern for inclusion in the Final Environmental Impact Statement for SRC II, or to otherwise impede the SRC II project schedule as currently planned. We appreciate the cooperation your staff has extended to us in consideration of these matters.

If you have questions or need additional information, please contact Jake Alexander of ORO's Environmental Protection Branch, FTS 626-0849, or commercial Area Code 615/576-0849; or James A. Reafsnyder, Research and Development Manager for the SRC projects, FTS 626-2429, or commercial Area Code 615/576-2429.

Sincerely,



J. F. Pearson, Jr.
Assistant Manager for
Solvent Refined Coal Projects

MS-331:JKA

Enclosures

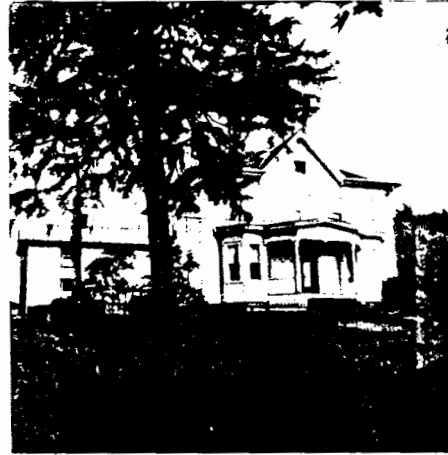
CC w/encls:
Mr. Clarence Moran, WV/SHPO

JUL 22 1980

1. Gingrich House

The Gingrich House and the associated complex of buildings attests to the substantial prosperity attainable by the Fort Martin farming residents of the late nineteenth century. The house is an eclectic mixture of Victorian-era elements. The mansard-roofed center tower is the most outstanding feature and is a statement of strong vernacular interpretation in architecture. The building is in excellent condition.

The house is located on the east side of Fort Martin Road (State Route 53), 0.95 miles south of the Pennsylvania/West Virginia border, Rural Route 1, Box 109, Maidsville, West Virginia, Zip Code 26541. The house and all surrounding property will be owned by the Department of Energy during the Demonstration Phase of the SRC II project.



GINGRICH HOUSE

JUL 22 1980

2. Fort Martin School

The present Fort Martin School was built in 1898 at a cost of \$590, and utilizes the foundation of an earlier subscription school that predated the establishment of the County School System in 1863. Grades 1 through 8 attended this one room school until the early 1940's, and Grades 1 through 6 attended until the school closed in the mid-1960's. The building is now used by the Monongalia County School System as a community meeting place.

The architecture is of the "one-room-schoolhouse" vernacular and is a rare specimen of this rapidly vanishing cultural style. The building will remain the property of the County through the Demonstration Phase of the SRC II project. It is located on the west side of Fort Martin Road (State Route 53) 1.08 miles south of the Pennsylvania/West Virginia border.

FORT MARTIN SCHOOL

JUL 22 1980

3. Fort Martin Church

The present church was built in 1910 and is the third building of this congregation which was founded in 1778-1784, making it one of the earliest formal religious organizations west of the Alleghany. The renowned Methodist itinerant bishop, Francis Asbury, met with the Fort Martin congregation on several occasions and recorded these meetings in his journal. This building and the School create the essence of the Fort Martin community. While the building itself is not outstanding architecturally, the use of brick for construction is found in only one other building in the area.

The church is located on the east side of Fort Martin Road (State Route 53) 0.57 miles south of the Pennsylvania/West Virginia border. The church and grounds will remain the property of the church trustees during the Demonstration Phase of the Project.



FORT MARTIN CHURCH

Advisory
Council On
Historic
Preservation

DRAFT

1522 K Street NW.
Washington D.C.
20005

MEMORANDUM OF AGREEMENT

WHEREAS, the Department of Energy (DOE) proposes to build and operate a Solvent Refined Coal (SRC-II) demonstration plant on the Monongahela River at Fort Martin, Monongalia County, West Virginia; and,

WHEREAS, the Department of Energy, in consultation with the West Virginia State Historic Preservation Officer (SHPO), has determined that this undertaking as proposed would have an adverse effect upon Beldina's Bottom Archeological Site, the Fort Martin Archeological Site, the Van Voorhis Farm Archeological Site, the Gingrich House, and the Fort Martin School/Community Center, properties eligible for the National Register of Historic Places; and,

WHEREAS, pursuant to Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. Sec. 470f, as amended, 90 Stat. 1320) and Section 800.4(d) of the regulations of the Advisory Council on Historic Preservation (Council), "Protection of Historic and Cultural Properties" (36 CFR Part 800), DOE has requested the comments of the Council; and,

WHEREAS, pursuant to Section 800.6 of the Council's regulations, representatives of the Council, DOE, and the West Virginia SHPO have consulted and reviewed the undertaking to consider feasible and prudent alternatives to avoid or satisfactorily mitigate the adverse effect; and,

WHEREAS, Solvent Refined Coal International, ^{Inc.} was invited and participated in the consultation process;

NOW, THEREFORE, it is mutually agreed that the undertaking will be implemented in accordance with the following stipulations to satisfactorily mitigate adverse effects on the above -mentioned properties.

Stipulations**DRAFT²**

DOE will ensure that the following measures are carried out.

A. Archeology

1. Prior to initiation of any construction activities which could affect the archeological sites, a data recovery program for the Beldina's Bottom (46 Mg 75), Van Voorhis Farm (46 Mg 77), and Fort Martin (46 Mg 72) archeological sites will be developed and carried out in accordance with the Council's "Recommendations for Archeological Data Recovery Programs" (Archeological Recommendations)(Attachment 1).
2. Data recovery plans for the three archeological sites will developed consistent with the Council's Archeological Recommendations. Before implementing the plans, DOE will submit them to the Council and the West Virginia SHPO for review in accordance with the Executive Director's "Policy for Review of Proposals for Archeological Data Recovery" (Attachment 2). Should neither the Council nor the West Virginia SHPO object within 30 days after receipt of the plans, DOE will ensure that the plans are implemented; if either party objects, DOE will consult with the West Virginia SHPO and the Council in an effort to resolve the objections.
3. All archeological work called for in Stipulations 1 and 2 above will be conducted under the direct supervision of an archeologist or archeologists who meet, at a minimum, the appropriate qualifications set forth in 36 CFR Part 1210 (formerly 36 CFR Part 66), Appendix C (Attachment 3), and who have appropriate knowledge and experience in relevant prehistoric or historic archeological work.
4. All archeological materials, along with field notes, maps, drawings, and photographic records, will be curated at a suitable repository agreed upon by the West Virginia SHPO and DOE. Material recovered under this Agreement and not initially stored within the State of West Virginia may be recalled for curation within the State of West Virginia at such time as adequate facilities are made available. DOE will have access to all archeological materials recovered as part of this project for public display purposes, and will ensure that all such materials are made available for future research by qualified scholars and students.
5. Copies of the final reports of archeological data recovery will be supplied to the West Virginia SHPO and the Council. A brief, non-technical account of the results of the archeological work will be provided to DOE and Solvent Refined Coal International, Inc., for local public dissemination at the plant information center. In addition, a copy of any final technical report will be furnished to Interagency Archeological Services (Heritage Conservation and Recreation Service, Department of the Interior, Washington, D. C. 20243),

DRAFT³

for possible submission to the National Technical Information Service (NTIS). Any precise locational data should appear in a separate appendix and may be withheld from NTIS publication pursuant to Section 11 of the General Authorities Act of 1970, as amended (P.L. 94-458).

B. Historic Structures

1. DOE will relocate the Fort Martin School/Community Center from its present location to a location agreed upon by the West Virginia SHPO and DOE.
2. Prior to moving the Fort Martin School/Community Center, DOE will ensure that it is properly recorded so that there will be a permanent record of its existence at that location. DOE will first contact the National Architectural and Engineering Record (NAER) (Heritage Conservation and Recreation Service, Department of the Interior, Washington, D.C. 20243, 202-343-6217) to determine the level of documentation required. All documentation must be accepted by NAER before the relocation.
3. Prior to the building's relocation, the SHPO will be given an opportunity to review and concur in the site to which the building will be moved and the procedures by which the move will be accomplished.
4. Within 30 days after the relocation of the School/Community Center, DOE will provide the SHPO with any documentation he may require concerning the condition of the building on its new site so that the SHPO may notify the National Register of the status of the property.
5. The SHPO will, within 90 days after the relocation of the School/Community Center, notify the National Register of the relocation and provide the Register with his opinion, and supporting documentation, on whether the property is still eligible for the National Register.
6. The Gingrich House will be adapted for reuse by DOE in its present location. Any renovation, alteration, or rehabilitation of the Gingrich House will be undertaken in accordance with the Secretary of the Interior's "Standards for Rehabilitation" (Standards)(Attachment 4). Application of the Standards will be done in consultation with the West Virginia SHPO.
7. If the work to be done cannot be carried out in accordance with the Standards, the plans for the Gingrich House will be submitted, at the design development stage, to the West Virginia SHPO for review and comment. If, after review of the plans, the West Virginia SHPO is of the opinion that the reuse will adversely affect the Gingrich

DRAFT ⁴

House, DOE will request the further comments of the Council in accordance with Section 800.4 (d) of the Council's regulations, and take no further action until the comments of the Council have been obtained.

8. DOE will ensure that the Fort Martin School/Community Center and the Gingrich House are preserved and maintained in accordance with the Secretary's Standards. Any future sale or transfer of the property containing the Gingrich House and/or the Fort Martin School/Community Center will include preservation covenants (Attachment 5) providing for the continued preservation and maintenance of the properties as a condition of the sale or transfer.

C. Additional Stipulations

1. Failure to carry out the terms of the Agreement requires that DOE again request the Council's comments in accordance with 36 CFR Part 800. If DOE cannot carry out the terms of the Agreement, it shall not take or sanction any action or make any irreversible commitment that would result in an adverse effect with respect to National Register or eligible properties covered by the Agreement or would foreclose the Council's consideration of modifications or alternatives to the SRC-II Plant and associated facilities that could avoid or mitigate the adverse effect until the commenting process has been completed.
2. In accordance with National Register Procedures (36 CFR Part 1202), DOE will forward documentation concerning the condition and significance of all listed or eligible sites to the Keeper of the National Register within two years following the completion of data recovery or alterations so that nominations, boundary changes, or eligibility status will be kept current.
3. If any of the signatories to this Agreement determine that the terms of the Agreement cannot be met or believes a change is necessary, that signatory shall immediately request the consulting parties to consider an amendment or addendum to the Agreement. Such an amendment or addendum shall be executed in the same manner as the original Agreement.
4. Within 90 days after carrying out the terms of the Agreement, DOE shall provide a written report to all signatories to the Agreement on the actions taken to fulfill the terms of the Agreement.

(date)
West Virginia SHPO

(date)
Executive Director, ACHP

(date)
Chairman, ACHP

(date)
Department of Energy

ATTACHMENT 1

PART III
RECOMMENDATIONS FOR ARCHEOLOGICAL DATA RECOVERY

The following recommendations are for agency consideration in developing archeological data recovery operations. They are not mandatory under the authority of the National Historic Preservation Act and 36 CFR Part 800, but full consideration of them will facilitate the consultation process. They are designed to be consistent with the standards of the Department of the Interior, issued pursuant to the Archeological and Historic Preservation Act of 1974 (P.L. 93-291), and embodied in 36 CFR Part 1210.3.

I. Identification

1. Data recovery operations should be based on an adequate understanding of the range of archeological properties subject to adverse effect, and their importance and nature relative to other such properties. Accordingly, plans for data recovery should be based on an adequate identification effort.
2. Identification studies should be conducted in a manner consistent with 36 CFR Part 1210, Appendix B, and with the recommendations of the State Historic Preservation Officer. If standards and guidelines for identification have been adopted as part of the State Historic Preservation Plan, the identification effort should be consistent with them.
3. Agencies should use "The Archeological Survey: Methods and Uses" (GPO Stock No. 024-016-0091-9), "Guidelines for Local Surveys: A Basis for Preservation Planning" (GPO Stock No. 024-016-00089-7), and relevant State, regional, and local literature for general guidelines.

II. Qualified Supervision

1. Data recovery operations should be conducted under the supervision of qualified professionals in the disciplines appropriate to the data that are to be recovered. Minimum qualifications commonly required for professionals are set forth in 36 CFR Part 1210, Appendix C. For supervision of most projects, Appendix C qualifications should be taken as a minimum. The agency should develop additional qualifications for supervision of the particular project.

In some cases, it may be appropriate to select a supervisor whose qualifications differ from those given in 36 CFR Part 1210, Appendix C. In such cases, the qualifications should be specified by the agency in project documents, together with the rationale for their selection.

2. A data recovery operation should be directed by a Principal Investigator, whose background and performance demonstrates:
 - A. an understanding of the research value of the property, as specified in location and identification studies,

documentation for determination of eligibility or nomination to the National Register, and/or other relevant documents;

- B. familiarity with previous relevant research, including research in the vicinity of the proposed undertaking and research on topics germane to the data recovery program regardless of where such research has been carried out;
- C. competence to address research problems pertinent to the data to be recovered, taking into account the identified research value of the property and other relevant research and general theory in the social and natural sciences and humanities.
- D. responsiveness to the need to recover a usable sample of data on the major research problems that reflect the property's research value, and a sensitivity to other valuable research problems that may become apparent during the project.
- E. competence in the methods and techniques necessary to recover the pertinent data contained in the property, or in supervising staff or consultants with such competence.

III. Relation to State Historic Preservation Plan and Other Plans

- 1. Where a State Historic Preservation Plan, developed by the State Historic Preservation Officer and approved by the Secretary of the Interior, details approved methods for data recovery from archeological properties, agency data recovery programs should take these methods into account.
- 2. Where regional or local plans, developed by the SHPO, professional organizations, local government, or others detail recommended methods for data recovery from archeological properties, agency data recovery programs should take these methods into account.

IV. Data Recovery Plan

- 1. Every data recovery operation should be conducted in accordance with a data recovery plan. The plan should be designed to ensure that the operation addresses legitimate research questions, that it produces useful results, that it is conducted efficiently, and that it produces the maximum direct and indirect benefit to the public for the least cost. Generally speaking, a data recovery plan should include the following elements:
 - A. Specification of properties to be studied and not studied within the environmental impact area of the undertaking. A rationale should be provided if it is proposed not to study any property included in or eligible for inclusion in the National Register that is subject to adverse effect.
 - B. Development of research questions, those questions of scientific or humanistic concern which are expected to be answered,

partially answered, or at least elucidated through the work proposed, such as

- (1) questions of recognizable importance to science (cf. Appendix A), and
- (2) questions of humanistic interest, or interest to a local community, or of defined local historical value (cf. Appendix B).

In most areas of the United States, enough is known of history and prehistory to establish at least some basic research questions. Therefore, a plan that proposes data recovery because "little is known of the history or prehistory of the area," without setting forth more explicit research questions, should be treated with caution. Such undirected plans provide little basis for conducting research, may result only in the accumulation of useless, trivial, or repetitive information, and are sometimes only masks for the ignorance of the parties preparing the plan. There are, of course, some areas, and some time periods in history and prehistory, for which this is not the case.

- C. Establishment of study topics, springing from the research questions. These are the specific topics to be addressed in the study area. For example, if the research question is: "Why was agriculture adopted?" a study topic might be: "When, and in what cultural context, did agriculture appear in the study area?"
 - D. Establishment of study priorities. It is not necessary, and is often counterproductive, to give the same level of effort to all study topics. The plan should consider all study topics but should establish and justify priorities for their investigation.
 - E. Definition of data needs. The plans should identify the data needed to address each topic selected for study.
 - F. Description of methods to be employed in fieldwork and analysis, in seeking the needed data. Methods should be justified in terms of the data sought or expected, but with recognition of the fact that unexpected important data may emerge during fieldwork or analysis and need to be addressed. As a rule, the fastest, least expensive available methods should be used, provided they are effective in recovering the data sought or expected, and provided they do not destroy properties or data that otherwise could be preserved in place.
2. The data recovery plan should be developed and reviewed by the agency, the SHPO, and where needed, the Council, Interagency Archeological Services, and others, before data recovery operations are begun.

V. Staff, facilities, equipment, and consultants

1. A data recovery program should provide for adequate personnel, facilities, and equipment to fully implement the data recovery plan.
2. A data recovery program should provide for adequate consultation with scholars whose research interests would enable them to contribute to the program.

VI. Methods: Basic Standards

1. Regardless of the research topics being addressed, a data recovery program should employ methods that will ensure full, clear, and accurate descriptions of all field operations and observations. For example, excavation techniques, recording methods, stratigraphic and associational relationships, environmental relationships, and analytic techniques should be described, insofar as is feasible, in such a way as to allow future researchers to reconstruct what was done, what was observed, and why.
2. To the extent feasible, the methods should take into account the possibility that future researchers will need to use the recovered data to address problems, not recognized at the time the data were recovered.
3. If portions or elements of the property under investigation can be preserved in place, the data recovery program should employ methods that will leave those portions or elements of the property in place. Destructive methods should not be applied to such portions or elements if nondestructive methods are practical.
4. Where architectural characteristics are recorded, such recording should be consistent with the standards published by the National Architectural and Engineering Record (NAER). Updated guidelines for recording architectural and engineering data may be obtained from the Director, Heritage Conservation and Recreation Service, or Executive Order Consultant for NAER.
5. To the extent feasible within the data recovery plan, data should be recorded in a manner compatible with those systems utilized by the State Historic Preservation Officer and by State and Federal agencies that store and utilize archeological data, so that they can have maximum applicability to future studies and planning efforts.
6. The data recovery program should include both field operations and post-fieldword analysis sufficient to address the research topics.

VII. Public Participation

1. To the extent feasible, a data recovery program should provide for public participation, through arrangements for public inspection of the work in progress, the use of volunteers, cooperation with local educational programs, etc.
2. A data recovery program should provide a means by which the public can be informed of the program and its results, before, during, and/or at the conclusion of the program.

VIII. Cost Minimization

1. In developing a data recovery program, agencies should consider methods to minimize costs. Examples of cost minimization methods include:
 - A. investment in full pre-fieldwork analysis of pertinent available data, to avoid spending time and money in the field gathering data to answer questions that are already answerable;
 - B. sharing of personnel and facilities among projects and agencies;
 - C. use of volunteers and trainees under appropriate supervision;
 - D. appropriate use of mechanized equipment and advanced technology (Experimentation with potentially cost-efficient methods of discovery, recovery, and processing of data is encouraged), and
 - E. use of methods to avoid late or accidental discoveries that could cause costly construction delays. (For example, where construction will destroy an archeological site, the last stage of data recovery should be to destroy the site under archeological supervision before construction begins).
2. Seeking to minimize costs by selecting contractors on the basis of bid is generally not encouraged; experience shows that this practice tends to produce substandard results. However, in cases where detailed data recovery plans have been developed in advance of soliciting proposals, and sufficient control is exercised to ensure receipt of technically comparable proposals, an agency might find this practice useful. Agencies should consider 36 CFR Part 1210, Appendix D, when preparing to procure services for data recovery operations.

IX. Reports and data management

1. In order for recovered data to be useful, they must be made available to scholars and planners in usable forms. Generally speaking, the following products (other than physical specimens) are expected from a data recovery operation:

- A. a report or reports that describes the operation and its results, with reference to the research topics addressed by the operation;
 - B. digested data in the form of tables, charts, graphs, computer software, etc.;
 - C. raw data in the form of field notes, photographs, magnetic tapes, etc.; and,
 - D. scholarly and other articles utilizing the results of the work for analytic or public-interpretive purposes.
2. All data recovery projects should result in a report or reports containing the reasons for the project, the data recovery plan, the methods employed in both field work and analysis, the data recovered, observations made, insights gained, and a presentation of pertinent data. The report should meet contemporary professional standards, and should be prepared in accordance with the format standards set forth in 36 CFR Part 1210, Appendix A.

Provision should be made for disseminating the report. At a minimum, two copies of the report must be provided to the Department of the Interior pursuant to P.L. 93-291, Section 3(a), and 36 CFR Part 1210.5. In addition, agencies are encouraged to disseminate reports to the widest possible audience. Appropriate methods of dissemination include, but are not limited to, publication in scholarly journals, monographs, popular articles, books, and the National Technical Information Service, and presentation of papers at scholarly Conference. Agencies should provide a copy of each report to the State Historic Preservation Officer and other appropriate archives and research libraries.

- 3. Digested data should be stored in a manner that makes them readily retrievable for further study and analysis. Use of modern systems of information storage and retrieval is encouraged. Such systems should be as compatible as possible with those used by the SHPO and other agencies and institutions with potential uses for the data.
- 4. Raw data should be stored in a manner that ensures their long-term maintenance and availability, usually in an appropriate research institution (cf. 36 CFR Sec. 1210.4).
- 5. Although agencies are not necessarily responsible for developing or supporting the development of scholarly analytic articles, beyond those embodied in the report(s) on each data recovery operation itself, use of recovered data for such purposes should be encouraged.

X. Curation of Specimens

- 1. A data recovery program should include provision for curation (care, maintenance, and where applicable, disposition) of recovered

specimens. In developing such provisions, the agency should give due consideration to the standards set forth in 36 CFR Sec. 1210.4, and recognize any competing public and private interests.

2. In general, acceptable curation arrangements may include, but are not necessarily limited to:
 - A. permanent storage at a regional research center or appropriate public or private repository meeting the standards set forth at 36 CFR Sec. 1210.4(a)(1), provided reasonable access is guaranteed for future study;
 - B. return to private owners where private property rights so require, after description, study, and analysis in accordance with the data recovery plan are complete;
 - C. loan or lease to public or private parties, after description, study, and analysis in accordance with the data recovery plan are complete, provided access for future study and proper care of the specimens can be expected, and
 - D. return of specimens having religious or cultural significance to practitioners of the religion or cultural institutions in question, after description, study, and analysis in accordance with the data recovery plan are complete.
3. Curation of human remains (skeletons, mummified bodies and body parts, etc.), requires careful balancing of the needs of science and a sensitivity to the concerns of genetic and cultural descendants of the dead. Where a demonstrable ethnic affinity exists between recovered human remains and living groups, all reasonable efforts should be made to seek out and consult with appropriate representatives of such groups to define acceptable methods of treatment. Where recovery of human remains is expected, prior consultation with such groups, and with cultural anthropologists or others capable of serving as sensitive intermediaries where needed, is strongly recommended. If reinterment, cremation, or other disposal is requested that will place the human remains out of the reach of future scientists, documentation of the remains in consultation with specialists in physical anthropology and other pertinent fields should be completed before disposal. Where no association can be determined between recovered human remains and living groups, the remains should be documented in accordance with the data recovery plan, and curated in a manner appropriate to the dignity and respect befitting any deceased person.

XI. Budgeting

1. At an appropriate stage in the process of developing a data recovery plan or procuring the necessary contractors or staff to execute it, the agency should develop or obtain a detailed budget, and subject it to careful analysis. Line items should refer clearly to elements of the data recovery plan, and should be justified. For example, if technical consultants are budgeted

for, they should be those required to recover and analyze the data that are needed to address the research topics. Estimates of man-hours required for supervision, administration, fieldwork, analysis, specialist consultation, and other activities should be developed, together with fee schedules for the various types of personnel required. Time and fee schedules should be realistic in terms of project needs and local conditions. To minimize the danger of establishing budgetary "targets" not based on actual needs, the budget should be prepared without reference to the 1% limitation imposed by Sec. 7(a) of Public Law 93-291 on data recovery funds transferred to the Secretary of the Interior. Should the budget for a project to which Sec. 7(a) applies exceed 1% of the total cost of the undertaking, the Council will assist the agency as possible during the consultation process to find ways to reduce costs or to obtain additional funding.

2. Sufficient funds to support the data recovery program should be clearly identified by the agency. Should there be any uncertainty about the availability of funds, this should be revealed to the Council and SHPO so it can be taken into account during the consultation process. If the agency anticipates that the Secretary of the Interior will fund the program under the authority of Sec. 3(b), Sec. 4(a), or Sec. 7(c) of Public Law 93-291, the agency should document to the Council and the SHPO that the Secretary is aware of and has accepted this responsibility.

XII. Treatment of non-archeological concerns

1. A data recovery program should relate positively to non-archeological concerns with the area and its archeological properties. Such concerns include, but are not limited to:
 - A. Religious and other cultural concerns of Native Americans and/or other descendants of the historic and prehistoric people of the study area;
 - B. The interests of local communities or other groups in the history of the area;
 - C. The educational interests of local museums, academic institutions, etc.;
 - D. The interests of private property owners in maintaining the integrity of their property rights;
 - E. Any architectural, artistic, or aesthetic values that may be present in the property;
 - F. Any paleontological, geological, or related values that may be present in the property; and
 - G. The environmental integrity of the property and its environs.

XIII. Flexibility

1. Situations may arise or data may be encountered that were not anticipated in designing a data recovery program, particularly when it is conducted on a potentially complex property (e.g., a recent town site; a prehistoric site that may contain many occupation layers, cemeteries, or architectural remains). Adequate provision should be made for modification of the program to cope with unforeseen discoveries or other unexpected circumstances.
2. Innovative approaches to data recovery, which are constantly being developed, should be encouraged as long as the basic purposes of data recovery to preserve significant information are addressed.

ATTACHMENT 2

SUPPLEMENTARY GUIDANCE
EXECUTIVE DIRECTOR'S PROCEDURES FOR REVIEW OF PROPOSALS
FOR TREATMENT OF ARCHEOLOGICAL PROPERTIES

I. Introduction

Under the authority of 36 CFR Sec. 800.14, the Executive Director of the Advisory Council on Historic Preservation issues the following supplementary guidance, to interpret elements of the Council's regulations to assist Federal agencies and State Historic Preservation Officers in meeting their responsibilities.

The following procedures will be used by the Executive Director of the Advisory Council on Historic Preservation in review of projects involving treatment of archeological properties. They are based on the Council's "Principles in the Treatment of Archeological Properties" (Appendix A). They do not amend or modify the duties of Federal agencies under Section 106 of the National Historic Preservation Act and the implementing regulations (36 CFR Part 800), but agency cognizance of them will make consultation under the regulations easier.

Archeological properties are those properties included in, eligible for, or potentially eligible for, the National Register, whose significance lies wholly or partly in the archeological data they contain. Archeological data are data embodied in material remains (artifacts, structures, refuse, etc.) utilized purposely or accidentally by human beings, in the spatial relationship among such remains, and in the environmental context of such remains. Archeological data include historic, prehistoric, and scientific data as defined by the Department of the Interior in accordance with Public Law 93-291 (cf. 36 CFR Part 1210).

An expanded version of this guidance, including detailed recommendations for agency use and several explanatory appendices, is available from the Executive Director under the title, "Treatment of Archeological Properties."

II. Identification of Archeological Properties

1. 36 CFR Sec. 800.4 establishes that "it is the primary responsibility of each Agency Official requesting Council comments to conduct the appropriate studies and to provide the information necessary for an adequate review of the effect a proposed undertaking may have on a National Register or eligible property, as well as the information necessary for adequate consideration of modifications or alterations to the proposed undertaking that could avoid, mitigate, or minimize any adverse effects. It is the responsibility of each Agency Official requesting consultation with a SHPO under this section to provide the information that is necessary to make an informed and reasonable evaluation of whether a property meets National Register criteria and to determine the effect of a proposed undertaking on a National Register or eligible property." Identification is the obvious first step to be taken by an Agency in defining its responsibilities with respect to archeological and other historic properties.

In evaluation of proposals for treatment of archeological properties, the Executive Director may review field surveys and other identification efforts

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that have been conducted as part of the Agency's planning process, to determine whether:

- A. the identification effort appears to be consistent with the scale and expected impacts of the proposed project;
- B. the identification effort appears to be conducted at a sufficient level of intensity in relation to the numbers and types of archeological properties expected to occur in the areas; and,
- C. the data recovery proposal submitted for Council consideration appears consistent with the results of the identification effort.

2. The Executive Director will use 36 CFR Part 1210, Appendix B, as a general standard for reviewing identification efforts.

3. The Executive Director will encourage recognition of the difference between "testing" archeological sites for identification and evaluation and excavating them for purposes of data recovery. Testing is usually conducted in order to answer questions about an archeological site's eligibility for the National Register, or to obtain data needed to make decisions about how to mitigate project impacts on a site already determined eligible or placed on the Register. Such testing is directed toward determining the site's boundaries, the depth of its deposits, and/or its basic nature and condition. Only a very small sample of the site need be disturbed in order to make such determinations. Excavation for data recovery, on the other hand, is directed toward recovering as much of the important information in the site as possible, given time and other constraints. Unlike testing, excavation for data recovery is seldom simply directed at defining the size, depth, nature and condition of the site; it is directed at answering or contributing to research questions. Excavation for data recovery may result in very extensive--even complete--disturbance of a site. While it is impossible to define a point, applicable in all instances, at which testing ends and data recovery begins, a rule of thumb is that testing is completed when sufficient information has been gathered to make a determination of eligibility or a management decision. Since testing is done, in most cases, before the fate of the site has been determined through the consultation process, it should be kept to the absolute minimum necessary for eligibility determination and/or management purposes. "Testing" that destroys large portions of a site forecloses the Council's opportunity to comment, and circumvents the intent of Section 106. The Executive Director will discourage such "testing," and will notify the Secretary of the Interior, pursuant to P.L. 93-291 Sec.4(a), in instances where such "testing" threatens the irrevocable loss of scientific, prehistoric, historic, or archeological data.

III. Consideration of In-Place Preservation

In review of projects involving archeological properties, the Executive Director will seek to ensure that all due consideration is given to practical methods of preserving such properties in place.

IV. Consideration of Non-archeological interests

In review of projects involving archeological properties, the Executive Director will seek to ensure that all due consideration is given to whatever non-archeological historical and cultural values the properties may represent. For example, if an archeological property is also valuable to a local community for cultural reasons, the Executive Director will seek to ensure that this value is considered and given appropriate weight in decisionmaking.

V. Data Recovery Directed to Research Questions

Where it is concluded through the consultation process that preservation in place is not practical, and that data recovery is appropriate, the Executive Director will seek to ensure that the data recovery effort addresses defined and defensible research questions. Such questions should relate to issues of importance in the sciences or humanities, or to matters of importance to local communities with historical connections to the property or properties. It is expected, however, that the specificity of research questions, and their relationship to larger issues, will vary with the character and quality of prior archeological work in the area, the state of existing knowledge of the property, the nature of local, regional, and topical research efforts pertinent to the property, and the quality of the State Historic Preservation Plan in force in the state at the time the project is undertaken.

VI. Sacrifice of properties without data recovery

Where an archeological property cannot practically be preserved in place, and the responsible agency proposes to destroy or damage it without data recovery, the Executive Director will seek to ensure that all reasonable consideration has been and is given to the property's potential to yield information relevant to important research questions. The Executive Director will not support or sanction the recovery of data simply because they exist, nor will the Executive Director support arbitrary destruction of data.

VII. Efficiency of data recovery

Where data recovery is to be undertaken, the Executive Director will seek to ensure that it is conducted in the most efficient manner possible, in the context of an appropriate data recovery plan. Data recovery programs should be organized to extract, digest, and make available the pertinent data in the most efficient manner possible, taking into account local conditions, the potential for unexpected discoveries, non-archeological concerns, and other relevant factors. The kinds of techniques, tools, and expertise required in a given data recovery program are dependent on the kinds of data to be recovered and analyzed. Although all archeological projects share certain basic principles, there is no single, standard way to conduct archeological fieldwork. As a rule, the Executive Director will seek to ensure that the fastest, most economical methods are used that will achieve the desired research result.

VIII. Consideration of guidance

Where data recovery is to be undertaken, the Executive Director will seek to ensure that due consideration has been given to the Council's "Guidelines for Archeological Data Recovery" and 36.CFR Part 1210 ("Recovery of Scientific, Prehistoric, Historic, and Archeological Data: Methods, Standards, and Reporting Requirements").

IX. Budgets

To the extent feasible given Council and staff priorities and agency contracting policy, the Executive Director will provide advice to agencies, seeking to ensure that budgets developed for data recovery and other archeological activities are reasonable and cost-effective.

X. Negating adverse effect: Documenting "No Adverse Effect" Determinations

1. Undertakings that result directly or indirectly in the disturbance of an archeological property clearly have adverse effects on that property. In some cases, however, this adverse effect can be essentially negated through data recovery; in such cases a determination of "no adverse effect," pursuant to 36 CFR Sec. 800.4(c), may be appropriate. When an agency makes such a determination, the Executive Director's review will focus on the extent to which the adverse effect will in fact be negated by the data recovery effort. The ability to negate adverse effect depends upon (a) the nature of the affecting action, (b) the nature of the archeological property, and (c) the quality of the data recovery effort proposed.

2. To determine whether a data recovery program will negate the adverse effects of an undertaking, the agency, in consultation with the State Historic Preservation Officer, should answer the following questions:

A(1) Does the significance of the property, as documented in the nomination to or determination of eligibility for the National Register, lie primarily in the data it contains, so that retrieval of the data in an appropriate manner may preserve this significance? If so:

A(2) Does it appear that preservation in place would be more costly, or otherwise less practical, than data recovery? If so:

B(1) Will the effects of the undertaking be minor relative to the size and nature of the property? Examples of such a condition include:

(a) Marginal disturbance to an extensive archeological site by construction along one edge.

(b) Minor disruption of the surface of an archeological site whose primary valuable information lies in subsurface deposits, where this disruption is unlikely to have long-range effects on subsurface conditions (e.g., by causing erosion, etc.).

B(2) Is the property subject to destruction regardless of the undertaking, so the agency's action is only slightly hastening an inevitable process? Examples of such a condition include:

(a) Disturbance of an archeological site on a rapidly eroding cliff, where measures to halt erosion are not practical.

(b) Disturbance of an archeological site that is being vandalized or clearly will be subject to vandalism, where there is no practical way to deter the vandals;

(c) Disturbance of an archeological site on land that has great potential for non-Federal development, where no mechanisms (zoning, State or local preservation ordinances, easements) are likely to be employable for protection.

B(3) Is the property not:

(a) a National Historic Landmark, a National Historic Site in non-Federal ownership, or a property of national historical significance so designated within the National Park System;

(b) important enough to fulfillment of purposes set forth in the State Historic Preservation Plan to require its protection in place;

(c) in itself, or as an element of a larger property, significantly valuable as an exhibit in place for public understanding and enjoyment;

(d) known or thought to have historic, cultural, or religious significance to a community, neighborhood, or social or ethnic group that would be impaired by its disturbance.

(e) so complex, or containing such complicated data, that currently available technology, funding time, or expertise are insufficient to recover the significant information contained in it.

3. If the agency and the SHPO agree that questions A(1) and A(2), and questions B(1), B(2) or B(3) are answered in the affirmative, and if the agency establishes a data recovery program consistent with the Council's "Recommendations for Archeological Data Recovery" and 36 CFR Part 1210, the agency has grounds for concluding that the data recovery program will negate the adverse effect, and can hence determine that the undertaking will have No Adverse Effect on the property.

4. In documenting a determination of No Adverse Effect based on this conclusion, pursuant to 36 CFR Sec. 800.4(c) and 800.13(a), the agency should:

(A) report clearly and concisely how it has reached its conclusion;

(B) document the concurrence of the SHPO and, if pertinent, consultation with, and the opinions of, other specialists and authorities concerned with the property, concerned social and ethnic groups, local government, and the public;

(C) provide a copy of the data recovery plan; and,

(D) guarantee that sufficient time and funds have been allocated to execute the data recovery plan.

3. The Executive Director will review the documentation provided in accordance with 36 CFR Sec. 800.6(a) to determine whether (a) the property is shown to be valuable primarily for the information it contains, or whether other public interests are involved, and whether (b) it appears that the adverse effects of the undertaking will in fact be negated, thereby justifying a determination of No Adverse Effect.

XI. Preliminary Case Reports

1. Where it is determined that the undertaking will have an adverse effect on historic properties, the Preliminary Case Report developed by the agency pursuant to 36 CFR Sec. 800.4(d)(1) should:

A. document consideration of alternatives that would preserve the archeological property in place, and give reasons for rejecting those alternatives not preferred;

B. where data recovery is proposed, provide a data recovery plan consistent with the "Guidelines for Archeological Data Recovery" and with 36 CFR Part 1210.

C. where data recovery is not proposed, explain why it is not proposed. An agency may demonstrate that loss of an archeological property without data recovery is acceptable by showing that:

(1) there is no reasonable way to protect the property in place; and,

(2) having made a good-faith effort to identify research questions of the kinds discussed in Appendices A and B of this guidance, to which the recovery of data from the property would contribute, the agency has been unable to identify such questions. In seeking to identify such questions, the agency should utilize available literature in archeology, anthropology, history, and other disciplines, consult with the State Historic Preservation Officer, and consult with State, regional, and local archeological and historical organizations. The Executive Director will review closely the documentation of such efforts, and may suggest additional research questions or sources of advice to be considered.

XII. Memoranda of Agreement

1. Ordinarily, Memoranda of Agreement executed pursuant to 36 CFR Sec. 800.6(c) that provide for data recovery from archeological properties should include or refer directly to a data recovery plan consistent with the "Recommendations for Archeological Data Recovery" and 36 CFR Part 1210. Exceptions to this rule may include, but are not necessarily limited to:

A. A Programmatic Memorandum of Agreement, which may provide for preparation and review of such plans in the context of an ongoing programs;

B. A Memorandum of Agreement that covers a planning process, which may provide for preparation and review of a data recovery plan at a subsequent stage in the agreed-upon process; and,

C. A Memorandum of Agreement that provides for archeological monitoring or other forms of data recovery as guards against uncertain discovery possibilities (for example, where there is some possibility that archeological data will be discovered when a building is demolished). In such an instance, it may not be feasible to develop a detailed data recovery plan because the nature of the possible discovery situation is too uncertain.

2. The purpose of the data recovery plan is to ensure that the data are recovered in an effective manner using the best applicable professional standards under the circumstances. Technical assistance in developing data recovery plans is available from the State Historic Preservation Officer and Interagency Archeological Services, Heritage Conservation and Recreation Service, Department of the Interior. The Executive Director will give data recovery plans the same level of professional review afforded to architectural designs, plans for adaptive reuse, development plans, etc.

3. Memoranda of Agreement may provide for phased data recovery. An example of phased data recovery is:

A. Phase 1: Testing of archeological sites and other research leading to development of a detailed data recovery work plan. The Memorandum of Agreement should set forth guidelines for the testing and other research.

B. Phase 2: Development of a data recovery plan. The Memorandum of Agreement should provide an opportunity for review of the plan by the SHPO and the Council, and possibly for peer review by outside parties.

C. Phase 3: Selection of a contractor. The Memorandum of Agreement should ensure that the agency provides a reliable mechanism for obtaining the best qualified contractor(s) for the project at the most reasonable cost, consistent with satisfactory work performance.

D. Phase 4: Conduct of the work plan, typically including recovery of data, analysis, curation, and dissemination of results.

4. In developing Memoranda of Agreement including provisions for data recovery, the Executive Director will attempt to ensure that the data recovery plan in fact is the best feasible method of addressing the archeological value of the property in the public interest. An agency can facilitate development of such Memoranda by notifying the Council of the steps it has taken to develop its data recovery plan, by identifying the parties consulted during its preparation, by ensuring that all concerned parties have had an opportunity to contribute to its preparation, and by articulating the plan as clearly and concisely as possible.

XIII. Programmatic Memoranda of Agreement

Where appropriate under 36 CFR Sec. 800.8, the Executive Director will consider execution of Programmatic Memoranda of Agreement with agencies to cover archeological data recovery activities and other activities discussed in this guidance. Such a Programmatic Memorandum of Agreement should specify:

1. Conditions in a given State or region, or with reference to the agency's specific types of undertakings, in which data recovery would be appropriate.
2. Guidelines for data recovery, taking into account conditions in a State or region, and/or the agency's types of undertakings and planning/development stages.
3. Methods for procuring appropriate specialists, and controlling costs, and
4. Consultation methods, establishing how the SHPO and other appropriate authorities will be involved in decisionmaking.

XIV. Counterpart Regulations

The Executive Director will use this guidance in reviewing and helping prepare guidelines, standards, and other measures as part of Counterpart Regulations authorized by 36 CFR Sec. 800.11.

XV. Archeology For Research

1. When archeological excavations are conducted on Federal land for research purposes, and the only Federal involvement in the excavations is issuance of a permit under the Archeological Resources Protection Act of 1979 (P.L. 96-95) the comments of the Council need not be sought (P.L. 96-95, Sec. 4(j)).
2. If Federal actions are involved in the research besides issuance of an ARPA permit (eg., funding, other permits or licenses) the Council's regulations (36 CFR Part 800) apply.
 - A. Research projects to which the regulations apply, that involve the physical disturbance of archeological properties, should in most cases be considered to have adverse effects on the properties; the responsible agency should seek the Council's comments in accordance with 36 CFR Sec. 800.4, or programmatically in accordance with 36 CFR Sec. 800.8.
 - B. Projects that address management needs as well as research interests may be taken to have no adverse effect on the properties they disturb, if the facts warrant. Generally, the Executive Director will concur in a "no adverse effect" determination when the following conditions exist:
 - (1) the research project addresses management needs, such as:
 - (a) excavation of a site that is subject to uncontrollable vandalism;
 - (b) excavation of a site that is subject to serious natural erosion;
 - (c) recording of a site or structure that is deteriorating;

(d) stabilizing a deteriorating or endangered site or structure

(2) the determination has been made following Sec. X ("Negating Adverse Effect") of this part of the Supplementary Guidance,

(3) the project will be conducted under the supervision of persons meeting, at a minimum, the qualifications set forth in 36 CFR Part 1210, Appendix C; and,

(4) the project will be conducted in accordance with a research design that takes into account the "Guidelines for Archeological Data Recovery Projects."

APPENDIX A
PRINCIPLES IN THE TREATMENT OF ARCHEOLOGICAL PROPERTIES

In consulting with Federal agencies and State Historic Preservation Officers regarding archeological properties, the Executive Director will observe the following principles.

Principle I: Archeological research, addressing significant questions about the past, is in the public interest.

Principle II: Archeological properties are valuable wholly or in part because they may contribute to research.

Principle III: Not all research problems are equally important; hence not all archeological properties are equally important.

Principle IV: Treatment of an archeological property depends on its value for research, balanced against other public values.

Principle V: Eligibility for the National Register suggests, but does not define, how an archeological property should be treated

Principle VI: If an archeological property can be practically preserved in place, it should be.

Principle VII: If an archeological property is to be preserved in place, extensive excavation of the property is seldom appropriate.

Principle VIII: Both data recovery and destruction without data recovery may be appropriate treatments for archeological properties.

Principle IX: Once a decision is made to undertake data recovery, the work should be done in the most thorough, efficient manner

Principle X: Data recovery should be based on firm background data and planning.

Principle XI: Data recovery should relate positively to the development of State Historic Preservation Plans.

Principle XII: Completion of an approved data recovery plan consummates an agency's data recovery responsibilities.

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local history and prehistory, but also with the professional literature in history, architecture, anthropology, archeology, or other disciplines that may provide bases for evaluating historic properties.

3. *Research Design.* The report should also set forth the research design or plan of study that guided the work, discussing what sorts of historic properties were expected in the area, what historic values they might represent, and what strategies were to be employed in seeking the resources. Often it will be possible to make specific predictions about what kinds of properties can be expected in the field and how they ought to appear. The researcher should also set forth any biases or sources of error that can be identified as having potentially influenced the results of the study. For example, researchers trained specifically in prehistoric archeology may be unable to accurately observe historic properties; if this bias is not corrected by adding an historian, historic archeologist, or architectural historian to the study team, it should be explicitly acknowledged in the report as a possible source of error.

4. *Field Inspection.* The composition of the field study team should be presented. An attempt should be made to insure that all pertinent professional disciplines are represented in this team. Names and qualifications of team members and consultants should be presented and their duties discussed. It is the researcher's obligation to employ persons and methods that will insure the accurate recognition of all classes of historic properties. Methods used in seeking, observing, and recording historic properties should be clearly set forth. The extent to which the study area was fully covered by inspectors on foot should be presented, textually and/or using maps and charts. Any portion of the area not inspected, or inspected at a lower level of intensity, should be indicated and discussed. On-the-ground observational procedures should be presented.

a. In reporting the inspection of lands thought to contain nonstructural historic properties, or structures in ruins, the following should normally be discussed:

- (1) How surveyors were distributed over the study area, how far apart they were placed and in what directions they walked;
- (2) What signs of historic and/or prehistoric activity surveyors were instructed to seek;
- (3) What special techniques, if any, were used to seek special kinds of properties thought to occur in the area (e.g., rock art, standing structures), and/or to cope with special difficulties (e.g., pavement, heavy brush, overburden);
- (4) If subsurface testing was done, under what conditions it was done, what techniques were used, and where it was done; and
- (5) If less than the entire area was inspected, a sampling deal should be presented and justified.

b. In reporting the inspection of lands containing buildings, and/or structures, the following should normally be discussed:

- (1) How surveyors covered the area—by foot, auto, etc.;
- (2) Whether surveyors proceeded individually or as teams;
- (3) Intensity of inspection of properties; did the inspection address only facades? exteriors? interiors?
- (4) How much of the area was covered at a time; did the inspection cover the entire area, proceed in stages, or cover only a portion? The rationale for the coverage strategy should be presented; and
- (5) What kinds of properties were surveyors instructed to seek (e.g., industrial as well as domestic buildings; vernacular architecture as well as "high style" build-

ings; buildings representing different "themes")?

c. The above categories are not presented as a "check list," but as an example of the kinds of questions that should be answerable using the report of a field inspection. To the extent possible, archeological and architectural/historical inspections should be coordinated, since many properties discovered may be of both archeological and historic architectural importance.

d. All procedures used should be justified in terms of their applicability to the area, its potential properties, its environment, and the plan of study.

5. *Results.* a. If an intensive survey has been done, all historic properties should be clearly and completely described. To the extent possible, documentation of properties should refer to Appendix A to the "Procedures for Requesting Determination of Eligibility," 36 CFR Part 63, published for comment in the *FEDERAL REGISTER*, April 27, 1976. Documentation can be provided on standard forms or as text, but should be complete and internally consistent.

b. If a reconnaissance survey has been done, the predicted distributions of historic properties should be presented and justified on the basis of background research and field inspection. Specific historic properties actually recorded during the field inspection should be described, insofar as possible, as set forth at section III(5)(a) above.

c. Negative data, as well as positive data should be presented and discussed, i.e., if historic properties were not found, this fact should be noted and, if possible, accounted for.

6. *Evaluation.*—a. Evaluations of historic properties should be made in sufficient detail to provide an understanding of the historical values that they represent, so that this understanding can serve as a basis for managing the properties or planning impact-mitigation programs if necessary. Properties of importance to a community, neighborhood, social or ethnic group should be discussed with reference to the values and concerns of those to whom the properties may be important.

b. If an intensive survey has been done, all historic properties should be evaluated against the criteria of eligibility for the National Register of Historic Places set forth at 36 CFR 60.6.

c. If a reconnaissance survey has been done, to the extent possible, the predicted significance of each kind of historic property likely to occur within the study area should be presented and justified in relation to its general cultural setting, with reference to the criteria set forth at 36 CFR 60.6.

7. *Recommendations.* In most cases it is expected that the report will provide recommendations concerning any need that may exist for further study, evaluation, or, where applicable, impact mitigation.

8. *Accompanying photographs, graphics, and tabular material.* A location and identification study report should contain sufficient photographs, maps, charts, tables, and appendix material to insure its accurate use for study and planning purposes.

APPENDIX C—PROFESSIONAL QUALIFICATIONS

1. *Basic professional Occupation Standards.* It is essential that any project proposal identify suitably qualified key professional personnel. Basic minimum qualifications for these types of personnel who most often serve as principal investigators and key consultants on contract projects are given below. Agencies which undertake or evaluate identification or data recovery projects using their own employees should also insure that these qualifications are possessed by appropriate staff members in a manner consistent with applicable Civil Service requirements.

Professional personnel of the Department of the Interior are available at all times to consult with other Federal, State and local agencies regarding the application of these criteria in given instances. For these services agency officials should contact the Chief, Office of Archeology and Historic Preservation, National Park Service, Department of the Interior, Washington D.C. 20240. In the following definitions, a month of professional experience need not consist of a continuous month of full-time work but may be made up of discontinuous periods of full-time or part-time work adding up to the equivalent of a month of full-time experience.

a. *History.* The minimum professional qualifications in history are a graduate degree in American history or a closely related field; or a bachelor's degree in history or a closely related field plus one of the following: (a) At least two years of full-time experience in research, writing, teaching, interpretation, or other demonstrable professional activity with an academic institution, historical organization or agency, museum, or other professional institution; or (b) substantial contribution through research and publication to the body of scholarly knowledge in the field of history.

b. *Archeology.* The minimum professional qualifications in archeology are (a) a graduate degree in archeology, anthropology, or closely related field, or equivalent training accepted for accreditation purposes by the Society of Professional Archeologists, (b) demonstrated ability to carry research to completion, usually evidenced by timely completion of theses, research reports, or similar documents, and (c) at least 18 months of professional experience and/or specialized training in archeological field, laboratory, or library research, administration, or management, including at least 4 months experience in archeological field research and at least one year of experience and/or specialized training in the kind of activity the individual proposes to practice. For example, persons supervising field archeology should have at least 1 year or its equivalent in field experience and/or specialized field training, including at least six months in a supervisory role. Persons engaged to do archival or documentary research should have had at least 1 year experience and/or specialized training in such work. Archeologists engaged in regional or agency planning or compliance with historic preservation procedures should have had at least 1 year of experience in work directly pertinent to planning, compliance actions, etc., and/or specialized historic preservation or cultural resource management training. A practitioner of prehistoric archeology should have had at least 1 year of experience or specialized training in research concerning archeological resources of the prehistoric period. A practitioner of historic archeology should have had at least 1 year of experience in research concerning archeological resources of the historic period. Experience in archeological research in the region where the project will be undertaken is usually desirable.

c. *Architectural History.* The minimum professional qualifications in architectural history are a graduate degree in architectural history, historic preservation, or closely related field, with course work in American architectural history; or a bachelor's degree in architectural history, with a concentration in American architecture; or a bachelor's degree in architectural history, historic preservation, or closely related field plus one of the following:

- (1) At least two years full-time experience in research, writing, or teaching in American history or restoration architecture with an academic institution, historical organization

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or agency, museum, or other professional institution; or

(2) Substantial contribution through research and publication to the body of scholarly knowledge in the field of American architectural history.

d. Architecture. The minimum professional qualifications in architecture are a professional degree in architecture plus at least 2 years of full-time professional experience in architecture; or a State license to practice architecture.

e. Historical Architecture. The minimum professional qualifications in historical architecture are a professional degree in architecture or a State license to practice architecture, plus one of the following:

(1) At least 1 year of graduate study in architectural preservation, American architectural history, preservation planning, or closely related field and at least 1 year of full-time professional experience on preservation and restoration projects; or

(2) At least 2 years of full-time professional experience on preservation and restoration projects. Experience on preservation and restoration projects shall include detailed investigations of historic structures, preparation of historic structures research reports, and preparation of plans and specifications for preservation projects.

APPENDIX D—RECOMMENDATIONS FOR THE PROCUREMENT OF LOCATION, IDENTIFICATION, AND DATA RECOVERY PROGRAMS

The following recommendations are provided under the Department of the Interior's responsibilities under section 5(c) of the Act, to coordinate all Federal survey and data recovery activities authorized by the Act. They are based on the Department's 30 years of experience in the procurement of archeological, architectural, and historical services in the location, identification, and study of historic properties.

1. The nature of required identification and data recovery programs varies with the kinds of historic properties expected or data to be recovered. The kinds of data to be recovered depend on both the information content of the properties to be investigated and the research questions that can be asked about the properties. Designing responsible identification and data recovery programs is a complex, professional activity, as is judging the quality of proposals from potential contractors and evaluating the final products of work performed. To the extent possible, the Department will assist Federal agencies in designing high-quality scopes-of-work and in evaluating offers. Those agencies intending to undertake substantial independent data recovery activities, however, should review their staffs and procedures to insure that (1) adequate expertise in archeology, history, architectural history, and/or other appropriate disciplines is represented to provide professional oversight of contract operations, and (2) adequate provision is made for receiving and utilizing input from agencies, institutions, organizations, and qualified individuals who can advise the agency in professional matters relating to archeological and historic data recovery.

2. Because the requirements of any given data recovery program will depend both on the data content of the property and the research questions relevant to its investigation, it is extremely difficult to define standard specifications for required contractual services and end products. As a result, negotiated competitive procurement is recommended for most kinds of data recovery activities. Sole source contracting has been found by the Office of Archeology and Historic Preservation to often result in low quality work by restricting intellectual competition among

offerers, and has been difficult to justify within Federal procurement regulations. On the other hand, formal advertising with price as the sole criterion for selection of a contractor has proven to be unsatisfactory as a method of insuring high-quality work because of the lack of a clearly specifiable and product. As a rule, negotiated competitive procurement has been found to be the most effective approach to obtaining high-quality services for location and identification of historic properties as well. Agencies that anticipate the need for very small-scale location and identification projects may find it useful to group these together and solicit proposals for an annual package of jobs. The following procedural steps are recommended in general for the procurement of location, identification, and data recovery programs:

a. Preparation of a Request for Proposals. The request for proposals should include a scope-of-work usually including the following elements:

(1) A description of the undertaking requiring the identification or data recovery activity, including a statement of the present status of planning, status of compliance with historic preservation authorities, and a projected timetable for future actions;

(2) The location of the undertaking including information on the size of the area to be affected, the terrain, access, land ownership, or other factors that might affect the logistics of identification or data recovery;

(3) For identification projects, the kinds of descriptive and evaluatory output required by statute and procedures; and

(4) For data recovery projects, the property or properties to be investigated, and the data or research values the property or properties are (is) known or thought to represent.

b. The request for proposals should be circulated to all qualified and potentially interested contractors, including both local and non-local universities, colleges, museums, private firms, and individuals and should be advertised in "Commerce Business Daily". Advertising in journals, newsletters, and other media likely to be seen by potential offerers, and distribution through the State Historic Preservation Officer, are desirable. The Department will assist agencies in compiling lists of potential offerers upon request.

c. Offerers should provide proposals for undertaking the requested work, setting forth their staff qualifications, facilities, research designs, and project plans.

d. Proposals should be evaluated for responsiveness and professional quality, and ranked accordingly, prior to a consideration of bids. The Department will provide qualified assistance in evaluating proposals upon request, to the extent permitted by staff limitations.

Dated: January 19, 1977.

GARY EVERHARDT,
Director, National Park Service.
[FR Doc. 77-2399 Filed 1-27-77; 8:48 am]

POSTAL SERVICE

[39 CFR Part 6]

GOVERNMENT IN THE SUNSHINE ACT—BYLAWS OF THE BOARD OF GOVERNORS

Proposed Rulemaking

Correction

In FR Doc. 77-1096 appearing at page 2699 in the issue of Thursday, January 13, 1977 the following corrections should be made:

1. On page 2702, middle column, in § 6.1 insert the following line immediately above the last line in the column, "ing may be varied by action of the".

2. On page 2702, third column, in § 6.3 the 16th and 17th lines are transposed and should read: "previous oral notice, must be sent in sufficient time to reach that address at least".

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 52]

[FRL 676-4]

APPROVAL AND PROMULGATION OF IMPLEMENTATION PLANS

Texas and New Mexico

On March 21, 1975, the Governor of Texas submitted a revision to the State Implementation Plan (SIP) concerning the re-classification of several Air Quality Control Regions (AQCRs) with respect to particulate matter, sulfur oxides, and carbon monoxide. The public hearing for this revision was conducted by the State on January 16, 1975. On October 1, 1975, the Texas Air Control Board (TACB) was notified of EPA's preliminary analysis results. On August 2, 1976, the Governor submitted a revision to Section IX, Air Quality Surveillance, of the SIP subsequent to a public hearing conducted by the State on April 6, 1976. In this revision, monitoring equipment requirements for sulfur oxides were proposed based on the preliminary evaluation results of the re-classification revision. Therefore, this notice of proposed rulemaking concerns both revisions to the Texas SIP.

AQCR RE-CLASSIFICATION

The priority re-classification revision concerns the pollutants and AQCRs indicated below. The original classifications are compared with the new classifications proposed by the State.

AQCR No.	Name	Pollutant	Original priority	Proposed priority
210	Abilene-Wichita Falls	Particulate	II	III
		Sulfur oxides	II	III
211	Amarillo-Lubbock	Particulate	II	III
		Sulfur oxides	I	III
213	Brownsville-Laredo	Particulate	I	III
214	Corpus Christi-Victoria	Sulfur oxides	I	III
153	El Paso-Las Cruces-Alamogordo	Carbon monoxide	I	II
		Sulfur oxides	I	IA

The criteria for AQCR priority classifications originally promulgated by EPA were measured ambient air quality or es-

timated air quality where measured data were not available. In addition, population data could be used to classify AQCRs

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
WASHINGTON, D.C. 20250

The Secretary of the Interior
**Standards for
Rehabilitation**
and Guidelines for
Rehabilitating Historic Buildings

"Rehabilitation means the process of returning a property to a state of utility, through repair or alteration, which makes possible an efficient contemporary use while preserving those portions and features of the property which are significant to its historic, architectural, and cultural values."

The following "Standards for Rehabilitation" shall be used by the Secretary of the Interior when determining if a rehabilitation project qualifies as "certified rehabilitation" pursuant to the Tax Reform Act of 1976 and the Revenue Act of 1978. These standards are a section of the Secretary's "Standards for Historic Preservation Projects" and appear in Title 36 of the Code of Federal Regulations, Part 1208 (formerly 36 CFR Part 67).

1. Every reasonable effort shall be made to provide a compatible use for a property which requires minimal alteration of the building, structure, or site and its environment, or to use a property for its originally intended purpose.
2. The distinguishing original qualities or character of a building, structure, or site and its environment shall not be destroyed. The removal or alteration of any historic material or distinctive architectural features should be avoided when possible.
3. All buildings, structures, and sites shall be recognized as products of their own time. Alterations that have no historical basis and which seek to create an earlier appearance shall be discouraged.
4. Changes which may have taken place in the course of time are evidence of the history and development of a building, structure, or site and its environment. These changes may have acquired significance in their own right, and this significance shall be recognized and respected.
5. Distinctive stylistic features or examples of skilled craftsmanship which characterize a building, structure, or site shall be treated with sensitivity.
6. Deteriorated architectural features shall be repaired rather than replaced, wherever possible. In the event replacement is necessary, the new material should match the material being replaced in composition, design, color, texture, and other visual qualities. Repair or replacement of missing architectural features should be based on accurate duplications of features, substantiated by historic, physical, or pictorial evidence rather than on conjectural designs or the availability of different architectural elements from other buildings or structures.

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7. The surface cleaning of structures shall be undertaken with the gentlest means possible. Sandblasting and other cleaning methods that will damage the historic building materials shall not be undertaken.

8. Every reasonable effort shall be made to protect and preserve archeological resources affected by, or adjacent to any project.

9. Contemporary design for alterations and additions to existing properties shall not be discouraged when such alterations and additions do not destroy significant historical, architectural or cultural material, and such design is compatible with the size, scale, color, material, and character of the property, neighborhood or environment.

10. Wherever possible, new additions or alterations to structures shall be done in such a manner that if such additions or alterations were to be removed in the future, the essential form and integrity of the structure would be unimpaired.

GUIDELINES FOR APPLYING THE SECRETARY OF THE INTERIOR'S STANDARDS FOR REHABILITATION

The following guidelines are designed to help individual property owners formulate plans for the rehabilitation, preservation, and continued use of historic buildings consistent with the intent of the Secretary of the Interior's "Standards for Rehabilitation." The guidelines pertain to buildings of all occupancy and construction types, sizes, and materials. They apply to permanent and temporary construction on the exterior and interior of historic buildings as well as new attached or adjacent construction.

Techniques, treatments, and methods consistent with the Secretary's "Standards for Rehabilitation" are listed in the "recommended" column on the left. Not all recommendations listed under a treatment will apply to each project proposal. Rehabilitation approaches, materials, and methods which may adversely affect a building's architectural and historic qualities are listed in the "not recommended" column on the right. Every effort will be made to update and expand the guidelines as additional techniques and treatments become known.

Specific information on rehabilitation and preservation technology may be obtained by writing to the Technical Preservation Services Division, Heritage Conservation and Recreation Service, U.S. Department of the Interior, Washington, D.C. 20243, or the appropriate State Historic Preservation Officer. Advice should also be sought from qualified professionals, including architects, architectural historians, and archeologists skilled in the preservation, restoration, and rehabilitation of old buildings.

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THE ENVIRONMENT

Recommended

Retaining distinctive features such as the size, scale, mass, color, and materials of buildings, including roofs, porches, and stairways that give a neighborhood its distinguishing character.

Retaining landscape features such as parks, gardens, street lights, signs, benches, walkways, streets, alleys and building setbacks that have traditionally linked buildings to their environment.

Using new plant materials, fencing, walkways, street lights, signs, and benches that are compatible with the character of the neighborhood in size, scale, material and color.

Not Recommended

Introducing new construction into neighborhoods that is incompatible with the character of the district because of size, scale, color, and materials.

Destroying the relationship of buildings and their environment by widening existing streets, changing paving material, or by introducing inappropriately located new streets and parking lots that are incompatible with the character of the neighborhood.

Introducing signs, street lighting, benches, new plant materials, fencing, walkways and paving materials that are out of scale or are inappropriate to the neighborhood.

BUILDING SITE

Recommended

Identifying plants, trees, fencing, walkways, outbuildings, and other elements that might be an important part of the property's history and development.

Retaining plants, trees, fencing, walkways, street lights, signs, and benches that reflect the property's history and development.

Basing decisions for new site work on actual knowledge of the past appearance of the property found in photographs, drawings, newspapers, and tax records. If changes are made they should be carefully evaluated in light of the past appearance of the site.

Not Recommended

Making changes to the appearance of the site by removing old plants, trees, fencing, walkways, outbuildings, and other elements before evaluating their importance in the property's history and development.

Leaving plant materials and trees in close proximity to the building that may be causing deterioration of the historic fabric.

BUILDING SITE--continued

Recommended

Providing proper site and roof drainage to assure that water does not splash against building or foundation walls, nor drain toward the building.

Not RecommendedArcheological featuresRecommended

Leaving known archeological resources intact.

Minimizing disturbance of terrain around the structure, thus reducing the possibility of destroying unknown archeological resources.

Arranging for an archeological survey of all terrain that must be disturbed during the rehabilitation program. The survey should be conducted by a professional archeologist.

Not Recommended

Installing inderground utilities, pavements, and other modern features that disturb archeological resources.

Introducing heavy machinery or equipment into areas where their presence may disturb archeological resources.

BUILDING: STRUCTURAL SYSTEMS

Recommended

Recognizing the special problems inherent in the structural systems of historic buildings, especially where there are visible signs of cracking, deflection, or failure.

Undertaking stabilization and repair of weakened structural members and systems.

Replacing historically important structural members only when necessary. Supplementing existing structural systems when damaged or inadequate.

Not Recommended

Disturbing existing foundations with new excavations that undermine the structural stability of the building.

Leaving known structural problems untreated that will cause continuing deterioration and will shorten the life of the structure.

BUILDING: EXTERIOR FEATURES--continued

Masonry: Adobe, brick, stone, terra cotta, concrete, stucco and mortar

Recommended *

Retaining original masonry and mortar, whenever possible, without the application of any surface treatment.

Repointing only those mortar joints where there is evidence of moisture problems or when sufficient mortar is missing to allow water to stand in the mortar joint.

Duplicating old mortar in composition, color, and texture.

Duplicating old mortar in joint size, method of application, and joint profile.

Repairing stucco with a stucco mixture that duplicates the original as closely as possible in appearance and texture.

Cleaning masonry only when necessary to halt deterioration or to remove graffiti and stains and always with the gentlest method possible, such as low pressure water and soft natural bristle brushes.

Not Recommended

Applying waterproof or water repellent coatings or surface consolidation treatments unless required to solve a specific technical problem that has been studied and identified. Coatings are frequently unnecessary, expensive, and can accelerate deterioration of the masonry.

Repointing mortar joints that do not need repointing. Using electric saws and hammers to remove mortar can seriously damage the adjacent brick.

Repointing with mortar of high Portland cement content can often create a bond that is stronger than the building material. This can cause deterioration as a result of the differing coefficient of expansion and the differing porosity of the material and the mortar.

Repointing with mortar joints of a differing size or joint profile, texture or color.

Sandblasting, including dry and wet grit and other abrasives, brick or stone surfaces; this method of cleaning erodes the surface of the material and accelerates deterioration. Using chemical cleaning products that would have an adverse chemical reaction with the masonry materials, i.e., acid on limestone or marble.

* For more information consult Preservation Briefs: 1: "The Cleaning and Waterproof Coating of Masonry Buildings" and Preservation Briefs: 2: "Repointing Mortar Joints in Historic Brick Buildings" (Washington, D.C.: Heritage Conservation and Recreation Service, 1975 and 1976). Both are available from the Government Printing Office or State Historic Preservation Officers.

BUILDING: EXTERIOR FEATURES--continued

Masonry: Adobe, brick, stone, terra cotta, concrete, stucco and mortar

Recommended

Repairing or replacing, where necessary, deteriorated material with new material that duplicates the old as closely as possible.

Replacing missing significant architectural features, such as cornices, brackets, railings, and shutters.

Retaining the original or early color and texture of masonry surfaces, including early signage wherever possible. Brick or stone surfaces may have been painted or whitewashed for practical and aesthetic reasons.

Not Recommended

Applying new material which is inappropriate or was unavailable when the building was constructed, such as artificial brick siding, artificial cast stone or brick veneer.

Removing architectural features such as cornices, brackets, railings, shutters, window architraves, and doorway pediments.

Removing paint from masonry surfaces indiscriminately. This may subject the building to damage and change its appearance.

Wood: Clapboard, weatherboard, shingles and other wooden siding

Recommended

Retaining and preserving significant architectural features, wherever possible.

Repairing or replacing, where necessary, deteriorated material that duplicates in size, shape, and texture the old as closely as possible.

Not Recommended

Removing architectural features such as siding, cornices, brackets, window architraves, and doorway pediments. These are, in most cases, an essential part of a building's character and appearance that illustrate the continuity of growth and change.

Resurfacing frame buildings with new material that is inappropriate or was unavailable when the building was constructed such as artificial stone, brick veneer, asbestos or asphalt shingles, and plastic or aluminum siding. Such material can also contribute to the deterioration of the structure from moisture and insects.

Architectural Metals: Cast iron, steel, pressed tin, aluminum and zinc

Recommended

Retaining original material, whenever possible.

Not Recommended

Removing architectural features that are an essential part of a building's character and appearance, illustrating the continuity of growth and change.

BUILDING: EXTERIOR FEATURES—continued

Architectural Metals: Cast iron, steel, pressed tin, aluminum and zincRecommended

Cleaning when necessary with the appropriate method. Metals should be cleaned by methods that do not abrade the surface.

Not Recommended

Exposing metals which were intended to be protected from the environment. Do not use cleaning methods which alter the color, texture, and tone of the metal.

Roofs and RoofingRecommended

Preserving the original roof shape.

Retaining the original roofing material, whenever possible.

Providing adequate roof drainage and insuring that the roofing materials provide a weathertight covering for the structure.

Replacing deteriorated roof coverings with new material that matches the old in composition, size, shape, color, and texture.

Preserving or replacing where necessary, all architectural features that give the roof its essential character, such as dormer windows, cupolas, cornices, brackets, chimneys, cresting, and weather vanes.

Not Recommended

Changing the essential character of the roof by adding inappropriate features such as dormer windows, vents, or skylights.

Applying new roofing material that is inappropriate to the style and period of the building and neighborhood.

Replacing deteriorated roof coverings with new materials that differ to such an extent from the old in composition, size, shape, color, and texture that the appearance of the building is altered.

Stripping the roof of architectural features important to its character.

Windows and DoorsRecommended *

Retaining and repairing window and door openings, frames, sash, glass, doors, lintels, sills, pediments, architraves, hardware, awnings and shutters where they contribute to the architectural and historic character of the building.

Not Recommended

Introducing or changing the location or size of windows, doors, and other openings that alter the architectural and historic character of the building.

BUILDING: EXTERIOR FEATURES--continued

Windows and DoorsRecommended*

Improving the thermal performance of existing windows and doors through adding or replacing weatherstripping and adding storm windows and doors which are compatible with the character of the building and which do not damage window or door frames.

Replacing missing or irreparable windows on significant facades with new windows that match the original in material, size, general muntin and mullion proportion and configuration, and reflective qualities of the glass.

Not Recommended

Replacing window and door features on significant facades with historically and architecturally incompatible materials such as anodized aluminum, mirrored or tinted glass.

Removing window and door features that can be repaired where such features contribute to the historic and architectural character of the building.

Changing the size or arrangement of window panes, muntins, and rails where they contribute to the architectural and historic character of the building.

Installing on significant facades shutters, screens, blinds, security grills, and awnings which are historically inappropriate and which detract from the character of the building.

Installing new exterior storm windows and doors which are inappropriate in size or color, which are inoperable, or which require removal of original windows and doors.

Installing interior storm windows that allow moisture to accumulate and damage the window.

Replacing sash which contribute to the character of a building with those that are incompatible in size, configuration, and reflective qualities or which alter the setback relationship between window and wall.

*For more information consult Preservation Briefs: 3: "Conserving Energy in Historic Buildings" (Washington, D.C. Heritage Conservation and Recreation Service, 1978). It is available from the Government Printing Office or State Historic Preservation Officers.

BUILDING: EXTERIOR FEATURES--continued

Windows and DoorsRecommendedNot Recommended

Installing heating/air conditioning units in the window frames when the sash and frames may be damaged. Window installations should be considered only when all other viable heating/cooling systems would result in significant damage to historic materials.

StorefrontsRecommendedNot Recommended

Retaining and repairing existing storefronts including windows, sash, doors, transoms, signage, and decorative features where such features contribute to the architectural and historic character of the building.

Where original or early storefronts no longer exist or are too deteriorated to save, retaining the commercial character of the building through 1) contemporary design which is compatible with the scale, design, materials, color, and texture of the historic buildings; or 2) an accurate restoration of the storefront based on historical research and physical evidence.

Introducing a storefront or new design element on the ground floor, such as an arcade, which alters the architectural and historic character of the building and its relationship with the street or its setting or which causes destruction of significant historic fabric.

Using materials which detract from the historic or architectural character of the building, such as mirrored glass.

Altering the entrance through a significant storefront.

Entrances, porches, and stepsRecommendedNot Recommended

Retaining porches and steps that are appropriate to the building and its development. Porches or additions reflecting later architectural styles are often important to the building's historical integrity and, wherever possible, should be retained.

Removing or altering porches and steps that are appropriate to the building's development and style.

BUILDING: EXTERIOR FEATURES--continued

Entrances, porches, and stepsRecommended

Repairing or replacing, where necessary, deteriorated architectural features of wood, iron, cast iron, terra cotta, tile, and brick.

Not Recommended

Stripping porches and steps or original material and architectural features, such as hand rails, balusters, columns, brackets, and roof decoration of wood, iron, cast iron, terra cotta, tile and brick.

Enclosing porches and steps in a manner that destroys their intended appearance.

Exterior FinishesRecommended

Discovering the historic paint colors and finishes of the structure and repainting with those colors to illustrate the distinctive character of the property.

Not Recommended

Removing paint and finishes down to the bare surface; strong paint strippers whether chemical or mechanical can permanently damage the surface. Also, stripping obliterates evidence of the historical paint finishes.

Repainting with colors that cannot be documented through research and investigation to be appropriate to the building and neighborhood.

BUILDING: INTERIOR FEATURES

Recommended

Retaining original material, architectural features, and hardware, whenever possible, such as stairs, elevators, hand rails, balusters, ornamental columns, cornices, baseboards, doors, doorways, windows, mantel pieces, paneling, lighting fixtures, parquet or mosaic flooring.

Repairing or replacing, where necessary, deteriorated material with new material that duplicates the old as closely as possible.

Not Recommended

Removing original material, architectural features, and hardware, except where essential for safety or efficiency.

Replacing interior doors and transoms without investigating alternative fire protection measures or possible code variances.

Installing new decorative material and paneling which destroys significant architectural features or was unavailable when the building was constructed, such as vinyl plastic or imitation wood wall and floor coverings, except in utility areas such as bathrooms and kitchens.

BUILDING: INTERIOR FEATURES--continued

Recommended

Retaining original plaster, whenever possible.

Discovering and retaining original paint colors, wallpapers and other decorative motifs or, where necessary, replacing them with colors, wallpapers or decorative motifs based on the original.

Where required by code, enclosing an important interior stairway in such a way as to retain its character. In many cases glazed fire rated walls may be used.

Retaining the basic plan of a building, the relationship and size of rooms, corridors, and other spaces.

Not Recommended

Removing plaster to expose brick to give the wall an appearance it never had.

Changing the texture and patina of exposed wooden architectural features (including structural members) and masonry surfaces through sandblasting or use of other abrasive techniques to remove paint, discoloration and plaster, except in certain industrial or warehouse buildings where the interior masonry or plaster surfaces do not have significant design, detailing, tooling, or finish; and where wooden architectural features are not finished, molded, beaded, or worked by hand.

Enclosing important stairways with ordinary fire rated construction which destroys the architectural character of the stair and the space.

Altering the basic plan of a building by demolishing principal walls, partitions, and stairways.

NEW CONSTRUCTION

Recommended

Keeping new additions and adjacent new construction to a minimum, making them compatible in scale, building materials, and texture.

Designing new work to be compatible in materials, size, color, and texture with the earlier building and the neighborhood.

Not Recommended

Designing new work which is incompatible with the earlier building and the neighborhood in materials, size, scale, and texture.

NEW CONSTRUCTION—continued

Recommended

Using contemporary designs compatible with the character and mood of the building or the neighborhood.

Protecting architectural details and features that contribute to the character of the building.

Placing television antennae and mechanical equipment, such as air conditioners, in an inconspicuous location.

Not Recommended

Imitating an earlier style or period of architecture in new additions, except in rare cases where a contemporary design would detract from the architectural unity of an ensemble or group. Especially avoid imitating an earlier style of architecture in new additions that have a completely contemporary function such as a drive-in bank or garage.

Adding new height to the building that changes the scale and character of the building. Additions in height should not be visible when viewing the principal facades.

Adding new floors or removing existing floors that destroy important architectural details, features and spaces of the building.

Placing television antennae and mechanical equipment, such as air conditioners, where they can be seen from the street.

MECHANICAL SYSTEMS: HEATING, AIR CONDITIONING, ELECTRICAL, PLUMBING,
FIRE PROTECTIONRecommended

Installing necessary mechanical systems in areas and spaces that will require the least possible alteration to the structural integrity and physical appearance of the building.

Utilizing early mechanical systems, including plumbing and early lighting fixtures, where possible.

Not Recommended

Causing unnecessary damage to the plan, materials, and appearance of the building when installing mechanical systems.

Attaching exterior electrical and telephone cables to the principal elevations of the building.

MECHANICAL SYSTEMS: HEATING, AIR CONDITIONING, ELECTRICAL, PLUMBING,
FIRE PROTECTION--continued

Recommended

Installing the vertical runs of ducts, pipes, and cables in closets, service rooms, and wall cavities.

Insuring adequate ventilation of attics, crawlspaces, and cellars to prevent moisture problems.

Installing thermal insulation in attics and in unheated cellars and crawlspaces to conserve energy.

Not Recommended

Installing vertical runs of ducts, pipes, and cables in places where they will be a visual intrusion.

Concealing or "making invisible" mechanical equipment in historic walls or ceilings. Frequently this concealment requires the removal of historic fabric.

Installing "dropped" acoustical ceilings to hide mechanical equipment. This destroys the proportions and character of the rooms.

Installing foam, glass fiber, or cellulose insulation into wall cavities of either wooden or masonry construction. This has been found to cause moisture problems when there is no adequate moisture barrier.

SAFETY AND CODE REQUIREMENTS

Recommended

Complying with code requirements in such a manner that the essential character of a building is preserved intact.

Working with local code officials to investigate alternative life safety measures that preserve the architectural integrity of the building.

Investigating variances for historic properties allowed under some local codes.

Not Recommended

SAFETY AND CODE REQUIREMENTS--continued

Recommended

Installing adequate fire prevention equipment in a manner that does minimal damage to the appearance or fabric of a property.

Adding new stairways and elevators that do not alter existing exit facilities or other important architectural features and spaces of the building.

Not Recommended

Adding new stairways and elevators that alter existing exit facilities or important architectural features and spaces of the building.

Heritage Conservation and Recreation Service
U.S. Department of the Interior
Washington, D.C. 20243

January 1980 (rev.)

ATTACHMENT 5
H

STANDARD

PRESERVATION COVENANTS

The premises above described are hereby conveyed subject to the conditions, restrictions, and limitations hereinafter set forth, which shall be considered as covenants running with the property, which the grantee, his heirs, and assigns covenant and agree, in the event that premises are sold or otherwise disposed of, will be inserted in the conveyance or other instrument disposing of the premises.

1. That with respect to the exterior (and architecturally and/or historically significant interior features) of the structures no physical or structural change and no change in the color or surfacing shall be made or changed or altered without the written approval of the State Historic Preservation Officer.

2. In the event of a violation of the above restrictions, the Agency/State Historic Preservation Officer may institute a suit to enjoin such violation or for damages by reason of any breach thereof.

3. The above restrictions shall be binding on the parties hereto, their heirs, successors, and assigns, in perpetuity/ [for _____ years] but the State Historic Preservation Officer may, for good cause, modify or cancel any or all of the foregoing restrictions upon application of the grantee, his heirs and assigns.

The acceptance of the delivery of this (deed/title) shall constitute conclusive evidence of the agreement of the grantee to be bound by the conditions, restrictions, and limitations and to perform the obligations herein set forth.



United States Department of the Interior

HERITAGE CONSERVATION AND RECREATION SERVICE

WASHINGTON, D.C. 20243

IN REPLY REFER TO: 436

Mr. John F. Pearson, Jr.
Department of Energy
Oak Ridge Operations
Oak Ridge, Tennessee 37830

Dear Mr. Pearson:

Thank you for your letter requesting a determination of eligibility for inclusion in the National Register pursuant to Executive Order 11593 or the National Historic Preservation Act of 1966, as amended. Our determination appears on the enclosed material.

As you understand, your request for our professional judgment constitutes a part of the Federal planning process. We urge that this information be integrated into the National Environmental Policy Act analysis in order to bring about the best possible program decisions. This determination does not serve in any manner as a veto to uses of property, with or without Federal participation or assistance. Any decision on the property in question and the responsibility for program planning concerning such properties lie with the agency or block grant recipient after the Advisory Council on Historic Preservation has had an opportunity to comment.

We are pleased to be of assistance in the consideration of historic resources in the planning process.

Sincerely yours,

Jerry L. Rogers
Acting Keeper of the
National Register

Enclosure

NOTE: Letter dated January 13, 1981.

DETERMINATION OF ELIGIBILITY
NOTIFICATION DISTRIBUTION

cc: State Historic Preservation Officer: Mr. Clarence E. Moran
Federal Representative: Mrs. Ruth Clusen
Bureau Liaison: Mr. Raymond Berube
Advisory Council on Historic Preservation: Washington, D.C.

bcc: ECRS Regional Office: Northeast
Interagency Archeological Services: Atlanta Office
NATIONAL REGISTER /DECR-Giesecke
FHR: W. R. Luce:jrb:343-6401:1-5-81
BASIC FILE RETAINED IN NATIONAL REGISTER

EO. 11593

DETERMINATION OF ELIGIBILITY NOTIFICATION
National Register of Historic Places
Heritage Conservation and Recreation Service

Name of property: Fort Martin School

Location: Monongalia County

State: WV

Request submitted by: DOE/John F. Pearson, Jr.

Date received: 8-18-80

Additional information received: 9-16-80

Opinion of the State Historic Preservation Officer:

☒ **Eligible**

☐ **Not Eligible**

☐ **No Response**

Comments:

The Secretary of the Interior has determined that this property is:

☒ **Eligible** **Applicable criteria:** A,C

☐ **Not Eligible**

Comments: *See typed sheet

☐ **Documentation insufficient**

(Please see accompanying sheet explaining additional materials required)

Bruce M. ...

for **Keeper of the National Register**

Date: _____

EO. 11593**DETERMINATION OF ELIGIBILITY NOTIFICATION****National Register of Historic Places****Heritage Conservation and Recreation Service****Name of property:** Fort Martin Church**Location:** Mononagla County**State:** WY**Request submitted by:** DOE/John F. Pearson, Jr.**Date received:** 8-18-80**Additional information received:** 9-16-80**Opinion of the State Historic Preservation Officer:**☐ Eligible☒ Not Eligible☐ No Response**Comments:****The Secretary of the Interior has determined that this property is:**☐ Eligible Applicable criteria:☒ Not Eligible**Comments:** *see typed sheet☐ Documentation insufficient

(Please see accompanying sheet explaining additional materials required)

Bruce MacC...
 For: **Keeper of the National Register**

Date: _____

EO. 11593

DETERMINATION OF ELIGIBILITY NOTIFICATION
National Register of Historic Places
Heritage Conservation and Recreation Service

Name of property: Gingrich House

Location: Monongalia County

State: WV

Request submitted by: DOE/John F. Pearson, Jr.

Date received: 8-18-80

Additional information received: 9-16-80

Opinion of the State Historic Preservation Officer:

☒ **Eligible**

☐ **Not Eligible**

☐ **No Response**

Comments:

The Secretary of the Interior has determined that this property is:

☒ **Eligible** **Applicable criteria:** c

☐ **Not Eligible**

Comments: *See typed sheet

☐ **Documentation insufficient**

(Please see accompanying sheet explaining additional materials required)

Keeper of the National Register

Date: _____

Please Note:

The Fort Martin School is eligible both as a well preserved example of a once common building type--the one room school, and for its importance in the education of area children. The building has been slightly modified by the addition of a kitchen/bathroom wing. The new wing is small, distinct from the original building, and does not impair the building's integrity.

Although the Ft. Martin Methodist Church is a very historic congregation, the current building does not appear to qualify for the National Register either for architectural significance or historical associations. A building can qualify for the National Register for historical associations only on the basis of events associated with that building, not with earlier structures.

The Gingrich House is eligible for the National Register as a vernacular house combining several late nineteenth century elements. The house which utilizes Italianate, Queen Anne and Second Empire elements also contains significant interior woodwork.



Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, Tennessee 37830

AUG 12 1980

Keeper of the National Register
Heritage Conservation & Recreation Service
Department of the Interior
440 G Street NW
Washington, D.C. 20243

Gentlemen:

REQUESTS FOR DETERMINATIONS OF ELIGIBILITY; HISTORICAL AND
ARCHAEOLOGICAL RESOURCES AT DOE'S SRC II SITE; MORGANTOWN,
WEST VIRGINIA

Enclosed you will find several reports describing the following
cultural resources at DOE's proposed SRC II Plant Site:

1. Belldina's Bottom Archaeological Site

Draft Report on Phase I and II Investigations by GAI
Consultants (Enclosure 1.)

2. Van Voorhis Farm Archaeological Site

Draft Report by Mid-Atlantic Archaeological Research, Inc.
(Enclosure 2)

3. Fort Martin Church, Fort Martin School and Gingrich House
Historical Sites

Draft Report of Additional Historical Data by Stearns-Roger
(Enclosure 3 — includes photographs of Gingrich House
interior)

This letter and information supplements our submittal of July 22,
1980 relative to the Fort Martin Historical/Archaeological site and
other resources. Although these reports are considered drafts, we
believe they contain accurate information in sufficient detail for
eligibility determinations. Please note GAI's most recent weekly
report inserted in their draft report for the Belldina's Lower
Terrace.

COPY

Keeper of the Register

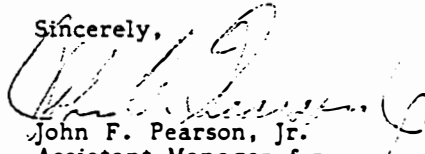
- 2 -

AUG 12 1980

Please contact us promptly if you believe any additional information is needed for the required determinations. We have provided a complete copy of this submittal to the West Virginia State Historical Preservation Officer, along with a request that he provide formal written concurrence to you as soon as possible. This should allow the Department of Interior to exercise the 10-day, determination option specified under Title 36, Section 63.3.

Jake Alexander, with ORO's Environmental Protection Branch, should be contacted if you have questions or need additional information regarding these matters, at FTS 626-0849, or commercial: Area Code 615/576-0849. We appreciate your cooperation ~~in helping us to resolve any potential conflicts between the SRC II project and these important cultural resources.~~

Sincerely,



John F. Pearson, Jr.
Assistant Manager for
Solvent Refined Coal Projects

MS-331:JKA

Enclosures

CC:
Clarence Moran, WV/SHPO, Charleston
Mr. Tannebaum, Advisory Council
on Historical Preservation, DC

DEPARTMENT OF CULTURE AND HISTORY



STATE OF WEST VIRGINIA
JOHN D. ROCKEFELLER IV, GOVERNOR
Norman L. Fagan, Commissioner

HISTORIC PRESERVATION UNIT Clarence E. Moran, AIA, Director

September 10, 1980

Mrs. Carol D. Shull
Acting Keeper of the National Register
HCRS, Department of the Interior
440 G Street, N.W.
Washington, D.C. 20243

RE: Determination of Eligibility
Van Voorhis Farm (46 Mg 77),
Belldina's Bottom (46 Mg 75),
Gingrich House, Fort Martin School
and Fort Martin Church

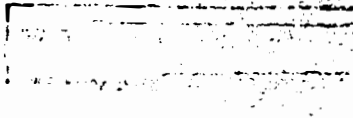
Dear Ms. Carol:

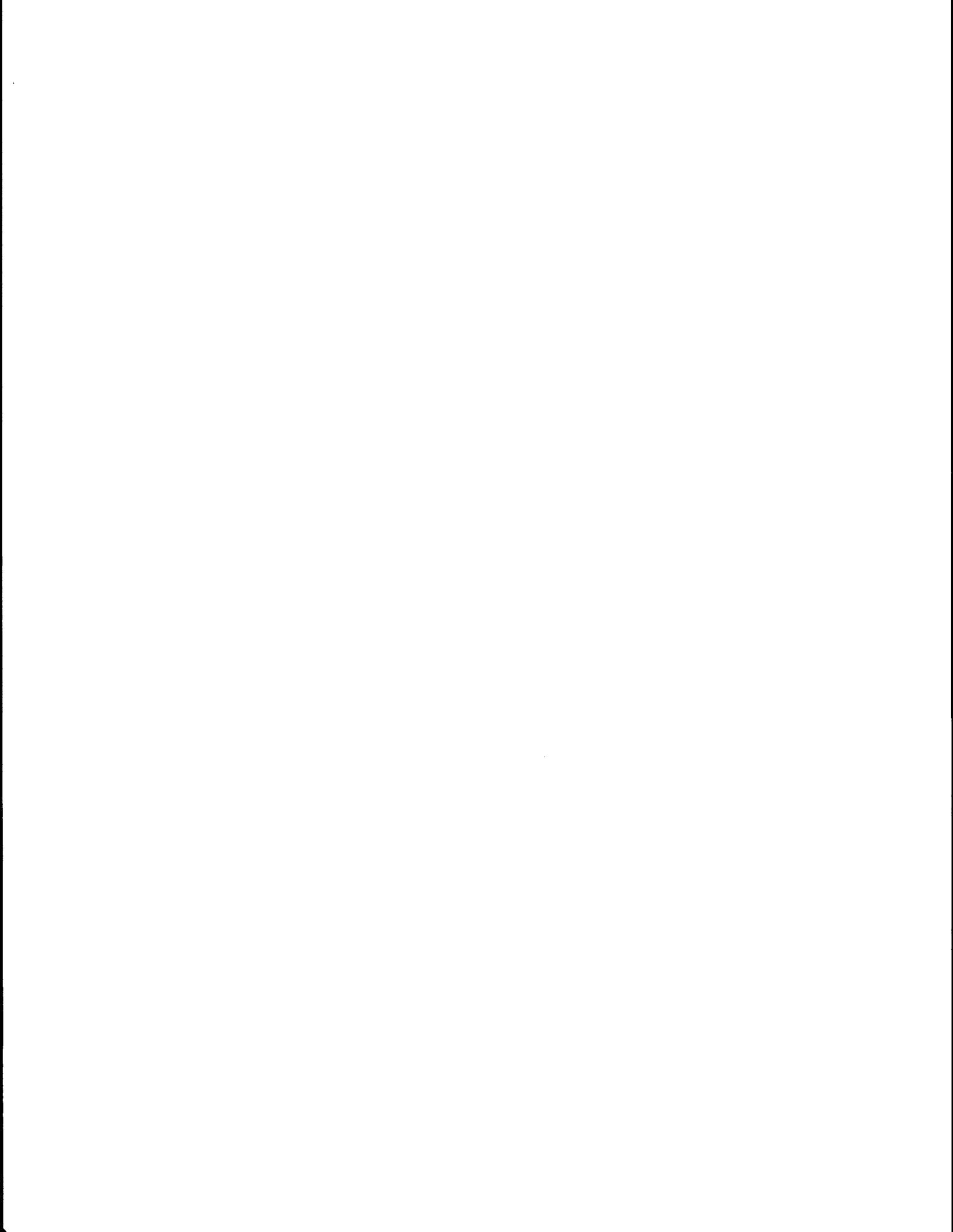
Please refer to the letter dated August 12, 1980 from J.F. Pearson, Jr., Oak Ridge Operations, Department of Energy, to you, and the reports "Draft Reports on Phase I and Phase II Archeological Investigation at Site 46 Mg 75 (Belldina's Bottom)", "Van Voorhis Farm Site (46 Mg 77) Archeological Investigation", and "Additional Historical Data". In our opinion, Van Voorhis Farm, Belldina's Bottom, and the Gingrich House as described are eligible for inclusion in the National Register; we do not believe the Fort Martin Church is eligible. In regard to the Fort Martin School, we have no opinion at this time, pending more data on other one-room schools, in Monongalia County that are extant.

Sincerely,

Clarence E. Moran, AIA
State Historic Preservation Officer

CEN/kfs:rw





Appendix V

SOCIOECONOMICS



Appendix V.1

THE EXPORT BASE AND SELECTED SECTORAL
INCOME AND EMPLOYMENT MULTIPLIERS



2.5.4 The Export Base and Selected Sectoral
Income and Employment Multipliers

2.5.4.1 The Export Base Multiplier

The export base multiplier is a highly aggregated estimate of the number of "service" or supportive local jobs that will be created in a given area as the result of an expansion of "basic" or "export" employment.* It is an analytical technique which has been widely used, and widely criticized. The basic assumption is that there is a stable relationship between the number of jobs in export activities, and the number of jobs in local activities which support the basic sectors.

This is a weak assumption. First, there is the major difficulty of distinguishing between export and local service activities. But even if this difficulty could be overcome, the basic-service ratio -- from which the export base multiplier (X_k) is calculated -- would be stable only if industry and product mixes remained constant, and if there were no technological or structural changes in the area under

*Export base terminology is far from consistent. This report will use the terms "export" and "basic" to denote jobs in activities that sell in national and international markets as opposed to those which are "local" or supportive of the "basic" jobs. For a discussion of this issue, see Richard B. Andrews, "Mechanics of the Urban Economic Base: The Problem of Terminology," in Ralph W. Pfouts (ed.), The Techniques of Urban Economic Analysis, New York, Chandler-Davis, 1960.

consideration. These assumptions are so stringent one might wonder why anyone would trouble to go through the lengthy and tedious process involved in calculating X_k . The only jurisdiction that can be offered is that the export base multiplier establishes an upper limit to the employment impact of new activities in a given area. Data collected for this analysis also give a concise description of the economic structure of the study area.

The reason the export base multiplier overstates the employment impact of a new activity in an area is the implicit assumption that all local employment is dependent, directly or indirectly, on exports. As the late Charles Tiebout pointed out, in a now classic debate with Douglas North, the validity of this assumption depends on the size of the area being analyzed. The world as a whole has experienced substantial economic growth with no exports. In a modern industrial society, however, the individual household "exports" everything it contributes to the economy. Between these extremes, the relative importance of exports can vary widely from city to city, from state to state, and from region to region.

The details behind the export base multiplier for the SRC II area are given in Table 2-13.* The first step in estimating the

*These are the summary details. Data for the five counties were aggregated to obtain Table 2-13. Comparable national and state data were needed to calculate some of the figures given in this table.

export base of the area, as of 1976, was to calculate location quotients for each sector from the relation:

$$LQ_i = \frac{\frac{\text{employment in sector } i \text{ in SRC II area}}{\text{total employment in SRC II area}}}{\frac{\text{employment in sector } i \text{ in nation}}{\text{total national employment}}}$$

The LQs are used to help identify sectors that produce for export. The assumption behind the use of LQs is that in an area is self-sufficient in a given activity, local production will equal local consumption and the LQ = 1. An LQ less than one is supposed to indicate imports of goods and services in that sector; similarly, an LQ greater than one indicates that the sector produces for export.

But how much does it import and how much does it export? LQs really cannot answer this question. This is the point at which the objective nature of export-base analysis breaks down. Estimates of how each exporting sector exports are made on a purely subjective basis.* The estimates for the SRC II area are given in column 6 of Table 2-13. Some of these require a few words of explanation.

The second largest employer in the area is the coal industry. Table 2-13 shows that it exports all of its output. How can this be?

*There are some methods, such as the minimum requirements techniques, which appear to provide completely objective estimates of sectoral exports, but these methods are no more free of subjective elements than the one used here.

Is none of the coal produced in the area used locally? Actually, yes. Some of it is sold to local utilities. But the utilities export much of the electricity they produce -- much more than the 10 percent estimate for the transportation-public utilities sector. But despite the large LQ for mining, the area also imports some coal and electricity from surrounding counties. An impression of greater accuracy might have been given if we had estimated mining exports at, say, 98 percent. But this would have been entirely spurious accuracy. The estimates in column 6 represent the best judgments of analysts familiar with the structure of this local economy. Furthermore, slight changes in these percentages would have no appreciable effect on the export base multiplier.

The multiplier itself -- shown at the bottom of the table -- is calculated in two simple steps. First, the export-service ratio is calculated as shown; then the numerator of this ratio is divided into the denominator to obtain the multiplier. The multiplier of 2.247 indicates that for every 1,000 new jobs in export sectors, 2,247 supporting jobs will be created in the area. Despite the rather generous estimates of export employment in some sectors -- including a few with LQs less than one -- this value is too high to be regarded as a realistic "equilibrium solution" or final impact of the expansion of a given export activity in the area. But it is far from a useless exercise to calculate

this multiplier. It can be considered as a first approximation of the employment impact on an entire area due to the expansion of a major export activity.

2.5.4.2 Industry-Specific Multipliers

Conceptually, there is no difference between industry-specific multipliers and the export base multiplier. They are interpreted in the same way. But accurate estimates of industry-specific multipliers require far more data than the export base multiplier. Indeed, the only known method to calculate highly accurate industry-specific multipliers for a region is to construct an input-output table for that area.* No such table exists for the SRC II study area, but the latest West Virginia input-output table has been used, in conjunction with a technique developed in the Regional Economic Analysis Division of the U. S. Department of Commerce, to calculate the multipliers shown

*An input-output table is a highly disaggregated table which shows purchases and sales among all sectors within the study area, as well as purchases of primary inputs plus imports, and sales to final consumers (including exports). There is a 1975 table for West Virginia which has been used to estimate sectoral employment and income multipliers for the study area. The West Virginia input-output data are from Anthony Loviscek, *et al.*, The 1975 West Virginia Input-Output Study, Morgantown, West Virginia University Library, forthcoming; and from William H. Miernyk, *et al.*, Simulating Regional Economic Development, Lexington, Massachusetts, D. C. Heath and Company, 1970, pp. 193-195. For a general discussion of multipliers, both export base and sectoral, see William H. Miernyk, *et al.*, Impact of the Space Program on a Local Economy, Morgantown, West Virginia University Library, 1967.

TABLE 2-13: Area Employment by Industry^a

(1) SIC	(2) Industry	(3) Employ- ment	(4) Percent of Total ^b	(5) IQ US	(6) Percent Export	(7) Export Employ- ment
--	Agricultural services	18	*	0.06612	0	--
--	Mining	13,165	17.5	14.30567	100	13,165
--	Contract construction	2,838	3.8	0.68619	10	284
20	Food and kindred products	51	*	0.02878	0	--
23	Apparel and textiles	1,519	2.0	9.55561	85	1,291
24	Lumber and wood products	764	1.0	1.00594	10	76
27	Printing and publishing	508	0.7	0.39085	2	10
32	Stone, clay and glass products	827	1.1	1.18554	20	165
33	Primary metals	809	1.1	0.61114	5	40
34	Fabricated metal products	1,166	1.5	0.67333	20	233
35	Machinery (excluding electrical)	1,850	2.5	0.77376	25	462
--	All other manufacturing	10,955	14.6	0.97764	40	4,382
--	Transportation and public utilities	2,176	2.9	0.45666	10	218
--	Wholesale trade	4,174	5.5	0.78020	5	209
--	Retail trade	17,616	23.4	1.13088	15	2,642
--	Finance, insurance, real estate	2,875	3.8	0.54413	0	--
--	Services	11,821	15.7	0.73787	10	118
--	NEC	191	0.3	1.41111	0	--
	Total	75,230				23,145 = 30.8 73,230

* Less than one-half of 1 percent.

^a Excluding government, self-employed, and railroad employees.

^b Detail does not add to total because of rounding.

Xk = 2.247

Export/Service = $\frac{30.8}{69.2}$

Source: U. S. Department of Commerce, Bureau of the Census, County Business Patterns, 1976 - West Virginia, Washington, D.C., Government Printing Office, June, 1978; and *idem*, Pennsylvania.

in Table 2-14. The relevant West Virginia multipliers are also included to indicate the contrast between statewide and smaller area multipliers.

In 1977, the Regional Economic Analysis Division prepared a set of gross output multipliers for 173 BEA economic areas by adjusting national input-output coefficients to reflect differences in economic structure among the BEA areas.* The BEA area closest to the SRC II area is area number 065 centered in Clarksburg, West Virginia. It includes the three West Virginia counties in the SRC II area, but not Fayette and Greene Counties in Pennsylvania. It also includes several other West Virginia counties.

Difference between the two geographic areas are not too important since the U. S. Department of Commerce multipliers -- known as RIMS (Regional Industrial Multiplier System) multipliers -- were used for one purpose only; namely, to adjust the West Virginia input-output multipliers to a set that would more logically apply both to BEA area 065 and the SRC II area.

*The method is much too lengthy to attempt even a summary description here. The complete method and a map of all BEA areas are given in Guideline 5 Regional Multipliers, Washington, D.C., Government Printing Office, January, 1977. This report was prepared for the United States Water Resources Council by the Regional Economic Analysis Division, Bureau of Economic Analysis, U. S. Department of Commerce.

TABLE 2-14: Sectoral Employment and Income Multipliers^a

(1) Sector	(2) Employment Multiplier		(3) Income Multiplier	
	WV	SRC	WV	SRC
Mining	1.83	1.76	1.69	1.50
Apparel and textiles ^b	1.19	1.19	1.37	1.37
Lumber and wood products	1.59	1.43	2.11	2.11 ^c
Fabricated metals	1.41	1.13	1.55	1.34
All other manufacturing	1.43	1.19	1.69	1.66
Retail trade	1.43	1.07	1.46	1.12
Contract construction	2.67	2.04	2.17	1.53
Petroleum and coal products ^a				
Based on BEA 064	4.1	2.38	2.6	1.51
Based on BEA 066	4.1	2.76	2.6	1.18

^aFor the six export sectors, as determined by LQ analysis, plus contract construction and petroleum-coal products.

^bCalculated SRC $k < 1$. WV k used as best estimate.

^cCalculated SRC $k > WVk$. WV k used as best estimate.

In our view, most of the RIMS multipliers are much too high. They more nearly resemble the export base multiplier discussed above than the sectoral multipliers in Table 2-14. The reason is that the RIMS multipliers do not adequately allow for "leakages" from small areas. We used them, however, to "scale" down the West Virginia employment and income multipliers. This was done by calculating an adjustment factor (a) using the relation:

$$a = \frac{(WVGO)_i (WV k_i)}{RIMS065GO_i}$$

where: GO = gross output,

k = the employment or income multiplier,

i = the appropriate sector.

The adjustment factor was then used to scale down the state multipliers to the SRC II area multipliers by the relation $aWV k_i = SRC k_i$. *

The same formula was applied to both employment and income multipliers to obtain the results given in Table 2-14. Where the calculated multiplier was either less than 1 (an economic impossibility) or greater than the West Virginia multiplier, as happened in two of the smaller sectors, the West Virginia unadjusted multipliers were used.

*The employment multiplier for mining, for example, was calculated by:

$$\frac{(1.3) (1.83)}{2.468} = 0.96,$$

and $(0.96) (1.83) = 1.65.$

The two sectors of critical importance to the SRC II project are contract construction and petroleum and coal products. As Table 2-13 shows, the construction sector in the SRC II area was an importer in 1965 -- as measured by its LQ -- and there was no petroleum-coal products sector in the area. There was no petroleum-coal products sector in BEA area 065 either. Thus, the RIMS multipliers for two adjoining BEA areas (Columbus and Pittsburgh) were used to obtain the two estimates for this sector in Table 2-14.

The multipliers in Table 2-14 are Type II multipliers; that is, they include direct, indirect, and induced (or consumption) effects. Type II multipliers are calculated from input-output tables which include households as another "industry," that is, they are included within the table from which the technical (or input) coefficients are calculated. Thus, they can be regarded as the final "equilibrium" results of an injection of new investment funds in the area.

The employment multiplier for contract construction in the SRC II area suggests that for each direct job on the project there will be one other job created somewhere in the area. This includes jobs in supplying business establishments, and it also includes jobs that will be created by increased household spending in the area. While it might seem high, a priori, it is smaller than the unadjusted RIMS multiplier of 2.247, and the latter does not include household spending

Appendix V.2

REGIONAL INDUSTRIAL MULTIPLIER SYSTEM

V.2 REGIONAL INDUSTRIAL MULTIPLIER SYSTEM

V.2.1 Introduction

The total economic effect of a project is substantially greater than the direct cost of building and operating the facility because the total includes secondary economic effects as well as the initial investment. The additional, or secondary, effect is estimated through a multiplier relationship: the ratio between the total increase in economic activity as a result of a project and the initial project investment. The initial effect, known as the final-demand change, represents the change introduced into the economy by the project itself. The secondary effect is the sum of the additional economic activity generated in the region by the initial effect. The analyses are particularly important because economic stimulation and new jobs created are often the key benefits of the construction or operations phases of a project, and lost jobs are a major source of controversy when an ongoing project must be terminated.

During construction of a new power-generating facility, for example, the initial economic effect is represented by expenditures for (1) equipment and materials purchased from local manufacturers and distributors and (2) labor. The local direct suppliers in turn purchase goods and services from secondary suppliers (e.g., wholesalers). The secondary suppliers in turn rely on other suppliers farther removed from the project. These successive rounds of interindustry purchases and sales are the secondary economic effects of the project.

The size of the regional multiplier depends on the proportion of direct and indirect input requirements that can be supplied by the region's economy, which in turn depends on the specific needs of the project and the ability of the regional economy to supply the inputs. Conceptually, therefore, the multiplier is different for every specific combination of industry and site in the nation.

V.2.2 Alternative methodologies

Economists have developed several alternative means for estimating the total economic effect, given the initial effect. The three main approaches are the economic base model, the econometric model, and the input/output (I/O) model.

The economic base model provides the simplest approach to estimating total economic effect. This model divides the regional economy into two sectors, the export, or basic, sector, which produces goods and services for export to other regions, and the residentiary, or nonbasic, sector, which produces goods and services for local consumption. The income earned (or employment) in the impact analysis requires identifying the initial change in the export sector. The product of this initial change and the multiplier is the total change in income (employment).

In the econometric model, the economy is represented by a set of interrelated equations describing the interactions among economic components. Time-series data are assembled for the variables of the model, and regression analysis is used to estimate coefficients of the equations. The economic impact analysis usually involves introducing the initial change in the appropriate equation of the model and recalculating the other equations to obtain the total impact.

The I/O model describes the flows of goods and services to markets and between industries in a region. Each industry in the economy has a particular set of inputs required to produce its output; these requirements generally differ from those of other industries. The I/O model describes the structure of the economy and may be used to analyze the implications of the changes in one portion of the economic effects that are set off by the final-demand change. Implicit in this process is a multiplier that relates total change to a specific initial change.

Each approach has advantages and disadvantages. The economic base model is simple to apply, but it fails to provide results tailored to the specific project being analyzed. Equal initial changes, whether in agriculture or energy supply, will produce equal total changes. The econometric model offers results that are moderately sensitive to differences in the nature of the project, but the data requirements for a long time series for all variables and the time required to assemble and estimate the model generally rule out its use, particularly for areas smaller than a state. The I/O model generally provides more useful industrial detail than the other two. But, even though it does not require time-series data, an I/O model is usually costly to construct, and applications involving regions smaller than a state are difficult, again because of data limitations.

V.2.3 RIMS multiplier

HDR-Sciences uses a variation of the I/O approach known as the Regional Industrial Multiplier System (RIMS).^{*} This system was developed to overcome the cost and/or small-area data limitations associated with traditional approaches and to provide both geographic and industrial flexibility. It is a system of interrelated data files and computer programs designed to estimate I/O-type regional multipliers for any of the industries specified in the Bureau of Economic Analysis (BEA) national I/O model and for any region that can be defined as one or more counties in the United States.

The system combines several advantages of the economic base and I/O approaches to regional impact analysis to produce regional multipliers that are conceptually similar to I/O multipliers. RIMS relies on secondary data sources; it is sensitive to differences between industries; it operates at a detailed industrial level; and it is relatively inexpensive to apply.

The regional multiplier estimates the portion of succeeding waves of expenditures that occur within a defined region, thus providing a measure of the increased economic activity within the region. RIMS estimates project-specific multipliers needed to estimate changes in regional gross output, regional employment, and regional earnings by first computing the study industry's dependence on other regional industries.

The relationship is used to estimate the multiplier effect of an increase in final demand in a given industry on the regional gross output. Earnings-to-gross-output ratios are then used to translate the output increase into increases in earnings. For any given region, the ratio of employment to earnings is used to obtain an estimate of the total increased employment within the region.

Each industry requires inputs that are converted to an output, which serves as input to other industries. For example, the manufacture of electric motors requires, as some of its inputs, copper, electricity, labor, and transportation. When the electric motors are completed (and become an output) they are purchased by (and become inputs to) the copper industry, the electric appliance industry, and others. Some of these suppliers and some consumers are located in the region of interest; others are not. An I/O model ordinarily requires the development of an entire I/O matrix to account for this interdependence. While retaining many of the analytical opportunities of the I/O framework, RIMS avoids the need for this costly process by viewing the gross output multiplier as containing four elements: initial-change, direct effect, indirect effect, and induced effect.

The initial-change component in the multiplier represents project expenditures that will occur in the study region. Because this initial change is exactly equal to project expenditures, it is always represented in the multiplier by unity (1.000). The remaining components, the secondary economic effects, are added to the initial economic effect to provide total economic effect.

The direct-effect component accounts for (1) industry input requirements and (2) the ability of the area to meet them. The former is obtained from the national I/O model; the latter is derived from data relating to the study region (e.g., U.S. Bureau of the Census, County Business Patterns Program). Inputs required by the study industry but not produced in the region (or produced in insufficient quantity) must be imported by the region, thus reducing the direct effect component of the regional multiplier.

The input requirements are identified in the BEA national I/O model. The first step in regionalization is the evaluation of this set of requirements in light of what is known about the project or specific industry. The suitability of the national model industry for the project analysis is assessed, and project-specific adjustments are made in the national model input requirements on the basis of available project descriptions or engineering information.

Input requirements that result from this first step represent the technical requirements of the industry. The second step in regionalization reconciles the technical requirements of the industry with the capacity of the region to supply the required inputs. The technical requirements are replaced by regional direct coefficients reflecting the actual purchases of inputs from suppliers within the study region. This step is accomplished with the use of the location quotient, which is a double ratio of the form:

^{*}The RIMS system was developed in the Regional Economic Analysis Division of the Bureau of Economic Analysis, U.S. Department of Commerce. The HDR version of RIMS has been refined and updated by staff to meet client and government requirements.

- industry i employment in the study region/total employment in the study region, and
- industry i employment in the nation/total employment in the nation.

County Business Patterns data are used to estimate these location quotients. If the location quotient for a given input is zero, no production is carried on in the region. Thus, all the required input must be imported, and the regional direct effect is zero. If the location quotient is equal to or greater than one, production in the region is assumed to be sufficient to supply the study industry, and the regional direct effect is equal to the national direct requirement. In cases where the location quotient is greater than zero but less than one, the region is assumed to supply some of the input requirement, the proportion being equal to the value of the location quotient.

The location quotient test is applied to each regional industry that potentially supplies inputs to the study industry. The sum of all resulting regionalized coefficients is the direct component of the regional multiplier.

The indirect component and the induced component are computed as a single combined value in RIMS. The indirect-induced effects are those resulting from expansion of supplier and service industries to meet the needs of the directly affected industry, as well as changes in local consumption expenditures. The indirect interactions measure additional rounds of expenditures and production that result from the initial stimulus. Local consumer's incomes are increased by direct and indirect effects, and some part of the income increases will be spent in the region, stimulating additional economic activity. This effect of increased incomes to local consumers is the induced effect and is an extension of the indirect component. Estimation of the indirect-induced component is possible through the finding that, in an I/O model under empirically common conditions, the indirect-induced component can be estimated as a linear homogeneous function of the direct component. A sample of 17 I/O models containing 500 observations was used to develop the relationship.

V.2.4 Updated RIMS program

Implementation of the RIMS methodology requires the articulation of several data bases. National input-output data provided by the Bureau of Economic Analysis must be coordinated with county business pattern employment figures furnished by the Census Bureau.

In contrast to the 1967 tables, the latest (1972) national input-output tables did not produce interindustry direct requirement coefficients. Such coefficients must now be generated through appropriate combination of published "use" and "make" tables.

Each row of a use table shows sales to (1) each industry and (2) final users of the output of the commodity named at the beginning of the row. Each column shows the value of the input of commodities and the value added that is generated in production of the industry named at the head of the column. Each row of a make table reveals the value of each of the commodities produced by the industry named at the beginning of the row. The columns of a make table show the total output of each commodity produced in each industry.

Each industry is assumed to have its own technology, which is determined by its principal product; in other words, all commodities, whether principal or subsidiary, produced in one industry are made by the same process and therefore require the same input structure. This is referred to as the assumption of an industry technology. (The assumption of a commodity technology, though perhaps preferable from a theoretical viewpoint, can yield negative coefficients and is not considered suitable for impact analysis.) Under this assumption, an input-output coefficient matrix (A) can be obtained as a matrix product of appropriately scaled versions of the use (U) and make (V) tables. $A = BD$, where $U = B\hat{g}$ and $V = D\hat{q}$. The vector $\hat{g}$ is a diagonal matrix with industry outputs in the diagonal, and $\hat{q}$ is a diagonal matrix with commodity outputs in the diagonal. The industry technology was employed to compute an industry coefficients table; the most disaggregated use and make tables (511 industries) available from the Bureau of Economic Analysis were used. Household coefficients were calculated as value added divided by total inputs. To extract employee compensation from value added — which consists of employee compensation, indirect business taxes, and property-type income — value added was multiplied by the proportion of employee compensation in value added at the broad industrial division level.

To generate regional location quotients, the relative proportions of employment in specific industries in the region to be investigated to those in the nation must be known because the input-output data are national in nature. Employment estimates for four-digit Standard Industrial Code (SIC) industries were obtained from county business pattern publications for the latest available year, 1976. Because many figures are not revealed, due to disclosure rules, a reconciliation procedure was implemented to estimate employment for nonreported industries. This procedure required employment estimates at one level of industrial classification that conformed hierarchically to employment estimates at the next broader level. Because five levels of

industrial classification exist, a computer subroutine was written to match any of four given levels with the level immediately above it.

Because the industrial classifications employed by the Bureau of Economic Analysis and the Census Bureau are disparate, a bridge program was written so that location quotients could be computed for each of the I/O industries. This was accomplished by taking the published bridge and rearranging (sorting) it so that SIC industries — as opposed to I/O industries — were in ascending order. This facilitated the assignment of county business pattern employment estimates to the appropriate I/O industries as data were read in from magnetic tape, in order of ascending SIC codes.

Once I/O industry regional employment estimates are obtained in this fashion, regional location quotients (LQs) — the ratios of regional to national industrial concentrations — are computed. These LQs are then applied to the national input-output coefficients, generated under the industry technology assumption, to calculate regional direct multipliers.

This procedure can be summarized in the following four equations. [The dot (.) refers to summing across that subscript.]

$$A_{ij}^r = (R_i) (A_{ij}^n) , \quad (V.1)$$

$$EC^r = g(P_1, P_2, S) , \quad (V.2)$$

$$C_{.j}^r = F(A_{.j}^r, EC^r) , \quad (V.3)$$

$$M_{.j}^r = A_{.j}^r + C_{.j}^r + 1 , \quad (V.4)$$

where

A_{ij}^r = estimated regional direct coefficient,

R_i = regionalizing factor for industry i ,

A_{ij}^n = national direct I/O coefficient,

EC^r = factor describing the economic characteristics of the region,

P_1 = agriculture proportion of total nongovernment earnings,

P_2 = manufacturing proportion of total nongovernment earnings,

S = regional nongovernment earnings divided by national nongovernment earnings — a measure of the economic size of the region,

$C_{.j}^r$ = estimated indirect-induced component of the multiplier for industry j ,

$A_{.j}^r$ = estimated direct component of the multiplier for industry j ,

$M_{.j}^r$ = estimated total multiplier for industry j .

Equation (V.1) shows employment editing of the national table and further regionalization by location quotients. Equation (V.3) indicates that the indirect-induced component of the multiplier is estimated as a function of both the direct component and regional economic characteristics, which are specified in Eq. (V.2). Equation (V.4) is the multiplier identity. One overall multiplier, ($M_{.j}^r$), is estimated for each column industry. The multiplier represents the effect of a change in final demand for each column industry's output on the total regional output of goods and services, as well as a change in the associated effects on regional earnings.

Appendix V.3

TABLES AND FIGURES FOR APPENDIX V

Table V.1. Baseline population, average household size, and number of households (forecasts rounded to nearest hundred)

County	Item	1960	1970	1975	1976	1980	1985	1990	1995	2000
Fayette, PA	Population	169,340 ^b	154,667 ^b	156,607 ^a	155,117 ^a	157,500 ^f	157,700 ^f	158,000 ^f	162,000 ^f	165,300 ^f
	Average Household Size		3.15	2.98 ^f	2.98	2.96 ^f	2.87 ^f	2.79 ^f	2.77 ^f	2.75 ^f
	Households		49,108 ^d	52,600	52,100	53,200	54,900	56,800	58,500	60,100
Greene, PA	Population	39,424 ^b	36,090 ^b	38,558 ^a	38,331 ^a	42,400 ^f	45,800 ^f	49,100 ^f	52,100 ^f	55,100 ^f
	Average Household Size		3.10	3.06 ^f	3.04	2.96 ^f	2.91 ^f	2.87 ^f	2.84 ^f	2.81 ^f
	Households		11,875 ^d	12,600	12,600	14,300	15,700	17,100	18,300	19,600
Marion, WV	Population	63,717 ^c	61,356 ^c	62,805 ^a	63,622 ^a	65,600 ^h	67,800 ^h	69,500 ^h	71,300 ^h	73,100 ^h
	Average Household Size		2.96	2.92	2.91	2.87	2.83	2.78 ^g	2.78	2.78
	Households		20,727 ^e	21,500	21,900	22,900	24,000	25,000	25,600	26,300
Monongalia, WV	Population	55,617 ^c	63,714 ^c	67,116 ^a	67,844 ^a	71,900 ^h	76,400 ^h	80,100 ^h	83,900 ^h	87,900 ^h
	Average Household Size		3.24	3.20	3.19	3.15	3.11	3.06 ^g	3.06	3.06
	Households		19,687 ^e	21,000	21,300	22,800	24,600	26,200	27,400	28,700
Preston, WV	Population	27,233 ^c	25,455 ^c	26,844 ^a	27,603 ^a	28,600 ^h	29,900 ^h	31,000 ^h	32,300 ^h	33,600 ^h
	Average Household Size		3.32	3.27	3.26	3.22	3.17	3.12 ^g	3.12	3.12
	Households		7,667 ^e	8,200	8,500	8,900	9,400	9,900	10,400	10,800
Study Region	Population	355,331	341,282	351,930	352,517	366,000	377,600	388,200	401,600	415,000
	Average Household Size		3.13	3.04	3.03	3.00	2.94	2.88	2.86	2.85
	Households		109,064	115,900	116,400	122,100	128,600	135,000	140,200	145,500

^a"Population Estimates and Projections"^b1978 Pennsylvania Statistical Abstract, Table 4, p. 16 (Census).^cWest Virginia Statistical Handbook, Table 1.2, "Areas, Total Population, and Selected Population Statistics of West Virginia Counties, 1960 and 1970," 1974, p. 5.^dDetailed Housing Characteristics, Pennsylvania, Table 60, "Occupancy, Utilization, and Plumbing Characteristics for Counties."^eHousing Characteristics for States, Cities, and Counties, West Virginia, Table 60, "Occupancy, Utilization, and Plumbing Characteristics for Counties."^fThese population estimates are revisions of forecasts made by the Southwest Pennsylvania Regional Planning Commission in January, 1979. The revisions retain expected county population growth rates and use the same ratios of total population to total number of households. However, Current Population Report estimates for 1976 were used instead of the estimates made by the planning commission. Estimates for subsequent years reflect this difference.^gThe Regional Comprehensive Plan - Housing and Land Use Elements, Region VI, Table 4, "Population Forecasts by County and Region," and Table 19, "Households by County and Region, 1970-1990."^hThese population estimates are revisions of the forecasts made by Region VI, The Regional Comprehensive Plan - Housing and Land Use Elements. The revisions retain the county population growth rates implied in Table 4, "Population Forecasts by County and Region." These growth rates were applied to the most recent Current Population Report estimates for 1976. The 1985 to 1990 growth rates were used to estimate populations in 1995 and 2000.

Source: ER, Vol 2, Baseline socioeconomic survey, Table 2.4.

Table V.2. Location quotients, nonagricultural, private sectors, 1970

Occupation	Marion		Monongalia		Preston		Fayette		Greene		SRC II Area
	U.S.	WV	U.S.	WV	U.S.	WV	U.S.	WV	U.S.	WV	U.S.
Professional, technical and kindred workers	0.63	0.74	1.55	1.82	0.63	0.74	0.70	0.73	0.74	0.78	0.86
Managers and administrators (nonfarm)	0.67	0.92	0.76	1.05	0.54	0.75	0.59	0.91	0.64	0.99	0.63
Sales workers	0.97	1.00	0.81	0.83	0.53	0.55	0.98	0.88	0.82	0.74	0.89
Clerical and kindred workers	0.75	0.94	0.86	1.09	0.56	0.70	0.67	0.68	0.60	0.60	0.71
Craftsmen, foremen, and kindred workers	1.47	1.09	1.01	0.75	1.43	1.06	1.43	1.23	1.60	1.38	1.37
Operatives (except transportation)	1.86	1.45	1.02	0.78	1.53	1.17	1.65	1.16	1.59	1.12	1.59
Transportation equipment operatives	1.28	0.93	1.03	0.74	1.92	1.39	1.56	1.49	1.28	1.22	1.36
Laborers (nonfarm)	1.15	0.90	0.96	0.75	1.87	1.49	1.48	1.51	1.27	1.29	1.31
Farmers and farm managers	0.10	0.22	0.14	0.33	1.05	2.44	0.24	0.63	0.86	2.25	0.33
Farm foremen and laborers	0.06	0.13	0.24	0.50	0.88	1.87	0.35	1.00	0.82	2.33	0.35
Service workers (nonhousehold)	0.85	0.90	1.11	1.17	1.08	1.14	0.90	0.96	0.87	0.94	0.94
Private household workers	1.11	1.18	1.11	1.18	0.61	0.65	0.78	1.27	0.89	1.45	0.61

Source: ER, Vol 2, Baseline socioeconomic survey, Table 2.10.

Table V.3. RIMS multiplier leakage factors
(percentage)

	Employee nontravelers ^a	Travelers ^b
Export of net income from 70 mile region	10	45
Social security taxes	6	6
Federal income taxes	20	20
State income taxes	2	2
Personal savings	7	7
Total income leakage from 70 mile region	45	80

^aLocal residents and persons moving household to within 70 miles of the SRC-II site.

^bSRC-II employees who live only part-time within 70 miles of the SRC-II site, most notably construction workers who reside near the job site during the week but return to their household residence on weekends, or less frequently.

Table V.4. Estimated demand for construction labor for coal conversion demonstration plant^a

Work Force and Occupation	Year and Quarter												
	1980	1981				1982				1983			
	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
General and Administrative													
Construction Managers	0	0	3	3	3	3	3	3	3	3	3	3	3
Superintendents	0	0	15	15	15	15	15	15	15	15	15	15	15
Field Engineers	0	0	20	20	20	20	20	20	20	20	20	20	20
Systems Personnel	0	0	15	15	15	15	15	15	15	15	15	15	15
Inspectors	0	0	15	15	15	15	15	15	15	15	15	15	15
Secretaries	0	0	20	20	20	20	20	20	20	20	20	20	20
Purchasing Agents	0	0	15	15	15	15	15	15	15	15	15	15	15
Accountants	0	0	20	20	20	20	20	20	20	20	20	20	20
Subtotal	0	0	123	123	123	123	123	123	123	123	123	123	123
Construction Crafts													
Carpenters	0	13	39	134	170	170	170	221	221	207	182	109	59
Operators	35	51	51	64	118	141	189	218	213	192	145	84	56
Concrete Finishers	0	0	0	8	13	16	30	36	54	50	24	18	6
Electricians	0	15	43	0	27	67	131	268	482	554	554	411	212
Painters	0	0	0	14	14	36	36	44	86	165	217	201	167
Pipefitters	0	15	43	100	100	176	327	629	918	918	918	704	277
Ironworkers	0	0	0	132	179	208	280	280	280	227	189	88	38
Boilermakers	0	0	0	80	151	151	151	360	360	307	185	151	75
Millwrights	0	0	0	8	8	23	23	42	42	77	77	61	27
Insulators	0	0	0	0	0	0	0	0	41	187	318	296	253
Teamsters	13	16	16	32	55	55	69	78	74	62	52	42	27
Laborers	0	13	13	111	216	216	261	261	261	223	206	144	91
Subtotal	48	123	206	683	1,052	1,262	1,670	2,437	3,031	3,168	3,067	2,308	1,287
Total for G&A and Crafts	48	123	329	806	1,175	1,385	1,793	2,560	3,154	3,291	3,190	2,431	1,410

^aFigures are quarterly averages and may obscure peaks and valleys occurring in particular months.

Source: ER, Vol 2, Table 2.19, p 2-123.

Table V.5. Estimated demand for operations labor for coal conversion demonstration plant

General and Administrative ^a		Plant Operators		Maintenance Craftsmen ^b	
Managers	5	Grade A	13	Instrument Fitters	12
Supervisors	25	Grade B	67	Pipefitters	12
Administrators	40	Grade C	70	Electricians	6
Professionals	5			Welders	12
Engineers	40			Millwrights	18
Scientists	15			Machinists	4
Technicians	20			Carpenters	2
Clerks/typists	30			Insulators	2
Secretaries	10			Operating Engineers	4
Others	10			Boilermakers	8
				Ironworkers	2
				Painters	2
				Riggers	4
				Laborers	18
				Teamsters	4
Subtotal	200	Subtotal	150	Subtotal	110

^aApproximate occupational breakdown of functional requirements summarized in Table 2-23.

Supervisors include 20 engineers and 5 craftsmen. Administrators include personnel with degrees and/or training in business, engineering or arts and sciences. Professionals are medical personnel.

^bContract maintenance will require an additional 100 or so craftsmen.

Source: ER, Vol 2, Table 2.22, p 2-133.

Table V.6. Estimated peak year construction — labor requirements^a and availability level by craft (90-minute (70-mile) zone, 1983)

Craft	Estimated peak construction demand	Estimated employment ^b	Demand as a percentage of employment
Insulators	821	480	171
Boilermakers	760	229	332
Carpenters	9325	8907	105
Concrete finishers	2048	1967	104
Electricians	4244	3572	119
Ironworkers	1656	1136	146
Laborers	5416	4913	110
Millwrights	328	229	143
Operating engineers	3841	3431	112
Painters	2074	1815	114
Pipe fitters/plumbers	4380	3186	137
Teamsters	1697	1546	110

^aTotal zone demand is the sum of baseline SRC-II and other large project demands.

^b1979 estimated employment assumed to grow at two percent per year.

Source: ORAU Table 1-5, p. 19.

Table V.7. Average annual payrolls per employee, private nonagricultural sector, 1976

Industry Group	1	2	3	4	5	6
	County					5-County Area
	Marion	Monongalia	Preston	Fayette	Greene	
Mining	\$16,133	\$15,577	\$16,215	\$16,289	\$16,264	\$16,027
Contract construction	12,620	10,526	10,176	13,250	8,484	12,083
Apparel and other textiles	--	--	--	6,028	--	6,028
Lumber and wood products	--	--	8,636	8,361	5,699	8,122
Printing and publishing	10,204	--	--	8,805	--	9,400
Stone, clay and glass	--	8,187	--	--	--	8,187
Primary metals	12,225	--	--	11,973	--	12,133
Fabricated metals	--	--	--	12,679	--	12,679
Machinery (except elec)	11,182	11,393	--	12,191	--	11,333
All other manufacturing	12,431	9,045	8,004	11,929	6,947	10,966
Transportation and public utilities	12,762	12,090	11,758	10,880	10,589	11,585
Wholesale trade	9,889	10,060	13,699	10,779	7,768	10,583
Retail trade	6,044	5,875	6,346	5,735	5,935	5,891
Finance, ins., real estate	7,618	8,064	10,649	8,700	7,804	8,321
Services	6,742	6,365	5,420	6,641	6,128	6,493
NEC	9,333	12,139	6,000	7,755	7,200	8,603
Annual Average	\$10,500	\$9,609	\$9,952	\$8,948	\$11,482	\$9,789

Source: ER, Vol 2, Baseline socioeconomic survey, Table 2.9, p 2-73.

Table V.8. Per capita income, 1969 and 1975

County	Per Capita Income				Percent Change 1969- 1975
	1969		1975		
	Dollars	Percent of U.S.	Dollars	Percent of U.S.	
Marion	2,465	79	4,163	82	68.9
Monongalia	2,465	79	4,196	83	70.5
Preston	1,824	59	3,495	69	91.6
Fayette	2,164	70	3,676	72	69.9
Greene	2,185	70	3,817	75	74.7
United States	3,111	100	5,077	100	63.0

Source: ER, Vol 2, Socioeconomic baseline survey, Table 2.12, p 2-83.

Table V.9. Total annual salary estimates for SRC-II noncraft construction personnel, 1981 through 1983^a

	Personnel required	1981	1982	1983
Construction managers	3	120	174	189
Superintendents	15	513	745	812
Field engineers	20	570	828	902
Systems personnel	15	342	497	541
Inspectors	15	342	497	541
Secretaries	20	228	331	361
Purchasing agents	15	342	497	541
Accountants	20	456	662	722
Total		2,910	4,230	4,610

^aIn thousands of dollars.

Source: Pittsburg and Midway Coal Mining Co., Denver, August 1980.

Table V.10. Total annual wage estimates for SRC-II craft construction personnel, 1980 through 1986^a

	1980	1981	1982	1983	1984	1985	1986	Total
Boilermakers	25	322	408	7,095	2,405	267	26	10,547
Carpenters	32	631	4,766	4,695	1,993	375	37	14,395
Finishers	8	125	1,183	406	22	61		1,805
Ironworkers	51	684	6,547	14,067	1,040	492	54	22,935
Laborers	59	1,246	8,766	8,661	2,943	642	55	22,372
Millwrights	8	130	113	2,846	935	96	13	4,142
Operators	54	1,120	7,081	9,610	2,932	528	49	21,373
Pipefitters	144	1,603	4,998	24,342	20,449	1,451	133	53,120
Teamsters	19	310	1,843	3,692	1,445	227	20	7,556
Electricians	27	292	757	3,320	5,730	338	28	10,491
Insulators	8	106	47	286	3,922	277	13	4,660
Painters	16	174	94	386	4,206	1,115	13	6,005
Total for year	456	6,837	37,312	80,105	48,319	5,926	446	179,401

^aIn thousands of dollars.

Source: Pittsburg and Midway Coal Mining Co., Denver, August 1980.

Table V.11. Preliminary estimates of recruitment and migration patterns for the coal conversion project construction and operations work forces

Work Force	Workers Recruited from Each Migration					
	Moving Zone		Traveling Zone		Commuting Zone	
	N	%	N	%	N	%
Construction						
Non-manuals ^a	75	68	0	0	35	32
Craftsmen	?	?	?	?	?	?
Operations						
G & A Personnel	130	65	0	0	70	35
Operators	100	67	0	0	50	33
Craftsmen	?	?	?	?	?	?

^a15 Supervising craftsmen are reclassified and included in the construction craftsmen category.

Source: ER, Vol 2, Socioeconomic impact analysis, Table 2.25, p 2-147.

Table V.12. Total annual salary estimates for SRC-II plant maintenance craftsmen, 1984 through 1987^a

	Personnel required	1984	1985	1986	1987
Instrument fitters	12	470	513	554	609
Pipefitters	12	470	513	559	609
Electricians	6	246	268	292	319
Welders	12	470	513	554	609
Millwrights	18	680	742	808	881
Machinists	4	164	179	186	203
Carpenters/insulators	4	150	164	179	195
Operators	4	142	157	171	186
Boilermakers	8	304	331	361	393
Ironworkers	2	79	86	94	102
Painters	2	76	83	91	98
Riggers	4	158	172	188	205
Laborers	18	490	535	582	635
Teamsters	4	119	130	141	154
Total		4,022	4,385	4,770	5,200

^aIn thousands of dollars.

Source: Pittsburg and Midway Coal Mining Co., Denver, August 1980.

Table V.13. Total annual salary estimates for plant operational personnel^a

	Personnel required	1984	1985	1986	1987
Grade A	13	470	512	558	608
Grade B	67	2,275	2,480	2,704	2,947
Grade C	70	2,201	2,398	2,615	2,880
Total		4,946	5,390	5,877	6,435
Total, maintenance and operations		8,968	9,775	10,648	11,635

^aIn thousands of dollars.

Source: Pittsburg and Midway Coal Mining Co., Denver, August 1980.

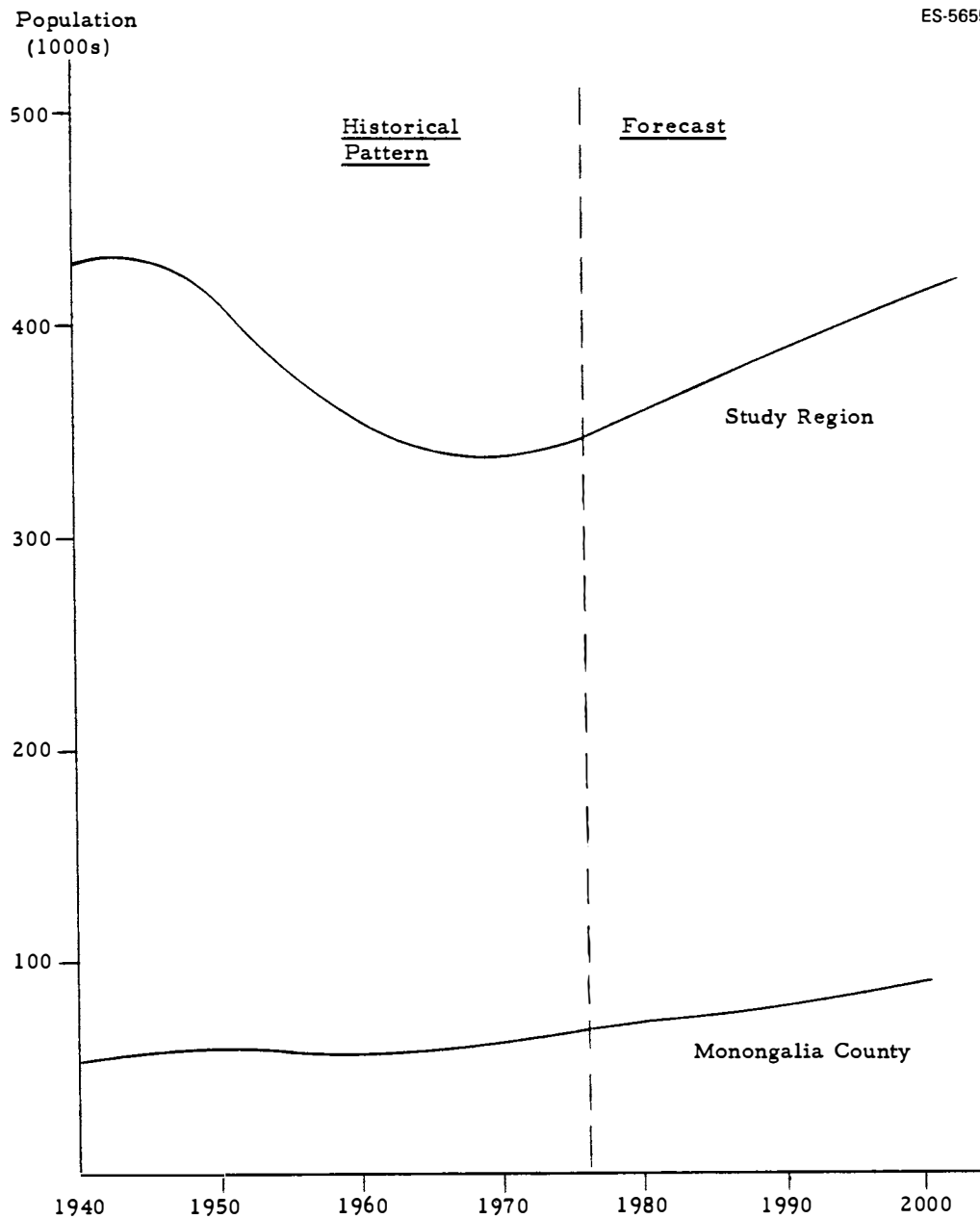
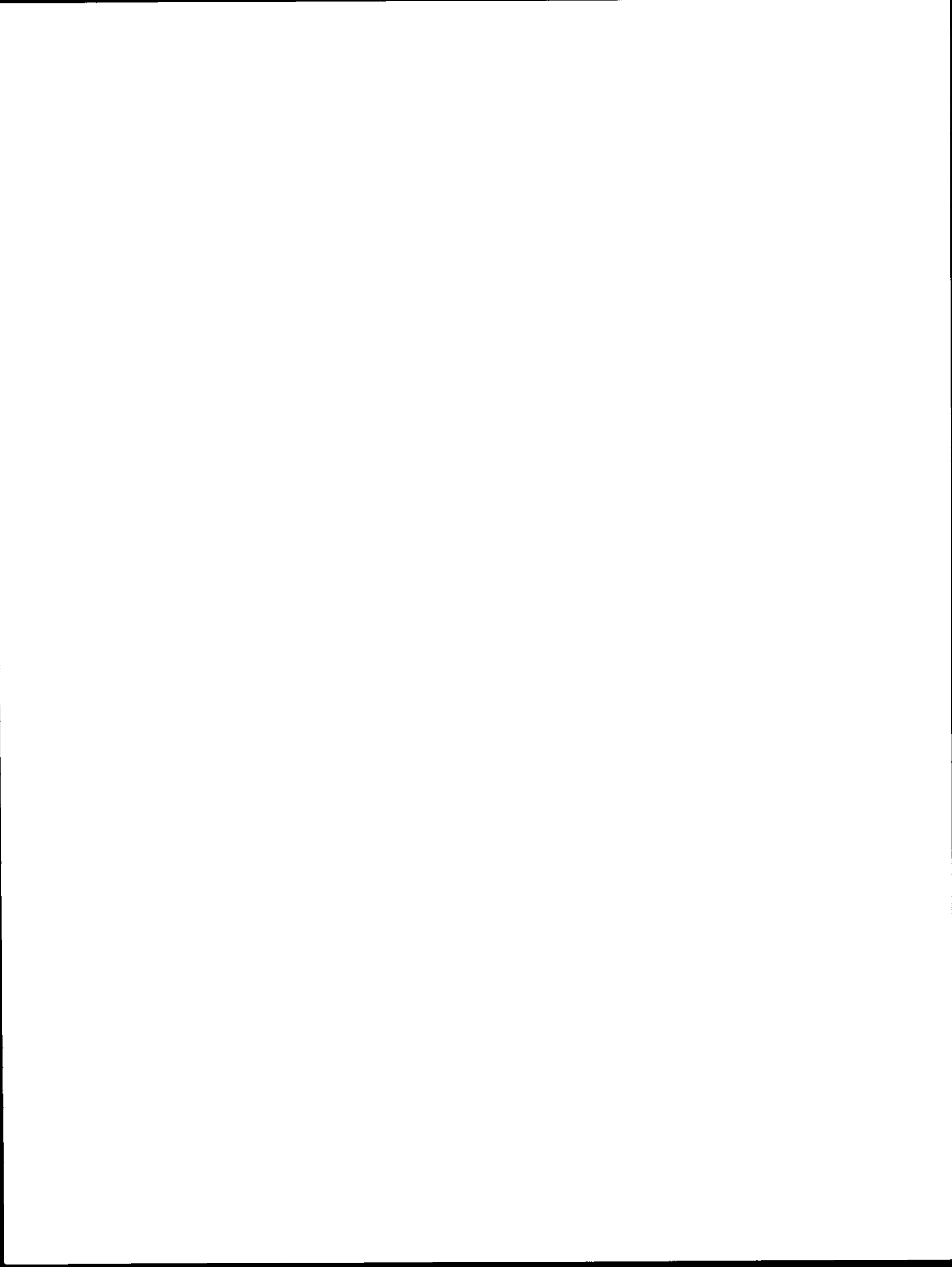


Fig. V.1. Baseline population forecast: Monongalia County and study region. Source: ER, Vol. 2, Fig. 2-7, p. 2-53.

Appendix V.4

HOUSING ANALYSIS



HOUSING ANALYSIS
for the
MONONGALIA COUNTY AREA OF WEST VIRGINIA

prepared for the
REGION VI PLANNING AND DEVELOPMENT COUNCIL
and the
MORGANTOWN AREA CHAMBER OF COMMERCE

by
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I. INTRODUCTION

The Monongalia County area of West Virginia is a prime site for energy development activities that will be undertaken to meet this country's future energy needs. Among the major factors that will contribute to the City of Morgantown's and Monongalia County's emergence as a major energy research and development center are:

- o The extensive coal mining operations in the area which present a variety of industrial opportunities, such as the construction and operation of coke manufacturing plants.
- o The construction of the country's major coal liquefaction demonstration plant (the SRC-II plant) at a site just north of Morgantown.
- o The location of the Department of Energy's Energy Research Technology Center in Morgantown.
- o The location of the Appalachian Laboratory for Occupational Safety and Health (ALOSH) in Morgantown.
- o The various energy research programs conducted at West Virginia University in Morgantown.

Because of the concentration of these activities in the Morgantown area and because of the increased reliance that will be placed on coal resources to meet our future energy requirements, it is considered likely that a number of other industries and activities that support and complement these basic activities will also consider a future Morgantown location.

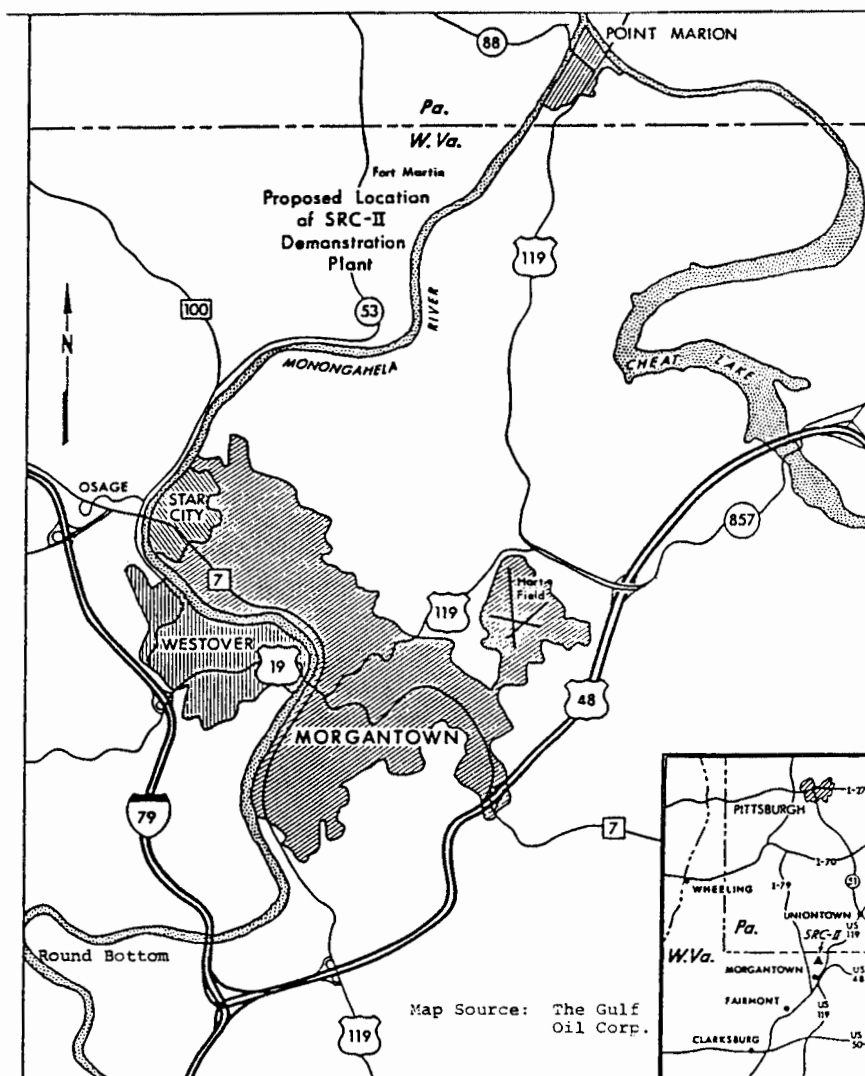
The City of Morgantown and Monongalia County are thus in a position to benefit from activities that will be undertaken to meet this country's future energy needs. However, activities associated with the development of energy resources (or any other rapid growth-inducing industries) can also negatively impact an area if not properly anticipated and planned for. The impact on housing is one such area of concern.

Because of the concern over housing availability, the Region VI Planning and Development Council headquartered in Fairmont, West Virginia has initiated this study to assess both the short-term and long-term impacts on housing demand and supply which could result if energy-related developments occur as is presently anticipated. A general locational map of the Monongalia County project study area is shown in Figure 1.

Chapter II of this report presents a summary of available information on the existing housing supply within Monongalia County. Chapter III presents information related to the demand for both temporary and permanent housing during the period between 1980 and 1985. Chapter IV presents an analysis of the factors affecting the meeting of the projected demand. Finally, in Chapter V recommendations concerning organizational responsibilities for the development of future housing within Monongalia County are presented and discussed.

Figure 1

MONONGALIA COUNTY STUDY AREA



II. MONONGALIA COUNTY HOUSING INVENTORY

A. Development of the Housing Inventory

When this study was initiated in June, preliminary 1980 census information was not yet available. Consequently, an initial attempt was made to develop a current inventory of housing within Monongalia County through the collection of secondary data (i.e., not through a comprehensive field survey).

Subsequent to the completion of this inventory, preliminary census information on housing within Monongalia County was released. Although still subject to revision and not yet detailed, this 1980 census data was used, as appropriate, to revise the 1980 housing stock estimates which were based on the available secondary data.

The following sections describe the approaches used to develop the housing inventory.

1. Development of Base Year Data

The 1970 census reported housing data by small statistical areas, including: the number of owner-occupied, renter-occupied and vacant units; the age of the housing stock; housing unit size in terms of number of rooms; and whether the housing was standard or substandard. In 1978 the Region VI Planning and Development Council published a report titled Region VI Comprehensive Plan: Housing, which updated the 1970 housing census information through 1975. As part of this effort, the Region VI Council staff conducted a field survey of approximately 17 percent of the housing stock in Monongalia County in order to develop estimates needed to classify housing as either standard, substandard but rehabilitable, or substandard and not rehabilitable.

An attempt was made as part of this study to update the 1975 Region VI housing inventory to 1980 with information available from a variety of sources on both new housing starts and housing unit demolitions. The various sources for this data are discussed in Sections A2 and A3 of this chapter.

However, based on the preliminary 1980 census information, it appears that the Region VI housing study significantly underestimated the number of housing units within Monongalia County in 1975. This assumption is based on the following:

- o The Region VI housing study estimated that an average of 562 new units per year were added to the County's stock between 1970 and 1975. In contrast, detailed data available from the Monongahela Power Company on new housing stock additions between 1976 and 1979 indicates that an average of 845 units per year were added to the County's stock. (It should be noted that detailed breakdowns on new housing additions within Monongalia County prior to 1976 are not readily available from Monongahela Power.)
- o The Region VI study estimated that an average of 370 housing units were lost from the County's housing stock by actions such as demolition during the period between 1970 to 1975. In contrast, a loss of only about 20 units per year for the period from 1976 to 1980 has been estimated based on limited available data.

In the Region VI study, the estimated net annual increase in the Monongalia County housing stock between 1970 and 1975 was 192. In contrast, the estimated net annual increase between 1976 and 1979 based primarily on Monongahela Power Company data was 825. Other factors that could have contributed to the discrepancies between the preliminary 1980 census data and the 1980 estimates based on secondary data sources include possible inaccuracies in the

1970 and/or 1980 census housing counts.

Because the preliminary housing census estimates are based on primary data and because this data constitutes the officially recognized baseline conditions, the preliminary 1980 census data was used as the base from which other housing estimates were derived.

The preliminary 1980 census indicates that there were 29,192 housing units in Monongalia County as of April 1980 (as compared to 21,004 units in 1970) and that 27,174 of these units were occupied.

2. Data on New Housing Starts

The availability of accurate data on new housing starts is important for two reasons: it enables census information to be updated on a continuous basis; and such data is essential to the analysis of development and housing market trends.

A number of data sources were reviewed and evaluated in order to determine the quality of information available on new housing stock additions within this County. These sources include:

- o The City of Morgantown Building Inspector for information on housing starts and demolitions. (Monongalia County does not operate a building permit program.)
- o The Monongalia County Health Department for information on septic tank permits that have been issued.
- o The Monongalia County Planning Department for information available from aerial photography.
- o The Monongahela Power Company for information on new utility extensions and housing tie-ons.

Information available from the Monongahela Power Company is easily the best source of information on new housing starts within Monongalia County. The utility maintains monthly records of new utility connections

for the following classifications: single family detached; multi-family attached (broken down by duplexes, apartments, townhouses and condominiums); and mobile homes. Table 1 summarizes the data available from the Monongahela Power Company on new housing connections for the period January, 1976 - May, 1980. This data is useful in evaluating trends in the type of housing being constructed.

TABLE 1

New Housing Units Provided Electrical Service Since 1975

Year	Single Family	Multi-Family	Mobile Homes	Total
1976	351	66	236	653
1977	397	222	375	994
1978	440	277	268	985
1979	307	215	226	748
1980	<u>103</u>	<u>95</u>	<u>81</u>	<u>279</u>
TOTAL	1,598	875	1,186	3,659

Source: Monongahela Power Company

Information available from the Monongalia Health Department is useful only for single family starts in areas without public sewers. Even this information is considered to be of somewhat questionable value since Health Department officials believe that septic tanks are frequently constructed in unincorporated portions of the County without obtaining the required permits.

Aerial photographs of the County, flown in March, 1977, are available. Based on interpretation of this

photography, there were 11,088 housing units in the County outside the City of Morgantown as of this date. However, it is not possible from the photography to estimate the number of units available in multi-family structures, which make up approximately one-quarter of the total County housing stock.

About 90 percent of the housing constructed within Monongalia County during the past decade has occurred in unincorporated portions of the County. Consequently, available building permit information is useful only in developing a breakdown of new housing inside and outside the City of Morgantown.

Because of the reasons discussed above, data available from the Monongahela Power Company should be used as the prime source for continually updating 1980 census data related to the Monongalia County housing stock. A recommended process for keeping the housing inventory current has been presented in a separate working paper.

3. County Housing Stock Estimates

Based on a review of 1970 census data, 1975 Region VI housing data on owner-occupied and rental units, and preliminary 1980 census data, it was estimated that approximately 37 percent of the housing units in the County are rental units and the remaining 63 percent are units which are either owner-occupied, vacant and available for sale or vacant and non-habitable (dilapidated). It was further assumed, based on available data, that approximately 80 percent of single family houses and mobile homes, and approximately 10 percent of multi-family units within Monongalia County are owner-occupied.

(NOTE: multi-family units include duplexes and townhouses.) Conversely, it was assumed that 20 percent

of all single family structures and mobile homes and 90 percent of the multi-family units are available for renter occupancy. Table 2 depicts the results of applying these assumptions to the 1980 housing stock estimates.

TABLE 2
1980 Estimates of Housing

	<u>Non-Rental Units*</u>	<u>Rental Units</u>	<u>Total</u>
Single Family	13,826	3,674	17,500
Multi-Family	677	6,468	7,145
Mobile Homes	<u>3,592</u>	<u>955</u>	<u>4,547</u>
TOTAL	18,095	11,097	29,192

* It should be noted that non-rental units are always potentially available for rental purposes.

4. Housing Availability

a. Non-Rental Housing Units

Information on the availability of non-rental housing units was obtained from two sources: from the Multiple Listing Service (MLS); and through telephone interviews with representatives of the firms that do not participate in the MLS system.

Summaries of the June 1980 and June 1979 MLS listings are shown below. The June 1979 listings were reviewed in order to examine changes in the owner-occupied housing market over the past year.

TABLE 3

	Number of MLS Listings by Price Range			
<u>Date</u>	<u>Below \$40,000</u>	<u>\$40,000-\$60,000</u>	<u>Above \$60,000</u>	<u>Total</u>
June 1979	45 (20%)	87 (38%)	97 (42%)	229
June 1980	54 (23%)	85 (37%)	93 (40%)	232

Information available from non-participating realtors is not available in the same degree of detail as with MLS. Realtors estimated that the number of units that have exclusive listings or that are being sold directly by owners presently fluctuates between 150 and 200, and generally falls within the following price categories:

Below \$40,000	- 20%
\$40,000-\$60,000	- 40%
Above \$60,000	- 40%

These estimates are consistent with information obtained from the MLS.

Based on available information, it appears that approximately 3 percent of Monongalia County's owner-occupied single family and multi-family units are presently available for sale.

If it is assumed that 3 percent (514 units) of the owner-occupied housing stock in the County is presently available for sale and that about 50 percent of these are vacant, the number of vacant units would be about 257.

b. Rental Units

A telephone survey was conducted of the County's apartment managers in order to obtain information on the number of units available and on present and normal vacancy rates. The managers of almost 25 percent of the rental units in Monongalia County were contacted through the survey. Additionally, privately conducted surveys taken over the past three years were reviewed and utilized in the analysis.

Based on the surveys conducted, it can be concluded that vacancy rates in Monongalia County vary

significantly throughout the year. This is primarily attributable to changes in enrollment at West Virginia University and to changes in student living patterns that occur over the course of an academic year. Vacancy rates for rental units are extremely low during the fall when enrollment is highest and gradually rise over the academic year until the summer, when vacancy rates are over 10 percent.

Based on the information developed, it has been assumed that rental vacancies within the County generally follow the pattern shown below.

<u>Vacancy Rate</u>			
<u>Sept-Nov</u>	<u>Dec-Feb</u>	<u>Mar-May</u>	<u>June-Sept</u>
2%	3-5%	5-7%	10+%

Based on these vacancy rate estimates and the telephone survey, it was estimated that about 603 rental units were vacant in April 1980 at the time the census was taken (this estimate was developed by utilizing a 6 percent vacancy rate).

c. Non-habitable Vacant Units

It has been estimated that 28,034 of the 29,192 dwelling units in the County in April 1980 were habitable (this is based on vacancy rate assumptions described above). This means that approximately 4.1 percent of the total housing stock (1,158 units) were vacant but not habitable. This 4 percent estimate is consistent with both 1970 census data and with data derived through the 1975 Region VI housing stock field survey.

d. Motels and Hotels

A telephone survey of all Monongalia County hotel

and motel operators was conducted to determine the number of rental rooms within the County. Approximately 800 such rooms are presently available.

5. Housing Structural Conditions

In the 1970 Census of Monongalia County, 79 percent of the housing units were identified as being in standard condition and 21 percent of the housing units were identified as being structurally deficient or sub-standard.

In 1975, the Region VI Planning Council conducted a sample survey of 17 percent of the housing units within Monongalia County. In this survey, housing units were classified as follows:

- o Standard: No observable exterior problems or only minor problems that could be easily corrected.
- o Substandard-Rehabilitable: The housing was deteriorated and major repairs were needed to one of the primary components of the building (roof, walls, siding or foundation), or on secondary components (doors, windows, stairs, chimneys, porches, etc.) in order to bring the unit up to standard condition.
- o Substandard-Dilapidated: The housing was beyond repair. Major and minor components were deteriorated to a point beyond economic repair, indicating demolition to be more economically feasible than rehabilitation.

There is no way of updating this data in the absence of a detailed field survey. Consequently, it was assumed that the additions to the housing stock between 1976 and 1980 have raised the percentage of standard housing to about 80 percent. It was assumed that about 75 percent of the total sub-standard units are rehabilitable.

Based on these assumptions 95 to 96 percent of the housing stock within Monongalia County is either presently suitable or potentially suitable for occupancy.

6. Rental Rates

Rental unit cost surveys are periodically conducted for major apartment projects in the Morgantown area. Results from the latest survey are shown in Table 4 below.

TABLE 4
Typical Monongalia County Rental Unit Rates
by Type of Unit

Year	1 BR	2 BR/1 B	2 BR/1-1/2 B	2 BR/2 B	3 BR	4 BR
1977	174	221	295	300	278	
1978	197	251	295	310	285	
1979	220	281	300	325	325	
1980	245	312	303	350	331	346

The above data is useful only in making rough estimates of what typical rental rates are in the Morgantown area. It should be used with caution, since no attempt has been made to account for the various factors that affect the comparative costs of similarly sized units. These factors relate primarily to whether the units are furnished or unfurnished, whether utilities are included in the basic rent, the length and terms of the lease, the age of the units and the amenities offered.

7. Housing Location

1970 census information on Monongalia County is available for 34 enumeration districts. A detailed breakdown of 1980 housing information by these

enumeration districts is not yet available. However, this level of detail is not really needed for this analysis, whose major objective is to contrast existing regional housing supply with future demand. Consequently, only the breakdown of housing between the City of Morgantown and for the area of Monongalia County outside the Morgantown corporate limits was analyzed.

Preliminary 1980 census information indicates that approximately 35 percent of the Monongalia County housing stock is located within the City of Morgantown

→ About 47 percent of the County's rental unit stock
→ and about 27 percent of its non-rental stock are located within the City. About 90 percent of new construction is occurring in unincorporated areas of the County.

8. University Housing

Students at West Virginia University meet their housing needs in a variety of ways. A summary of presently available university housing and private dormitories reserved for university students is shown below.

TABLE 5
Summary of Student Housing Availability

University Housing		
Single Student Housing	3,566	
Married Student, Faculty and Staff Housing	<u>361</u>	3,927
Sororities and Fraternities		765
Private Dormitories		
Carlyle Hall	114	
Glennlock Hall	120	
Pierpont House	540	
Summit Hall	585	
Westchester Hall	<u>270</u>	
		<u>1,625</u>
TOTAL		6,317

B. SUMMARY OF KEY FINDINGS

1. It is estimated that in April 1980, there were approximately 29,192 housing units located in Monongalia County. Of these, 27,174 units were occupied, 860 units were vacant and habitable, and 1,158 units were vacant and not habitable.
2. There were 3,659 housing units added to the Monongalia County housing stock in the period between 1976 and May 1980 (an average of over 800 units per year), as shown below.

	<u>Units Added</u>	<u>Percent of 1976-1980 Increase</u>
Single Family	1,598	44
Multi-Family	875	24
Mobile Homes	<u>1,186</u>	32
	3,659	

3. Mobile homes are becoming an increasingly important source of housing for the residents of Monongalia County as is shown below.

	<u>Percent of Total Stock</u>		
	<u>1970</u>	<u>1975</u>	<u>1980</u>
Single Family	70	63	60
Multi-Family	22	24	24
Mobile Homes	8	13	16

4. Approximately 88 percent of the new housing constructed in Monongalia County in the period of between 1976 and 1980 was constructed outside the City of Morgantown.
5. Despite the relatively old age of the County's housing stock, housing stock loss is estimated as being very low between 1976 and 1980--only about 20 to 25 units per year.

6. Approximately one-third of the housing in Monongalia County is utilized for rental purposes. The other two-thirds is owner-occupied, vacant and for sale or vacant but not habitable.
7. Based on sales figures from 1979 and 1980, single family housing stock appears to fall within the following price ranges.

<u>Price</u>	<u>Percentage of Stock</u>
Below \$40,000	20
\$40,000 - \$60,000	40
Above \$60,000	40

8. Approximately 3 percent of the County's single family stock in May, 1980 was available for sale (over 500 units).
9. The vacancy rate for rental units varies throughout the year from about 2 percent in the fall when West Virginia University enrollment is highest, to between 5 and 7 percent in the spring, and to over 10 percent in the summer.
10. Approximately 6,317 WVU students, or only about 40 percent of full-time enrollment, can be accommodated in university housing or in university-approved dormitories.

III. HOUSING DEMAND WITHIN MONONGALIA COUNTY

A. Approach for Estimating Demand

The future demand for housing within Monongalia County is principally dependent upon two factors:

- o Employment growth within the County; and
- o West Virginia University enrollment levels.

Consequently, the analysis of projected housing demand was based on: an analysis of baseline employment growth (essentially "normal" growth that would be expected to occur within Monongalia County based on past growth trends and overall State of West Virginia economic growth); an analysis of large employment generators, such as the SRC-II demonstration plant, that might be developed over the next few years, but which should be considered in addition to the baseline employment projections; and enrollment trends and projections for West Virginia University.

Once adequate data related to Monongalia County growth was collected, the next step was to convert the projected employment and university growth into additional demands for both temporary and permanent housing.

B. Baseline Employment Projections

Detailed information on Monongalia County employment through 1978 is available from data published by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA). Summary totals of Monongalia County employment for the years 1971 through 1978 are presented in Table 6. A detailed categorical breakdown of 1978 employment is contained in the Appendix.

Based on information summarized in Table 6, the annual employment growth rate for this period was about 2.8 percent.

TABLE 6

Monongalia County Employment 1971-1978

<u>Year</u>	<u>Total Employment Within Monongalia County</u>
1971	25,582
1972	27,835
1973	27,747
1974	27,938
1975	28,549
1976	30,194
1977	30,636
1978	31,658

An analysis of projected employment growth within the County was recently conducted for the Monongalia County Department of Planning. This analysis was based on BEA data and on a special analysis of Monongalia County's share of total projected State of West Virginia employment growth over the period 1979-1985. The results of this analysis are presented in Table 7. Detailed projections are shown in the Appendix.

If these employment projections prove to be correct, Monongalia County would experience a baseline employment growth of 6,235 (approximately 18.7 percent) during the period 1980-1985. This growth does not include that attributable to large-scale construction projects, such as the SRC-II plant or the Round Bottom coke plant, that have been proposed for the County.

TABLE 7
Monongalia County Employment
Estimates and Projections
1979-1985

<u>Year</u>	<u>Estimated/Projected Employment</u>
1979	32,212
1980	33,293
1981	34,427
1982	35,613
1983	36,857
1984	38,161
1985	39,528

Baseline Housing Demand

The 1970 census estimated that there were 19,687 occupied housing units within Monongalia County. There were also approximately 24,900 jobs in the County at that time. This produces a ratio of about 1.25 jobs per household in 1970. Based on preliminary 1980 census data, there were 27,174 occupied housing units within the County on April 1, 1980. Consequently, the number of jobs per occupied housing unit dropped to 1.225. Normally, the housing needs in any given year between 1980 and 1985 could be estimated by dividing the projected number of jobs in that year by 1.225. However, the location of West Virginia University in Morgantown precludes this approach. The increase in rental unit housing supply during the 1970's can be attributed almost solely to WVU enrollment increases (a 4,500 increase in full-time, on-campus enrollment) and related University growth. Since University enrollment is expected to either decrease or remain fairly constant through the mid 1980's, it was necessary to adjust the jobs/housing unit factor

so that 1970-1980 WVU growth would not skew the 1980-1985 projections. Based on these adjustments, the jobs to housing units ratio used in making the 1980-1985 projections was 1.32.

Table 8 depicts the results of applying the 1.32 ratio to the 1983 and 1985 employment projections. 1983 is used because that is the year that construction employment will likely peak. 1985 is used because the major energy construction projects are due to be completed by that year and 1985 demand will therefore represent "normal" demand.

TABLE 8
Estimated Baseline Housing Demand

<u>Year</u>	<u>Projected Employment Increase</u>	<u>Estimated Increase in Housing Demand</u>
1983	3,564	2,700
1985	6,235	4,723

To meet projected housing demand associated with baseline economic growth, between 900 and 950 additional housing units per year would have to be available for occupancy between 1980 and 1985.

C. Employment Estimates for Individual Projects

In addition to examining baseline employment growth, it was also necessary to examine other potentially large employment generators to determine if any are of such magnitude that they should be considered in addition to the baseline projections. Based on information provided by representatives of the Study Steering Committee, six projects were investigated:

- o The SRC-II Coal Liquefaction plant;
- o A proposed coke plant at Round Bottom;
- o A proposed coke plant at Fairmont;
- o Expansion of the U.S. Department of Energy's Energy Research Technology Center in Morgantown;
- o The expansion of the Appalachian Laboratory for Occupational Safety and Health (ALOSH); and
- o The development of industrial parks, including the Mason-Dixon Industrial Park and the Morgantown Ordnance Works.

Available employment information associated with these projects is described in the sections that follow.

1. SRC-II Coal Liquefaction Plant

On July 31, 1980, President Carter signed an agreement with West Germany and Japan to jointly finance the development of a pilot plant to demonstrate the commercial feasibility of a process that converts high sulfur coal to solvent refined coal (SRC), a clean burning liquid.

The demonstration plant is proposed to be built at a site in Monongalia County, north of the City of Morgantown. The plant will convert 6,000 tons of coal per day into the equivalent of 20,000 barrels of oil. If demonstrated to be a commercially feasible process, the demonstration plant could be converted to a 30,000 tons of coal per day commercial plant.

A draft Environmental Impact Statement (EIS) has been prepared for this SRC-II plant. As part of this process, a socio-economic impact analysis was conducted by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. That analysis contains a detailed assessment of employment growth related to both the construction and operation of the plant. Table 9 summarizes the employment impacts of the SRC-II plant derived from information contained in the draft EIS.

TABLE 9

SRC-II Labor Force Summary

Construction Phase

<u>Year-Quarter</u>	<u>Total Employees</u>
1981-II	48
-III	123
-IV	329
1982-I	806
-II	1,175
-III	1,385
-IV	1,783
1983-I	2,560
-II	3,154
-III	3,291
-IV	3,190
1984-I	2,431
-II	1,410

Demonstration Phase

<u>Years</u>	<u>Total Employees</u>
1981-III through 1987	460

In addition to the direct employment impacts, it was estimated that the SRC-II plant would have secondary employment impacts of the approximate magnitudes shown below. (Secondary employment consists of jobs created to support the needs of, or provide services to, plant employees who either move to or set up temporary residences in the Monongalia County area.)

TABLE 10

SRC-II Secondary Employment Impacts

<u>Year</u>	<u>Employment</u>
1981	117
1982	317
1983	519
1984-1985	465

The U.S. Department of Energy recently contracted with Oak Ridge Associated Universities to conduct another analysis of the employment associated with the SRC-II facility. One of the ground rules of the Oak Ridge study was that employment projections should be based on a 40 hour work-week rather than on the 45 hour work-week used in the CONSAD study. Consequently, employment projections shown in the Oak Ridge study are higher than in the EIS. However, one conclusion of the Oak Ridge study was that under conditions of strong labor demand in Pittsburgh and other employment centers, it would be unlikely that SRC-II would be able to attract many skilled workers from those employment centers within commuting distance unless substantial incentives, such as overtime, were offered. Consequently, the 45 hour work-week assumption used in the CONSAD analysis appears reasonable, and employment projections in the EIS that were based on this assumption have been used in developing this report.

Projected SRC-II Housing Demand

The draft EIS contains estimates of housing demand which are based on the following assumptions:

- a. 75% of the construction work force would commute to the site and the other 25% would either move to the area or stay at the site during the week and travel to and from their permanent residences only on weekends.
- b. 10% of the secondary employment associated with SRC-II would consist of in-migrants to the area.
- c. Approximately 83% of the total in-migrant population (movers and weekend travelers) would locate in Monongalia County.

Based on the above assumptions and the SRC-II construction schedule, it was estimated that the maximum demand

for temporary construction worker housing in Monongalia County will peak at 506 in 1983. During the operations phase, the total demand would be 310 housing units. The EIS estimated that the peak demand would likely be satisfied as follows.

<u>Type of Units</u>	<u>Number of Units</u>
Purchased houses	46
Rented houses	46
Apartments	120
Hotels/motels	45
Mobile homes	249
	<u>506</u>

The Oak Ridge Associated Universities' study did not address housing issues.

2. Coke Plant Construction

Coke is one of the basic ingredients in steel production. In 1978, domestic coke production fell below 500 million tons for the first time in over 40 years, and the U.S. was forced to import over 10% of its domestic coke needs. This has resulted in increased interest in domestic coke production. The construction of two coke plants has been proposed for the Monongalia County/Marion County area. One plant would be located at Round Bottom to the south of Morgantown and the other at Fairmont. Available information on these projects is discussed below.

a. Round Bottom Plant

On November 7, 1979, Governor Rockefeller and Alla-Ohio Valley Coals, Inc. announced that a coke plant would be constructed at Round Bottom, a 373-acre site located south of Morgantown off Route 273.

The initial announcement stated that the plant would consist of 48 coke ovens and would convert approximately 1 million tons of coal to 700,000 tons of coke per

year. However, because of the increased costs of required pollution control measures it presently appears that it will be more economically feasible to increase the size of the plant to about 110 ovens. A plant of this size would produce approximately 1.5 million tons of coke from 2 million tons of coal annually.

The Round Bottom Plant must still obtain operating permits from the U.S. Environmental Protection Agency and from the State of West Virginia. If these permits are successfully obtained, the most likely date for groundbreaking presently appears to be in late spring, 1981. A 24-month construction period would be followed by an 18-month start-up period.

Current estimates are that the construction work force would be about 1500 and the permanent work force would be in the range of 500 to 600. A detailed breakdown of work force needs during the 24-month construction period is not available. However, the following assumptions can be made.

- o In the early stages of the project, the emphasis will be on ordinary construction related to site preparation and foundation work.
- o The major trade employed during the construction period will be bricklayers. The sophisticated fire-bricklaying that will be required could require significant in-migration.
- o A significant number of pipefitters will be needed in order to develop systems for collecting gaseous by-products. (Pipefitters are one of the trades where shortages have been identified in the SRC-II EIS).

Projected Housing Demand

Because of the potential need to import fire-bricklayers and pipefitters, and because of other possible labor shortages resulting from the simultaneous construction of the SRC-II plant, it is assumed that up to 25 percent of construction force workers might in-migrate to the area. Using the same assumptions regarding family status, persons per unit, etc., as in the SRC-II EIS, this would result in an additional demand of up to 233 housing units in Monongalia County during the construction phase. Permanent demand for housing is difficult to assess at this time because of the uncertainty associated with the Fairmont coke plant. If the coke plant at Fairmont is not built, a large number of experienced coke plant workers would likely commute from Fairmont and Marion County.

b. Fairmont Coke Plant

The Salem Corporation has announced plans to construct a coke plant in Fairmont at the site of the abandoned coke plant previously operated by Sharon Steel. The proposed plant would convert 850,000 tons of coal to 550,000 tons of coke annually.

Needed permits for the Fairmont Plant have not yet been applied for. It is estimated that at the earliest, the 30-month construction period would begin next spring or summer. In order to get the project off the ground, two things are needed in addition to the required permits: a contract to sell the coke (this is highly dependent on conditions in the steel industry which are presently depressed); and a price for coal that the Salem Corporation considers advantageous.

The construction work force for the Fairmont Plant has been announced at about 300 and would consist

primarily of bricklayers, pipefitters, ironworkers, electricians and laborers. A detailed breakdown of the work force during the construction period is not now available. A permanent, operational work force of about 175 is anticipated.

Projected Housing Demand

The status of the Fairmont coke plant is still uncertain. Additionally, it is considered likely that if construction occurs during the same period as it does for the SRC-II plant and the Round Bottom coke plant, the tight housing situation in Monongalia County would force most construction phase movers and travelers of the relatively small construction work force to locate in Marion County.

If it is also assumed that the permanent work force will consist primarily of former Sharon Steel workers, the housing impacts on Monongalia County from this project are likely to be minimal.

3. Department of Energy's Energy Research Technology Center

The Energy Research Technology Center operates a variety of research programs generally related to the conversion of coal to oil and gas. The Center presently has about 265 permanent employees. This number has remained fairly constant over the past five years due to federal employment ceilings. There is currently a construction work force of about 100 working at the Center, and about 40 non-federal researchers are working on various grant programs.

The Energy Technology Center has plans for expanding its present facilities. However, employment growth associated with this expansion is not presently anticipated.

Projected Housing Demand

Physical expansion of the Center is not expected to have any impact on housing. Any growth that does occur is likely to be relatively small and should be considered as a component of County baseline employment growth.

4. Appalachian Laboratory for Occupational Safety and Health (ALOSH)

The Appalachian Laboratory for Occupational Safety and Health (ALOSH) conducts programs related to respiratory and safety factors associated with mining activities. ALOSH is planning a \$25 million dollar expansion to its facilities in Morgantown.

Project construction is scheduled to start in June, 1981 and be completed in May, 1983 (a construction period that coincides with the anticipated SRC-II and Round Bottom Coke Plant construction schedules).

A construction work force of 300 will consist of representatives of the building construction trades. No specialized trade skills that would require immigration to the area are anticipated. The construction work force is expected to be available from the Morgantown area.

The ALOSH expansion will result in an increase of 313 employees in the permanent ALOSH work force. ALOSH administrators anticipate that all technical, clerical and support staff as well as 50% of the professional staff are currently available in the Morgantown area (this means that approximately 78 employees will relocate to Morgantown). ALOSH anticipates that the secondary employment impacts will be one job for each professional employee who relocates to the Morgantown area (about 78).

Projected Housing Demand

Because of the nature of the project, it is assumed that the construction work force will consist primarily of workers who commute to the project site.

An environmental Impact Statement prepared for the ALOSH expansion by Robert and Company Associates estimates that the expansion will result in 157 new households in the Morgantown area. Because of the nature of this expansion and its relatively small size, it is felt that permanent housing needs should be considered as a component of the baseline employment and housing need projections.

5. Industrial Park Development

a. Mason-Dixon Industrial Park

The Monongalia County Industrial Development Authority has previously proposed the development of the Mason-Dixon Industrial Park on a 130 acre tract located near Core off Route 39. Development of the park is dependent upon receipt of a Title 1 grant from the U.S. Economic Development Administration (EDA). Receipt of this grant has been delayed pending the completion of an archeological survey of the tract to determine its significance as the location of an ancient Indian burial ground. It is assumed that if historical significance is determined, that the EDA grant will not be forthcoming.

The only industrial expansion that would be accommodated at the Park that was previously announced was that of Mylan Pharmaceuticals, Inc. Mylan had announced its intention to build two plants at the Park. The plants would employ 20 professional, 80 skilled and 50 non-skilled employees.

The Monongalia County Industrial Authority estimates that when totally built out, the Mason-Dixon Industrial Park would employ about 800.

Projected Housing Demand

The Mason-Dixon Industrial Park must be considered as a very uncertain project at this time. If the project does move forward, employment would best be considered as a part of the County's total baseline employment growth rather than as an additional component.

b. Morgantown Ordnance Works

Princess Coals, Inc. is developing a 250-acre tract on the site of the former Morgantown Ordnance Works as an industrial park.

There are about 300-350 people employed by companies located at the Ordnance Works. Sterling Faucet is the Park's major tenant. Additionally, the commercial dock which provides loading and unloading facilities from the Monongahela River to rail and truck connections is now in operation.

Princess Coals is considering a number of prospects that could result in an employment increase of about 100 over the next few years.

Projected Housing Demand

Any employment growth at the Morgantown Ordnance Works should be considered as part of the County's total baseline employment growth.

6. Other Projects

The only other major development project in the County that could coincide with SRC-II and other energy project construction that was identified is the construction by the Allegheney Power Service Corporation of precipitators for the Monongahela Power Company plant at Fort Martin. The project employs about 100 workers from

the general Morgantown area. Construction was started in November 1979 and is scheduled to be completed by November 1981. This schedule would overlap only slightly with those of the other major construction projects planned for the County. The November 1981 completion date must be met in order for Monongahela Power to meet a consent order from the U.S. Environmental Protection Agency (EPA).

Projected Housing Demand

No additional projects that would have any significant impacts on housing demand within Monongalia County have been identified.

D. West Virginia University Enrollment

During the 1970's West Virginia University enrollment increased by about 40%. However, published estimates indicate that enrollment will decrease by about 12% by 1985.

Enrollment at WVU over the next five years is difficult to assess with any certainty. For example, Table 11 depicts the official WVU enrollment projections developed in 1977 and 1980.

TABLE 11
WVU Total Enrollment Projections

<u>Year</u>	<u>1977 Projections</u>	<u>1980 Projections</u>
1979-1980	23,725	21,289*
1980-1981	24,135	20,644
1981-1982	24,083	20,163
1982-1983	24,075	19,336
1983-1984	23,887	19,237
1984-1985	23,728	18,757

* Actual enrollment 9/79

As can be seen, the estimates have changed significantly over a 3-year period. It is difficult to project enrollment with any real certainty because the projections are based on a computer program derived from state high school enrollment data, but the actual enrollment can be controlled by administrative policies. Examples of such policies are:

- o Lowering or raising admission standards;
- o Setting of tuition rates;
- o Control of total enrollment among all State supported universities and colleges; and
- o Out-of-state student admission policies.

It is our conclusion that a significant decline in WVU enrollment should not be anticipated regardless of what the present projections indicate, since such projections do not reflect official WVU policy.

Projected University Housing Demand

WVU enrollment is extremely important to the private housing market in the Morgantown area since the private sector must absorb any increases and decreases in demand (assuming dormitory enrollment will remain relatively constant). Our best estimate is that while there will not be any enrollment increase at WVU, a decline of 12 percent over the next five years is unlikely and that policies will be adopted over the next five years with the objective of seeing that enrollment remains fairly constant. If enrollment does remain relatively constant, there should not be any significant changes in student housing demand. In contrast, if enrollment declines by 12 percent, the student demand for housing could decrease by up to 1,200 units by 1985.

E. Summary of the Housing Problem

1. The Existing Situation

Preliminary 1980 census information indicates that there were 27,174 occupied housing units in Monongalia County at the time the census was taken in April, 1980. Based on information summarized in Chapter II, it has been assumed that approximately 37 percent of these were rental units (10,054 units) and that 63 percent (17,120 units) were owner-occupied.

West Virginia University (WVU) has the capacity to meet the housing needs of only about 40 percent of its students. WVU relies on the private sector to meet the remainder of its student housing needs. This creates a situation where vacancy rates for rental units are extremely low during the fall when enrollment is highest and gradually rise over the academic year until the summer when vacancy rates are over 10 percent. Various surveys have estimated the rental unit vacancy rate at about 2 percent for the past three years (1977-1980), but this rate has undoubtedly been higher in the spring of each year. It is assumed that rental vacancies in the County generally follow the pattern shown below.

<u>Vacancy Rate</u>			
<u>Sept-Nov</u>	<u>Dec-Feb</u>	<u>Mar-May</u>	<u>June-Sept</u>
2%	3-5%	5-7%	10+%

Based on a 6 percent vacancy rate, there were about 603 vacant rental units in the spring at the time the census was taken. Likewise, if it is assumed that 3 percent of the habitable non-rental housing stock (514 units) in the County were available for sale and that 50 percent of these units were vacant, the number of vacant units was about 257. Thus, the estimated

number of habitable dwelling units in Monongalia County in April 1980 was 28,034. Of these, about 3 percent (860 units) were vacant.

Because vacancy rates are so cyclical, the private housing sector is naturally reluctant to provide housing significantly in excess of what it considers to be the need during its peak demand period (the fall). This situation could make rental housing availability extremely tight if any other significant additional demands for this housing, such as for use by construction workers, occur during peak demand periods.

2. Housing Demand

Projections of housing demand for the period from 1980 to 1985 are based on the following assumptions:

- o That baseline employment growth projections will prove to be relatively accurate;
- o That the SRC-II facility will develop as projected and scheduled, and that only the SRC-II plant and the Round Bottom coke plant should be considered in addition to the baseline projections;
- o That the possible development of a coke plant at Fairmont will have no significant impact on housing within Monongalia County;
- o That West Virginia University enrollment will remain relatively constant; and
- o That a 2 percent peak period vacancy rate in the future is desirable for rental units (recognizing that this will increase each year according to the pattern shown on p. 33), and that 1 percent of habitable non-rental units will be both available for sale and vacant at any given time.

Based on these assumptions, projected baseline employment growth within the County will increase the County's housing needs by 2,249 units by 1983 (750 units per year) and by another 2,051 units by 1985 (1,025 units per year). This represents a total increase of 4,300 housing units over the 5-year period (the average

annual increase would be 860). This is consistent with recent trends - about 850 units per year added to the County's housing stock during the period from 1976 to 1979. If WVU enrollment actually declines by 12 percent, the demand for additional units will decrease by 240 to about 620 units per year. If the Round Bottom coke plant is not constructed, it is estimated that permanent demand will decrease by an additional 100 units.

The demand for temporary construction worker housing during the period 1981 to 1983 is a significant component of the total housing demand that must be considered in addition to permanent long-term demand.

Monongalia County has been announced as the location of a number of energy related projects. These include: the SRC-II Coal Liquefaction plant; a proposed coke plant at Round Bottom; and the expansion of the Appalachian Laboratory for Occupational Safety and Health (ALOSH). Each of these projects has a likely construction start date of spring 1981 and a two to three year construction period. The estimated construction work forces for these projects are shown below:

<u>Project</u>	<u>Construction Work Force</u>
SRC-II (peak)	3,291
Round Bottom	1,500
ALOSH	300
Total	<u>5,091</u>

Based on experiences of similar construction projects, the Draft EIS prepared for the SRC-II project estimated that about 25 percent of the construction work force would seek local temporary housing. If this is correct and if a similar 25 percent rate is assumed for the other projects, between 1,200 and 1,300 construction workers could be seeking temporary housing in and around Monongalia County during the period between 1981 and 1983.

This would result in a demand for between 600 and 1,000 housing units, primarily rental units.

Table 12 summarizes the demand for additional housing units that is expected.

TABLE 12
Summary of Projected Housing Demand

Number of occupied units, 1980	27,174
Number of vacant habitable units, 1980	<u>860</u>
Total number of habitable units, 1980	28,034
Number of additional units needed	
1980-1983 to meet baseline demand	2,249
Number of additional units needed	
1983-1985 to meet baseline demand	<u>2,051</u>
Total number of additions needed	
1980-1985 to meet baseline demand	4,300 (860 per year)
Number of units needed to meet peak	
construction worker demand 1983	600-1,000

3. The Problem

Meeting the projected increase baseline demand for additional housing will not present significant problems if the local building industry is able to maintain the level of new construction experienced for the past five years (about 850 new units per year). However, energy development activities in Monongalia County during the next three years will probably create an increased demand for rental housing by temporary construction workers that cannot be met through utilization of the existing housing stock. Moreover, a number of factors are inhibiting the construction of new rental housing that could help meet this increased demand. These factors include:

1. High interest rates and shortages in private funds for housing construction and mortgage financing.

2. Uncertainty over future West Virginia University enrollment.
3. The questionable economic feasibility of temporary housing projects.
4. Deficiencies in infrastructure (primarily sewer, water and access roads).

These factors are discussed in detail in Chapter IV.

The result of significantly increasing demand without a corresponding increase in supply will be most detrimental to West Virginia University students and to the elderly and low and moderate income residents of Monongalia County who rely on reasonably priced rental units to meet their housing needs, but who are not in a position to compete for such housing if serious supply shortages and escalating rental prices occur.

IV. FACTORS INHIBITING THE MEETING OF SHORT-TERM DEMAND

A. Availability of Financing

The housing industry nationally and in Monongalia County has been in a recession attributable to shortages of both construction financing and mortgage financing. Monongalia County housing starts in 1980 are only approximately half of the annual average starts during the period from 1975 to 1979. While this presents no immediate housing shortage problems because of a relatively large number of available units that are presently on the market, new construction will have to pick up over the next year in order to meet even the projected growth in baseline housing demand. Otherwise, significant shortages can be anticipated if employment growth continues as projected and if construction is initiated simultaneously on the SRC-II, Round Bottom and ALOSH projects during 1981.

In order to ascertain the effects of high interest rates and a tight money supply on the local housing industry, interviews were conducted with representatives of local financial institutions, the local home building industry and local governmental officials. The following findings and assumptions are based on those interviews:

1. The availability of adequate funds for construction and mortgage financing is largely beyond the control of local financial institutions. Monetary policies established and implemented by the Federal Reserve Board are the predominant factors in determining the amount of money available for these purposes.
2. Local financial institutions and builders generally feel that they are in, or will be in, a position to meet the demand for additional housing that future permanent growth within the County will generate. Construction financing was not viewed as a potential problem as long as a project appears to be well conceived and a market demand can be demonstrated. However, continuing high interest rates could create problems.

3. In 1979, the Monongalia County Commission issued tax exempt mortgage bonds that permitted participating local lenders to provide mortgage financing at rates below prevailing private interest rates. The County Commission has recently announced its intention to sell up to an additional \$120 million in tax exempt mortgage revenue bonds in three installments. The first installment of \$20 to \$40 million would be used over a 12 to 18 month period. Proceeds from the sale of the bonds would provide a mortgage pool for loans for both existing and new housing purchases. Income ceilings would be set in the \$35,000-\$45,000 range, which would make about 97% of the families in the County eligible to participate in the program. Such a program would alleviate shortages in mortgage financing.
4. The provision of temporary construction worker housing has not yet received significant attention. There is considerable concern about the financial feasibility of any housing project constructed primarily to meet what is perceived to be only a temporary demand. At this time, the availability of private financing for such projects must be considered very questionable.

Conclusion: An assessment of the future availability of construction funding is based on the perceptions and opinions of local financial officials about future national fiscal policies that are largely beyond their control. The prevailing opinion is that adequate construction funding to meet permanent housing needs will be available. The availability of mortgage financing should not present a problem if the planned Monongalia County Commission mortgage bond program is implemented. Consequently, the major housing financing problem that must be addressed locally is the financing of a program to provide temporary housing. The prevailing opinion is that such an investment would not be financially feasible without some form of subsidy.

- B. West Virginia University Enrollment Uncertainty
WVU enrollment is extremely important to the private housing sector in the Morgantown area. There is an

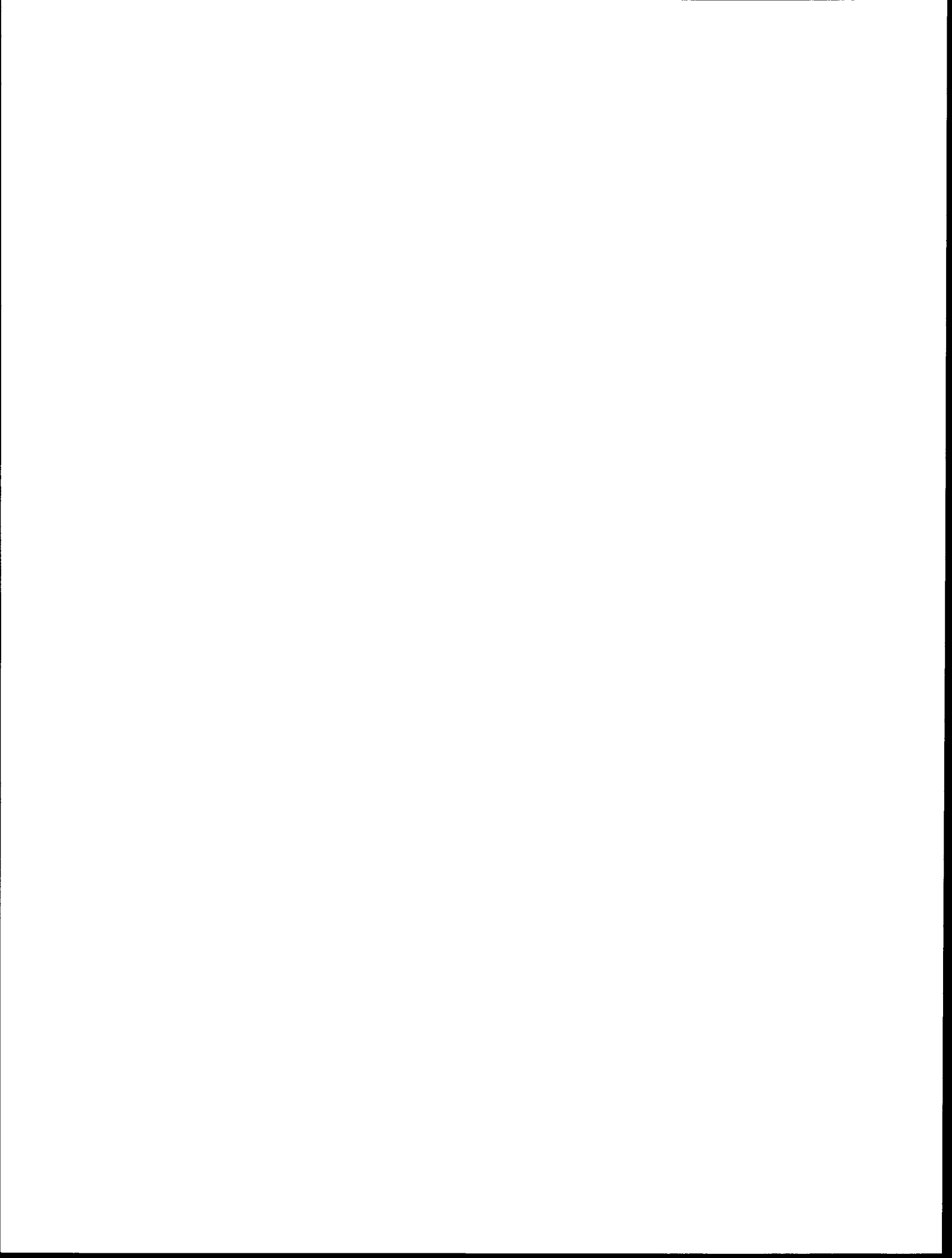
informal agreement between the University and local builders that the private sector will meet student housing needs. This means that the private sector must absorb any increases and decreases in demand (assuming dormitory enrollment remains relatively constant). Consequently, the projected 12% decline in University enrollment over the next five years has essentially stopped the development of new rental unit projects. This would probably be the case even if adequate construction financing were available.

It now appears that the predicted 12% enrollment decline is probably unlikely (1980 enrollment is about equal to 1979 enrollment) and that University policies will probably be established over the next few years with the objective of ensuring that enrollment remains relatively constant.

However, the continuing uncertainty concerning enrollment has created a reluctance on the part of developers to build additional rental units in Monongalia County because the development of new rental projects can historically be directly correlated with WVU growth.

If WVU enrollment does not decline, the combination of large construction work forces in search of rental housing, increased baseline demand, and a possible increase in demand for rental housing due to decreased housing starts would make the rental housing market extremely tight and probably create shortages.

Conclusion: If West Virginia University is to continue to rely on the private sector to meet student housing needs, it must end the present uncertainty over future enrollment by clearly stating its policy objectives with respect to enrollment. The private housing sector is not likely to act without such University action. If



Depending on land costs, it now costs between \$6,000 and \$7,000 per space to develop a mobile home park (\$4,000-\$5,000 excluding land costs). These costs include the provision of paved roads, underground utilities and curb and gutter, but not basic infrastructure improvements such as the construction of a water trunk line or the construction of a package sewage treatment plant. An investment of this magnitude cannot be amortized over the two to three year energy project construction period. Consequently, a long-term commitment for use of the park would be necessary to make such an investment attractive and feasible. Such commitments do not now appear to be a realistic possibility.

Conclusion: The mobile home industry in Monongalia County is likely to meet a portion of the demand for temporary construction housing through infill (the placement of mobile homes on vacant lots). However, based on interviews with representatives of the local mobile home industry, it is unlikely that a new mobile home park for the use of construction workers will be developed without either (a) a long-term commitment for its use or (b) government or developer subsidies.

2. Lease of Temporary Facilities by Project Developers

There are a number of companies in the business of designing, planning, installing, managing and dismantling (when the project is completed) temporary housing facilities for field construction personnel. Such facilities are primarily found at remote construction sites where it is not possible to utilize existing housing stock, and where there is no market for more permanent type housing beyond the construction period.

A firm would be selected to install modular housing units, a cafeteria, and all kitchen and recreational equipment. The energy project developer or a public agency would be responsible for land acquisition and infrastructure improvements.

Temporary modular housing units can vary significantly in quality. At one extreme is the dormitory type project with two men to a room and no individual baths. Of higher quality are the developments that provide single rooms with baths (the rooms are approximately 11' x 15'). This latter type of facility would probably be required in Monongalia County in order to make such a project attractive to construction workers in comparison to other available rental housing within the County.

Modular housing parks are typically built with six rooms per module and four modules per cluster, with the clusters surrounding a centralized community center. Such a center could include a cafeteria, registration desk, laundry facilities and a recreation area/lounge.

Management services are also provided for a fee. These services can include: food service, housekeeping, security, and maintenance. Food service typically includes breakfast and dinner service and the provision of a box lunch.

Modular housing developments of this type require a minimum of about 100 workers to locate at the facility. However, for an efficient and cost effective operation, at least 250 to 300 project residents are needed.

Modular housing developments can be either purchased or leased. Leasing offers a number of advantages: it eliminates the need for a large, front-end

capital investment; it fixes the costs by setting a monthly fee for the life of the contract; and it eliminates problems associated with the disposal of facilities and equipment upon the completion of the project.

Rough cost estimates associated with both the purchase and lease of facilities to house 250 and 500 construction workers are shown below. Detailed costs would have to be negotiated based on specific facility needs.

Facility Costs

<u>No. of Workers</u>	<u>Purchase</u>	<u>Lease</u>
250	\$1.5-\$2.5 million	(About \$30,000 per month for every
500	\$3.0-\$4.0 million	\$1 million worth of facilities leased.)

Management services would cost between \$14 and \$21 per day per man (\$16 to \$17 per day is typical). The energy project developer would be billed one lump sum per week for all management services and would, in turn, establish a daily use rate for workers utilizing the facilities. This could then be deducted from weekly paychecks. In most projects of this type, daily charges to workers are subsidized by the energy project developers.

Conclusion: There are a number of potential problems associated with this approach to providing temporary housing: it is expensive; in the West, workers have little housing choice and the developers have a captive market--in Monongalia County there would be other options available to workers and the developers would be in a position of having to commit themselves to a project without any guarantees that it would be used; and there is no obvious institution anxious to step forward and assume the financial responsibility

for such a project--in the West, the energy project developer frequently has to sponsor such a project in order to attract a skilled work force, but this would probably not be the case in Monongalia County.

3. A Dual-Purpose Housing Project

In addition to the temporary housing needs associated primarily with short-term construction projects, Monongalia County is also faced with another continuing housing problem that must be addressed--the provision of adequate housing for the elderly and for low and moderate income families.

Various studies on Monongalia County conducted by the Region VI Planning and Development Council and the West Virginia Housing Development Fund have documented the housing needs of the elderly and of low and moderate income families. The problem is essentially two-fold: on a short-term basis, these families cannot compete with relatively high paid construction workers for rental housing in a tight market situation; and in the longer term, the private sector is building housing that is affordable only by higher income families which makes it increasingly difficult for low income families to obtain affordable standard housing. The West Virginia Housing Development Fund estimates a need of 6,299 housing units for low and moderate income families in the County by 1985 (approximately 22% of this need is for adequate housing for the elderly).

One potential solution to both of these housing problems is the development of a housing project that could initially be used to meet the temporary needs of energy project construction workers and then be converted to low and moderate income housing that would help meet the broader housing needs of Monongalia County.

Conclusion: A project of this type would offer a number of advantages:

1. It would help solve the temporary construction housing shortages that the County will inevitably be faced with.
2. By providing the housing that will be needed by construction workers during the period 1981-1984, it would not place WVU students and the low and moderate income residents of Monongalia County, who are reliant on low cost rental housing, at a competitive disadvantage in securing existing rental housing.
3. It would contribute to satisfying the previously documented longer term needs for appropriately priced, standard housing for the low and moderate income families of the County.
4. It would be potentially eligible for a number of federal and state financial assistance programs. As such, it would meet needs not presently being met or anticipated to be met by the private housing sector.

It would be possible to develop a project of this type either as an apartment project or as a mobile home park.

D. Required Infrastructure Improvements

Based on 1970 and preliminary 1980 census information, well over 90 percent of the growth within Monongalia County occurred outside the City of Morgantown. This trend can be expected to continue. The rapid growth projected for the County in the period 1980 to 1985 will require that many infrastructure improvements (water, sewer and access) and other increased services be provided within the County. This will significantly increase the financial, technical and operational demands that are placed on local governments within the County.

The following sections review the need for basic infrastructure improvements associated with a temporary

housing development. It is assumed that such development(s) would be located in the north central portion of the County on the western side of the Monongalia River within easy commuting distance of the SRC-II project site.

1. Water Service

The City of Morgantown is the primary supplier of water throughout Monongalia County. The City's new 16 million gallon per day (MGD) treatment facility has adequate capacity to accommodate projected residential development in the County.

A new water trunk line extending to the north from Morgantown has the capacity to provide service in the immediate vicinity of the SRC-II project site.

2. Sewer Service

A Section 201 regional wastewater facilities plan for the City of Morgantown and unincorporated areas of Monongalia County has been completed. Because of drainage basin configurations, the proposed facilities will not serve the SRC-II site area. This means that a package sewage treatment plant would be required in order to provide sewerage service to any housing developments in the immediate vicinity of the plant.

3. Access

Access from the City of Morgantown north to the SRC-II site is not good. Existing roads are not capable of handling projected traffic loads. New or improved feeder routes from the interstate highways to the SRC-II site will be required.

The West Virginia Department of Highways is conducting a study of the road improvements that will be made in the general vicinity of the SRC-II site. It is assumed that future housing developments

in the area will be located off the selected feeder routes. Consequently, access both to the site and to services available in the City of Morgantown should not present any significant problems.

An additional problem concerning the provision of needed facilities and services is of an institutional nature. The SRC-II site is not located within the boundaries of an established public service district. Therefore, at this time there is no institution to deal with increased service demands as the area develops.

A Consolidated Countywide Public Service District was recommended in the 201 facility plan. Such an institution would offer a number of advantages, including:

- o Increased financial soundness in comparison to small local public service districts--this should be reflected in better bond ratings and more predictable cash flows.
- o Professional administration--because of their small size, public service districts must place heavy reliance on voluntary efforts.
- o Cost savings due to economics of scale related to purchasing, administration and contracting for services.
- o Increased ability to attract better trained and qualified employees with specialized skills.

Of particular importance with respect to future residential and industrial development in unincorporated areas of the County is that a Consolidated County Public Service District would offer the potential for programming needed service improvements in a systematic way rather than in the present piecemeal fashion which is typical where many jurisdictions possess similar responsibilities.

Conclusion: A site for temporary construction housing should be selected based on proximity to the trunk water line and a new feeder road or an access road programmed

for upgrading. Assuming this occurs, the main infrastructure improvements required would be normal on-site improvements. A package sewage treatment plant will also be required. In order to improve the prospects for the systematic programming of improvements to achieve sound development objectives, the creation of a Consolidated Public Service District for the unincorporated areas of the County should be supported.

V. RECOMMENDATIONS

A. Development of a Project to Provide Temporary Housing

It appears that the private housing sector within Monongalia County will only meet a portion of the temporary housing needs created by the proposed energy related developments. Unsubsidized new developments are unlikely because the private sector will provide permanent housing only to meet needs it expects to exist beyond the three year construction period.

Some of the need for temporary housing will probably be met through the provision of additional mobile homes. However, such units will not be reserved for the exclusive use of construction workers. Consequently, unless additional actions are taken to meet the housing needs of energy project construction workers, serious rental housing problems could occur for residents of Monongalia County who rely on such housing.

Three options for meeting the housing needs of a temporary construction work force have been identified. Ideally, it would be preferable for the local private housing industry to meet these needs. Unfortunately, it does not appear that this will happen, and concerned local officials cannot risk waiting for the private sector to act since construction start-up is only about nine months away.

The second option--to provide temporary modular housing--has some major disadvantages associated with it: it is relatively expensive in comparison to other options; there is no readily apparent private project developer willing to sponsor such a project and accept the costs and risks that go with it; and such a project would not address the longer term needs for additional low and moderate income housing within Monongalia County.

At the present time, the best alternative appears to be to continue to investigate a dual purpose project that could be used in its initial years to satisfy the housing needs of energy project construction workers, and then be converted to a subsidized rental housing development. Such a project could be developed as a mobile home park or as an apartment project.

The immediate need is to prepare a detailed feasibility analysis for a housing project of this type. Such a feasibility analysis would have three major components as described below.

1. Locational Analysis. This would consist of the selection of a site that provides a suitable location for both temporary construction housing and for permanent elderly or low and moderate income housing. Factors that would be considered are: access to the SRC-II site; access to services required by the residents of such a development; land availability; and the availability of other needed public facilities, primarily water and sewer service.
2. Institutional Analysis. For a project of this type, it would be necessary to identify what agency or organization can best construct the project, operate and manage it during its different stages, provide the necessary services, and most importantly, finance the project. Organizations that could potentially be involved in the implementation of a project of this type are discussed in Section B, which follows.

As part of the institutional assessment, the potential role of each possible project participant would be analyzed. Discussions would then be held with each organization whose support is needed. Organizational responsibilities would then be recommended. An important component of the institutional analysis would be to outline the steps necessary to make the transition from a project that satisfies temporary construction housing needs to housing for the elderly or for subsidized low and moderate income housing.

3. Financial Feasibility. A detailed analysis of the economic and market feasibility of the project would be conducted. Based on this analysis, a recommended financial management plan would be prepared.

The feasibility analysis should be prepared as a decision making tool which would provide the basis for negotiating both public and private participation in the project.

B. Potential Organizational Responsibilities

The development of a housing project of the type described in this report will require the active cooperation and support of both private organizations and governmental agencies. Appropriate organizations must be selected to assume the following roles and responsibilities

- o The development and operation of programs to encourage commuting by construction workers.
- o The financing and construction of the housing project.
- o Site development and the provision of required services.
- o Management of the project for construction worker housing.
- o Purchase and management of a project as a permanent housing project for the elderly or for low and moderate income families.

A discussion of the potential ways of filling each of these roles is contained in the sections that follow. In some cases there is little choice with respect to the agency or organization that should assume certain responsibilities. With others, there are organizational alternatives. Regardless, much negotiation lies ahead before agencies will readily assume these various responsibilities. Final decisions will probably be dependent upon the completion of a detailed project feasibility analysis.

1. The Encouragement of Commuting by Construction Workers
Construction worker commuting rather than relocation is desirable for a number of reasons. It would: reduce the demand for temporary housing; minimize other negative community impacts; and alleviate local fiscal impacts associated with the provision of services (the tax returns to local governments rarely equal their service expenditures during the construction phase of large scale development projects).

While the encouragement of commuting is desirable, concern has been expressed that a number of factors could discourage such commuting and, therefore, increase the demand for temporary construction housing beyond levels that are now anticipated. These factors include: the relatively long-distance commuting (up to 90 minutes each way) that will probably be necessary to secure the skilled work force that will be needed; uncertainty regarding gasoline availability; and rising gasoline prices. The impacts of these factors are difficult to predict with any degree of certainty. However, steps can be taken to make commuting more attractive. In fact, the Oak Ridge Associated Universities labor study of the SRC-II work force identified the need to develop commuter incentives as a major priority. One example of the type of incentive that could be provided is direct subsidized bus or van service to and from a central point in major employment centers (e.g., Pittsburgh) to the project site.

There are a number of reasons why the various energy project developers (Gulf Oil Corporation, the U.S. Department of Energy, prime project contractors, etc.) should take the lead in developing commuter incentive programs. Among these are:

- o The project developers must maintain good will in the communities where they are located. If significant potential community impacts are identified but are not addressed, resulting community relations problems could cause significant project delays.
- o The developer is responsible for seeing the project is completed on schedule. Therefore, he must make long distance commuting more acceptable and must also help provide adequate housing for non-commuters if he is to attract the skilled workers needed to maintain a stable work force.
- o Experience with similar projects has shown that long tedious commuting and inadequate local housing lead to recruitment problems, heavy turnover rates, increased absenteeism, declining productivity and declining employee morale.

Because the SRC-II plant is being developed as a federal demonstration project and the owner will be the U.S. Department of Energy, it is probably unrealistic to expect the private project developers to take the financial lead in attempting to resolve such problems as they do with other energy development projects where the private sector is putting major revenue producing facilities into production. DOE should consider assuming the lead role in developing subsidized commuter incentive programs.

2. Housing Project Development

The West Virginia Industrial Development and Commercial Development Bond Act appears well suited for use in constructing a dual purpose housing project such as the one recommended in this report.

- o The Act allows counties and cities to construct commercial projects, including residential developments.
- o Under State law, the government body which issues the bonds holds title to the facilities involved and can lease those

facilities to a private operator provided that the proceeds from the lease are sufficient to amortize the bonds. A housing project could thus be constructed and leased to an energy developer or prime contractor to manage and operate during the construction period.

- o The Act permits the project to be sold and also contains a redemption provision that permits the governmental body to redeem the bonds at any time--this means at the end of the construction period (e.g., 1984) the project could be sold by prearranged agreement to a non-profit housing sponsor or to a private investor with the proceeds from the sale used to redeem the bonds.

Three public entities--the Monongalia County Commission, the Monongalia County Development Authority and the City of Morgantown (a city can issue bonds for a project in the unincorporated portion of the county in which it is located)--have the legal authority and the necessary management capability to issue commercial development bonds that could be used to finance a housing project in the unincorporated areas of the County. One of these entities would issue the bonds and then contract with private builders to develop the project. The Monongalia County Commission would be the most logical agency to assume this responsibility because of the nature and potential location of the project.

3. Site Development and the Provision of Needed Infrastructure

The public entity that owns and develops the housing project should also assume responsibility for site development and the provision of needed infrastructure. However, such activities are eligible for a variety of state and federal funding assistance. In fact, 100% non-local financing of such activities would appear to be both appropriate and desirable.

Among the potential state and federal funding sources for site development assistance are:

- o State of West Virginia. Under the West Virginia Business and Occupational Tax program, a tax of \$2.20 per \$100 of gross contract value is levied on construction work performed within the State by private contractors. It has been estimated that the SRC-II project alone could generate up to \$11 million in tax revenues.

Unincorporated areas are not empowered to enact their own business and occupational tax (as are incorporated municipalities). Consequently, counties such as Monongalia County do not necessarily benefit directly from this tax. Additionally, there are currently no provisions for returning a specific percentage of these tax revenues to local jurisdictions in which the construction projects are located.

It is recommended that the State earmark sufficient revenue from the various energy development projects for activities designed to minimize adverse impacts that have been identified. At a minimum, funds should be provided for needed road improvements and for the provision of one or more package treatment plants at the site of the construction housing projects.

- o Farmers Home Administration. The Farmers Home Administration administers the Section 601 Energy Impact Area Development Assistance Program. This program has been designed specifically to meet the type of energy impact needs that are described in this report. Under the provisions of the 601 program, the Farmers Home Administration can fund up to 75% of the actual costs of acquiring and/or developing sites for housing. Site development costs can include grading, the provision of water and sewer lines and access roads. Actual housing construction is not an eligible activity.
- o Appalachian Regional Commission. The Appalachian Regional Commission administers a housing assistance program that can be used to fund up to 10% of site development costs. Legislation is pending to raise this limit to 25%.

In order to provide the services required for this project and also to support industrial and residential growth in other unincorporated areas of Monongalia County, other actions are desirable. These include:

- o The establishment of a consolidated county-wide public service district which would enable a single agency to systematically program needed improvements that will be required by projected growth in unincorporated portions of the County.
- o The establishment of county development controls. Monongalia County is experiencing significant growth which is expected to be sustained with its continued emergence as an energy development center. Well over 90% of this growth is occurring in unincorporated areas of the County. To service this projected growth, it will be necessary to make major infrastructure investments. To protect such investments, the County should consider initiating some basic controls over where and when development occurs within the unincorporated portions of the County.

4. Operation of the Project for Construction Worker Housing

Once construction is completed, the local government owner should lease the project to one of the energy project developers for use by construction workers during the 1981-1984 construction period. As the owner of the SRC-II demonstration project, the Department of Energy would be the most likely lessee. The lease must guarantee sufficient revenue to amortize the commercial development bonds. DOE could then contract with a private firm to manage the project.

5. Purchase or Lease of the Project for Low and Moderate Income Housing

Once the need for temporary construction worker housing has passed, the owner would have the option of leasing or selling the project to a non-profit organization, such as the Human Resources Development Foundation Inc., or to a private investor who provides subsidized housing for the elderly or for low and

moderate income families. It is assumed that sale of the project and redemption of the bonds would be preferable, although as long as the lease is guaranteed for the period required to amortize the bonds, either approach is potentially acceptable.

Federal and state agency assistance would be essential in order to make a successful transition to a subsidized elderly or low and moderate income housing project. The prime federal agency whose assistance would be required would be the U.S. Department of Housing and Urban Development (HUD). HUD administers an array of assistance programs that could be used to assist in the purchase of such a project or to provide rental assistance to future residents of the project.

The West Virginia Housing Development Fund should also be explored as a funding source for converting the temporary construction housing to rental assistance housing for low and moderate income families.

6. General Project Assistance

The U.S. Department of Energy (DOE) will be the owner of the SRC-II facility during its demonstration phase. Because it is a national demonstration project, DOE should be prepared to assume the responsibility for mitigating adverse project impacts just as any private project developer would be required to do. Specifically, DOE should provide financial assistance as needed to develop the dual purpose housing project recommended in this report.

The mechanisms for providing DOE financial support are already available. Because DOE will own the project during both the construction and demonstration phases, the project will be exempt from local property

taxes. The Federal Government has the option of making payments to the County in lieu of such taxes. The specific terms of such an agreement would have to be negotiated. As a guiding principle, payments in lieu of taxes should be the mechanism for financing the provision of any special services that the project requires and also for helping to alleviate adverse community impacts that are identified.

APPENDIX

MONONGALIA COUNTY BASELINE EMPLOYMENT PROJECTIONS

	1978 (Actual)	1980	1983	1985
Total Employment	31,658	33,293	36,857	39,528
<u>No. of Proprietors</u>	2,117	2,116	2,184	2,232
Farm Proprietors	527	512	497	487
Non-Farm Proprietors	1,590	1,604	1,687	1,745
<u>Wage & Salary Employment</u>	29,541	31,177	34,673	37,296
Farm Employment	49	28	22	18
Non-Farm Employment	29,492	31,149	34,651	37,278
<u>Private</u>	19,211	20,432	22,998	24,947
Mining	3,483	3,749	4,089	4,333
Construction	1,783	1,815	2,185	2,472
Manufacturing	2,926	2,928	3,003	3,055
Non-Durable Goods	927	870	855	845
Durable Goods	1,999	2,058	2,148	2,210
Transportation and Public Utilities	905	848	824	808
Wholesale Trade	781	916	1,111	1,263
Retail Trade	4,192	4,455	5,092	5,566
Finance, Insurance, and Real Estate	1,012	1,264	1,658	1,987
Services	4,129	4,457	5,036	5,463
<u>Government and Govt. Enterprise</u>	10,281	10,717	11,653	12,331
Federal Civilian	1,023	1,340	1,530	1,671
Federal Military	295	261	226	205
State and Local	8,963	9,116	9,897	10,455

Source: U.S. Department of Commerce, Bureau of Economic Analysis



MONONGALIA COUNTY HOUSING IMPLEMENTATION PLAN

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion.

As the world's population grows, the demand for food and other resources will increase. This will put pressure on the environment and on the world's food supply.

One way to meet this demand is to increase the amount of food that is produced. This can be done by using more land for agriculture.

Another way to meet this demand is to increase the efficiency of food production. This can be done by using better farming techniques.

Both of these methods have their own problems. Increasing the amount of land used for agriculture can lead to deforestation and loss of biodiversity.

Increasing the efficiency of food production can lead to the use of more pesticides and fertilizers, which can be harmful to the environment.

One solution is to use a combination of these methods. This would involve using better farming techniques on existing farmland and also using more land for agriculture.

Another solution is to reduce the amount of food that is wasted. This can be done by encouraging people to eat less meat and to use food more efficiently.

Both of these solutions have their own problems. Reducing the amount of meat eaten can lead to a loss of jobs in the meat industry.

Using food more efficiently can lead to a loss of jobs in the food processing industry.

One way to solve these problems is to use a combination of these methods. This would involve using better farming techniques on existing farmland and also using more land for agriculture.

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Monongalia County Housing Implementation Plan

A recently completed Housing Analysis for the Monongalia County area of West Virginia estimates that the number of units needed to meet peak construction worker demand will be between 600 - 1,000 units. This demand will be created principally because of the construction of the SRC II facility and other energy related projects.

It is anticipated that the private sector will meet a portion of the expected demand. It is the position of this Task Force that the public sector should not compete with the private sector but, where and when necessary, provide support with adequate public services or additional housing units if warranted.

In order to meet the demand which the private sector cannot meet, the following recommendations are being made by a Task Force representing various community interests. The provision of adequate housing in Monongalia County during the construction of the S.R.C. II facility will serve a dual purpose. First, an acceptable housing choice will provide the Department of Energy/Gulf Oil with the skilled workers necessary to maintain a stable work force and second, the existing residents of the County will not be negatively affected by the influx of construction works.

1. Locational Analysis

The Task Force believes that, with proper site selection, the impact of additional housing units on existing public facilities - water, sewers, schools, roads, etc. - and services can be kept at a minimum. The locational analysis would consist of the selection of sites which would be suitable for mobile homes and for both temporary construction housing and for permanent elderly or low and moderate income housing. Factors which would be considered are: access to the SRC II site to minimize traffic congestion on secondary roads; access to services required by the residents of such a development; land availability; and the availability of other needed public facilities - primarily water and sewer service.

It is quite apparent that a few sites can meet the selection criteria with minimal public investment. The Morgantown Ordinance Works and locations along Green Bag Road as well as the Marion County Poor Farm are well suited for single and multi-family housing. Areas near U.S. 19 North and Green County Pennsylvania may be suitable for mobile home courts.

The Department of Energy should provide the financial resources necessary to assess the availability and acceptability of housing sites within Monongalia County.

2. Local Construction Capability

The homebuilders of Monongalia County, in conjunction with the State Homebuilders Association, should develop the administrative framework which will permit joint ventures among the many small and medium sized builders in the county. A joint venture would enable the homebuilders to possess the financial, management and manpower resources necessary to assist in the construction of the duplex/town house type of rental units as outlined in recommendation four. The joint venture would enable the homebuilders to complete a relatively large undertaking in a short period of time - an important consideration when attempting to meet the needs of the SRC II construction work force. The structure should be patterned after the Builders Emergency Housing Council.

3. Mobile Home Spaces

The Task Force recommends that, based on the locational analysis, one or more mobile home parks, with a total capacity of 150 units, be constructed with easy access to the SRC II facility. The site(s) should be located in the western end of Monongalia or southern Green County and be serviced by a public water supply and be capable of being serviced by a package sewerage facility.

While there are mobile home spaces available at the present time, the anticipated demand will far outstrip available sites. In order to insure

that the proposed sites do not hamper the filling of existing spaces, the proposed site(s) should not be available until the initiation of construction. One year after the initiation of construction is when the greatest influx of potential movers in the skilled trades (pipefitters, boilermakers, insulators, ironworkers) will begin.

Design of said facility would be of such a nature that, when construction of the SRC II facility is completed, it would be converted into sites for single family dwellings. With an appropriate design, two mobile home spaces would result in a single conventional built housing lot. Since water, sewer and roads would be in place at the mobile home park, a minimal amount of financial resources would be necessary to convert the site to single family lots.

The conversion of the mobile home park will serve a twofold purpose. First, it will not be competing with existing mobile home parks once construction on the S.R.C. II facility is completed. Second, the availability of moderately priced single family lots in the western end of Monongalia County and in Green County is in short supply.

Funding for a project of this scope could be made available through the Farmers Home Administration 601 program, the Appalachian Regional Commission, the Department of Housing and Urban Developments Community Development Block Grant Program or through the Department of Energy.

The most appropriate vehicles for accomplishing this objective would be a non-profit arm of the homebuilders association, the West Virginia Housing Development Fund, the Monongalia County Commission or the Department of Energy.

4. Dual-Purpose Housing Project

Based on the location analysis outlined in recommendation number one, up to two hundred (200) rental units of the duplex/town house variety should be constructed for occupancy by the SRC II construction work force.

A project of this type would offer a number of advantages.

- A. It would help solve the temporary construction housing shortages that the County will inevitably be faced with.
- B. By providing the housing that will be needed by construction workers during the period 1981-1984, it would not place WVU students and the low and moderate income residents of Monongalia County, who are reliant on low cost rental housing, at a competitive disadvantage in securing existing rental housing.
- C. It would contribute to satisfying the previously documented longer term needs for appropriately priced, standard housing for the low and moderate income families of the County.
- D. The structures could be placed on more than one site which would minimize the impact on existing public facilities and services, i.e., police, fire, roads, schools, water and sewer systems.
- E. It could enable the homebuilders in the county, based on the outline in recommendation number two, to become an active participant in the construction.

Ownership of said sites could reside in a non-profit corporation or the West Virginia Housing Development Fund. Site development costs could be offset by the Farmers Home 601 program, the Appalachian Regional Commission or the Department of Housing and Urban Development.

Construction financing would be made available through either the Department of Energy or Gulf Oil, within whom ownership would reside.

Once construction on the SRC II facility were complete, the units would be purchased and administered as an existing facility for use by low and moderate income families with mortgage financing and rent subsidy provided by the Department of Housing and Urban Development. H.U.D. should make these units available through the Secretary's Discretionary Fund, rather than through the State of West Virginia's annual allocations.

The West Virginia Housing Development Fund estimates a need for approximately 4,800 housing units for low and moderate income families in Monongalia County by 1985.

5. Making Existing Housing Available

The Department of Housing and Urban Development should make available, from the Secretary's Discretionary Fund, up to 200 units of subsidized housing for the elderly in Monongalia County. Because projects of this type frequently take up to thirty-six (36) months to complete, the process should be implemented immediately. The provision of these units would make available for rent or purchase the many large old single family units now occupied by the elderly which are more economically suited for families. These units would be available during the peak of construction on the SRC II facility.

Financing and rent subsidy would be provided through H.U.D. with ownership by a non-profit corporation or a private developer.

It is important to note that of the 4,042 units occupied by the elderly in Monongalia County in 1970, 3,134, or 77 percent of the units, are owner occupied. However, many of the elderly would rather live in housing such as Unity Manor which is evidenced by the list of over 500 elderly desiring occupancy in that facility. The West Virginia Housing Development Fund estimates that there will be a need for 1,800 elderly subsidized units in Monongalia County by 1985.

6. Information Exchange

Those responsible for maintaining the employment records of the construction work force should make available to the Monongalia County Board of Education, Monongalia County Commission, City of Morgantown and the Chamber of Commerce the following information:

- A. Name of employee
- B. Local address
- C. Number of people residing and local address
- D. Ages and sex of residents

7. Transportation

Because the SRC II is served by secondary roads every effort should be made to minimize the number of vehicles using the state road network. Van, car pooling and private bus service should be carefully analyzed.

8. Implementation

In order to implement the above in a timely manner, the task force believes that the Department of Energy or the State of West Virginia should make available one of its staff people to implement the recommendations.

The Task Force believes that this individual should be physically located in Monongalia County, be responsible to the Executive Committee of the Task Force and be available as soon as possible. However, if this is not an acceptable alternative, D.O.E. or the State of West Virginia should provide the funding necessary to implement the plan.

Appendix V.5
FEDERAL ASSISTANCE PROGRAMS

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Appendix V.5

FEDERAL ASSISTANCE PROGRAMS

This list of Federal assistance programs is divided into function areas such as housing and education. The Office of Management and Budget (OMB) number is given to identify each program; it can be used to locate the program in the catalog of Federal Domestic Assistance. Monongalia County and the city of Morgantown are judged to be eligible for these programs.

V.5.1 GENERAL FUNDS

The Energy Impacted Area Development Assistance Program 601 Administered by FmHA.

Section 601 of the Powerplant and Industrial Fuel Act of 1978 authorizes the Farmer's Home Administration (FmHA) of the U.S. Department of Agriculture (USDA) to provide assistance to areas affected by coal or uranium development activities. It also provides for direct land acquisition by FmHA through purchase, trade, or condemnation, although it is anticipated that the latter provision will be seldom used.

The State of West Virginia has received \$5 million of FmHA Section 601 funds in 1980 to help alleviate energy impact problems.

V.5.2 EDUCATION

V.5.2.1 Construction and equipment

Office of Education
HEW

OMB: 13.477

This program provides project grants (distributed on a formula basis) to help build and equip schools. It is especially intended for use in areas that have recently experienced or are experiencing a rapid increase in school enrollment due to increased Federal activity in the area.

V.5.2.2 Maintenance and operation

Office of Education
HEW

OMB: 13.478

Local educational agencies may apply for these formula grants designed to help ameliorate the impact on local schools caused by substantial Federal activity in the area. This program applies particularly to areas where Federal acquisition of real property has reduced the district's tax base and has caused an increase in school attendance.

V.5.3 HEALTH

Health Resources Administration, Public Health Service
HEW

OMB: 13.253

This program is intended to assist in the planning and provision of mental health facilities in areas of rapid population growth. Any entity with bonding authority is eligible to apply for direct loans. Private nonprofit agencies may apply for loan guarantees.

Alcohol, Drug Abuse, and Mental Health Administration
HEW

OMB: 13.242

This program provides funds for project grants (up to five years' duration) available to public or private nonprofit agencies, state, local, and regional governments, hospitals, and institutions of higher education for research projects designed to develop new knowledge and approaches to all aspects of mental health care.

Office of the Assistant Secretary for Health
HEW

OMB: 13.226

States, their political subdivisions, towns, universities, hospitals, and nonprofit organizations are eligible to apply for project grants and research contracts under this program. Funds may be used for the direct costs involved in a particular project as well as some indirect costs. Priority is given to projects that will improve the quality and availability of health services.

Center for Disease Control
HEW

OMB: 13.262

This program provides project grants to public or private nonprofit organizations capable of conducting the appropriate research to fund direct research costs. The research must be directed toward understanding the characteristics of occupational safety and health problems and their solutions.

Funds are disbursed according to established policies of the Public Health Service.

Health Services Administration
HEW

OMB: 13.258

Under this program, service personnel are disbursed to areas designated as having critical health manpower shortages.

Center for Disease Control
HEW

OMB: 13.263

Any public or private nonprofit organization that trains at a technical, professional, or graduate level may apply for project grant funds to develop personnel specialized in occupational medicine, nursing, industrial hygiene, and safety.

V.5.4 HOUSING

Office of Housing
HUD

OMB: 14.133

This program provides Federal mortgage insurance to finance ownership of individual units in multifamily housing projects. HUD insures mortgages made by private lending institutions for the purchase of individual family units in multifamily housing projects under Section 234(c). Sponsors may also obtain FHA-insured mortgages to finance the construction or rehabilitation of housing projects that they intend to sell as individual condominium units under Section 234(d).

Office of Housing
HUD

OMB: 14.220

Direct Federal loans finance rehabilitation of residential, mixed-use, and nonresidential properties in the Federally aided Community Development Block Grant, Urban Homesteading (Section 810), Urban Renewal, and Code Enforcement areas that have been certified by the local government. By financing rehabilitation to bring the property up to applicable code, project, or plant standards, the loans prevent unnecessary demolition of basically sound structures.

V.5.5 MORTGAGE INSURANCE — LAND DEVELOPMENT (Title X)

Office of Housing
HUD

OMB: 14.125

Prospective developers are eligible to apply for insured loans to help develop subdivisions. The loans may also be used for water and sewer system installation.

V.5.6 WATER AND SEWAGE

Farmers Home Administration (FmHA)
DOA

OMB: 10.411

This program provides funds for site acquisition and development, new water and sewer facilities, engineering, legal fees, and landscaping required for the development of rural subdivisions to be sold on a nonprofit basis to low- and moderate-income families, cooperatives, and nonprofit rural rental housing applicants.

EPA

OMB: 66.418

Any municipal, state, or interstate agency or Indian tribe responsible for waste disposal is eligible to apply for project grants. The funds may be used to construct or upgrade municipal sewage treatment works that have to meet Federal and state water quality criteria. This program emphasizes treatment of industrial wastes.

Office of Planning and Management
EPA

OMB: 66.603

This program is designed to assist state and interstate agencies, municipalities, or intermunicipal agencies and to serve as an incentive in construction of municipal sewage treatment works that are required to meet state and Federal quality standards. It is also designed to ensure that inability to borrow necessary funds from other sources on reasonable terms does not prevent the construction of any wastewater treatment works for which a grant has been, or will be, awarded.

V.5.7 SPECIAL PROGRAMS

Community Development Block Grants, Small Cities Program, Administered by HUD

HUD awards "block" grants to local governments to fund a wide range of community development activities to promote sound community development. In a single, flexible, multipurpose program, block grants finance activities previously eligible under separate categorical grant programs: Urban Renewal; Neighborhood Development Grants; Model Cities; Water and Sewer Grants; Neighborhood Facilities Grants; Public Facilities Loans; Rehabilitation Loans; and Open Space, Urban Beautification, and Historic Preservation Grants.

Spending priorities are determined at the local level, but the law enumerates general objectives that the block grants are designed to fulfill. These include adequate housing, a suitable living environment, and expanded economic opportunities for lower-income groups. Specifically, recipients are required to estimate their lower-income housing needs and address them in the overall community development plan they submit when applying for a grant.

Metropolitan cities and qualified urban counties are guaranteed an amount called "entitlement." It is based on need, objectively calculated by a formula that takes into account population, poverty, overcrowded housing, age of housing, and growth lag.

Smaller cities compete for the Small Cities Program funds. However, local governments that participated in certain grant programs but do not qualify for an equivalent block grant are "held harmless" for three years (i.e., they are funded at the same average level in order to complete projects already under way). After the three years, they are held harmless over the formula amount for one year and then given one-third of the excess for the next year.

The authorization for fiscal years 1978-80 is \$10.95 billion. The program has been fully funded each year.

V.5.8 INTERGOVERNMENTAL PERSONNEL ACT

Office of Personnel Management

V.5.8.1 Technical assistance

The purpose of the IPA technical assistance program is to provide assistance, principally on a reimbursable basis, to state, general purpose, local, and Indian tribal governments in the areas of personnel and general management. This assistance can be provided by the Office of Personnel Management or certain state IPA programs.

V.5.8.2 Grants

The purpose of the IPA grant program is to provide financial assistance on a matching fund basis for personnel, general management, and training projects so that small jurisdictions will have managers who have skills and expertise in these areas.

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Appendix V.6

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Appendix V.6

BIBLIOGRAPHY

For more information about the socioeconomic aspects of the SRC-II project, consult:

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2. The documents listed in the bibliographies listed at the end of Sects. 2.8 and 2.9 in the *Environmental Report*, and
3. Oak Ridge Associated Universities, *Construction Labor Assessment for SRC-II at Phase Zero*, Oak Ridge, Tenn., 1980.

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Appendix W

NOISE

the 1990s, the number of people in the world who are under 15 years of age has increased from 1.1 billion to 1.5 billion, and the number of people aged 65 and over has increased from 0.2 billion to 0.4 billion (United Nations 1999).

There is a growing awareness of the need to address the needs of the young and the old. The United Nations (1999) has identified the need to address the needs of the young and the old as one of the major challenges of the 21st century. The United Nations (1999) has identified the need to address the needs of the young and the old as one of the major challenges of the 21st century.

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NOISE

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W.1 INTRODUCTION

The proposed SRC-II plant (Shown in Figs. 2.2 and 2.3) is to be located about 6 km (4 miles) north of Martinsburg, West Virginia. The plant and freight-handling area would be between the Monongahela River and Highway 53, with the slag disposal area to be west of the highway. This Appendix reports a study of probable noise problems in the area as a result of construction and operation of the plant.

W.1.1 Noise

Noise is defined as undesirable sound produced when an object that is in contact with air vibrates, thus producing local variations in atmospheric pressure. The size of this disturbance is defined as the sound pressure, and the summation of the number of these variations occurring per second is defined as the frequency.

Sound pressure is measured in very small units called micropascals (μPa). The ordinary range of values is from 20 to 100 million μPa . For convenience this unit has been converted logarithmically to a widely used unit called the decibel (dB). Figure W.1 shows the effect of this scale by relating decibel changes to perceived sound changes. For comparison, 0 dB equals 20 μPa and 130 dB equals about 6,200,000 μPa .

The human ear does not hear all sound frequencies equally. To make the relationship between what we hear and measurements closer, a filter known as the A-weighting network is often used to discriminate between low and very high frequencies. The resultant measurement is referred to as the A-weighted sound level in units designed as dBAs. Table W.1 shows the dBA rating for common noises.

The three noise measurement notations used most in this report are L_{eq} , L_{dn} , and L_{np} . Harris¹ defines these measurements as

equivalent continuous sound level (L_{eq}): the level of a steady sound that, in a stated time period at a stated location, has the same A-weighted sound energy as the time-varying sound,

day-night average sound level (L_{dn}): the 24-h equivalent continuous sound level, that is, the time-averaged A-weighted sound level, in decibels, from midnight to midnight, obtained after the addition of 10 dB to sound levels from midnight to 7:00 AM and from 10:00 PM to midnight, and

noise pollution level (L_{np}): a noise rating that takes into account the equivalent continuous sound level and the magnitude of the time variations in the sound level (the usual abbreviation is NPL).

In this SRC-II situation the area is exposed to multiple noise sources. Under these conditions the combined effect of all sources is determined by adding logarithmically the sound contribution from each source to obtain L_{eq} . Similarly, L_{dn} is obtained by adding logarithmically the L_{eq} for 15 daytime hours and L_{eq} plus 10 dBA for 9 nighttime hours. More detailed computational methods, including equations, are found in Sect. W.7.2.

W.1.2 Noise regulations

Pertinent regulations for the construction and operation of the SRC-II plant include the following.

The Department of Energy (DOE) has accepted the Environmental Protection Agency (EPA) guidelines² as being regulatory for the proposed SRC-II plant. The guidelines identified an L_{dn} of 55 dBA outdoors to protect against activity interference and annoyance in residential areas. With the plant operating day and night, an L_{eq} of 48.6 dBA should be achieved at residential receptor sites to compensate for the 10 dB "penalty" between 10 PM and 7 AM.

The EPA³ quotes the Department of Health and Human Services (HHS) guidelines for construction noise. The guidelines place the highest acceptable NPL for a community at about 74 dB (Fig. W.2).

The Department of Labor Occupational Safety and Health Administration (OSHA) standards⁴ limit exposure to impulsive noise (e.g., blasting) to a sound pressure level of 140 dB.

The EPA⁵ defines permissible train noise levels as shown in Table W.2.

The Federal Highway Administration standards⁶ limit traffic noise in residential areas to an L_{eq} of 67 dBA.

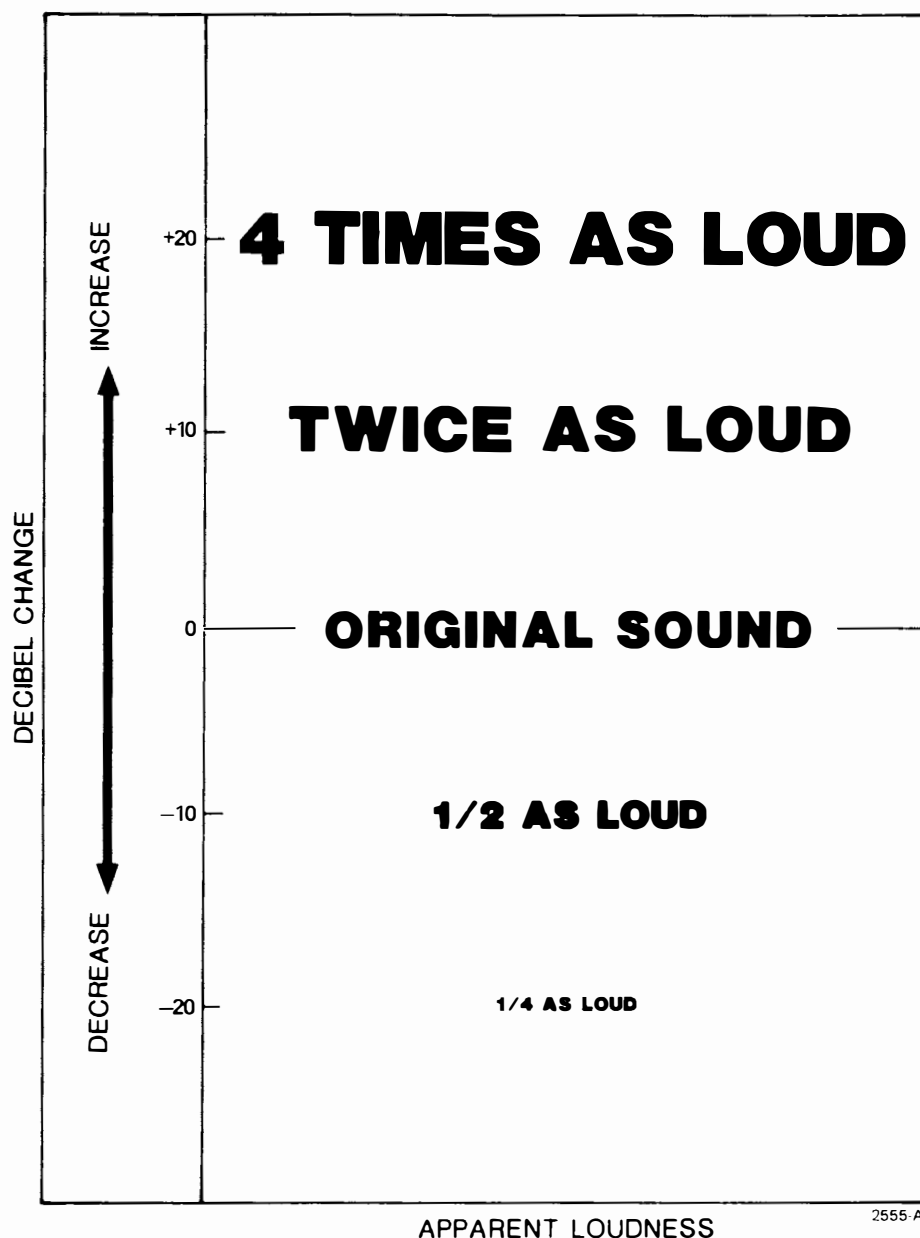


Fig. W.1. Apparent loudness as a function of decibel change.

W.2 CONSTRUCTION NOISE

Construction of the plant will be carried out in several reasonably discrete steps, each of which has its own mix of equipment and, consequently, its own noise characteristics. Assuming all construction on the site will be during daylight hours, ambient noise levels will be unchanged at night. The phases of construction (some of which can be subdivided) are (1) clearing, (2) excavation, (3) foundations, (4) erection, and (5) finishing and cleanup.

Defining the construction phases as above allows us to account for the variation in site noise output with time. By inventorying the equipment found at the site in each phase, we can derive a representative source level for each phase by the process described below.

Table W.1. Common noise levels

dBA ^a	Common noise levels
130	Threshold of pain
120	Chipping of metal
110	Rock band
100	Jackhammer
	Jet takeoff (½ mile)
90	Threshold of hearing damage
	Motorcycle (urban residential)
80	Busy freeway
70	Ice-cream truck with music (urban residential)
	Power lawn mower (urban residential)
	Children playing (urban residential)
60	Normal conversation
50	Radio playing music (urban residential)
	Bird (normal suburban area)
40	Suburban neighborhood (distance traffic)
30	
20	Quiet rural area (no traffic)
10	
0	Threshold of audibility

^adBA, A-weighted decibels.

W.2.1 Equipment noise characteristics

Despite the variety in type and size of construction equipment, similarities in the dominant noise sources and in patterns of operation permit one to assign all equipment to a very limited number of categories. These categories are indicated in Fig. W.3, together with corresponding noise level data. The data shown are for an observer within 15 m (50 ft) of the equipment.

W.2.2 Construction site noise characteristics

To characterize the noisiness (i.e., the average noise annoyance potential) of the various types of construction sites during each phase of construction, an NPL is usually calculated for each type of site and each construction phase. The NPL (in dBA) is defined as the sum of the A-weighted average sound pressure level and 2.56 times the standard deviation of the A-weighted sound pressure level; thus, NPL accounts for the effect of the steady noise, plus the annoyance as a result of fluctuations.

On the basis of an evaluation of domestic and foreign social surveys and physiacoustic studies, the HHS has adopted a set of "guideline criteria" for outdoor noise levels in residential areas as shown in Fig. W.2. According to this chart, the community noise situation is evaluated by comparing a measured distribution of A-weighted levels with the criteria curves. The situation is categorized by the region of least desirability penetrated by the actual noise distribution. Because this criterion is based on sound-level distributions, the boundaries between regions of acceptability may be defined in terms of the NPL. Thus, the following descriptors of NPL values may be used interpreting the site NPLs.

1. Clearly acceptable — The noise exposure is such that both the indoor and outdoor environments are pleasant: NPL less than 62 dBA.
2. Normally acceptable — The noise exposure is great enough to be of some concern, but common building constructions will make the indoor environment acceptable, even for sleeping quarters, and the outdoor environment will be reasonably pleasant for recreation and play: NPL between 62 and 74 dBA.
3. Normally unacceptable — The noise exposure is significantly more severe so that unusual and costly building constructions are necessary to ensure some tranquility indoors, and barriers must be erected between the site and prominent noise sources to make the outdoor environment tolerable: NPL between 74 and 88 dBA.

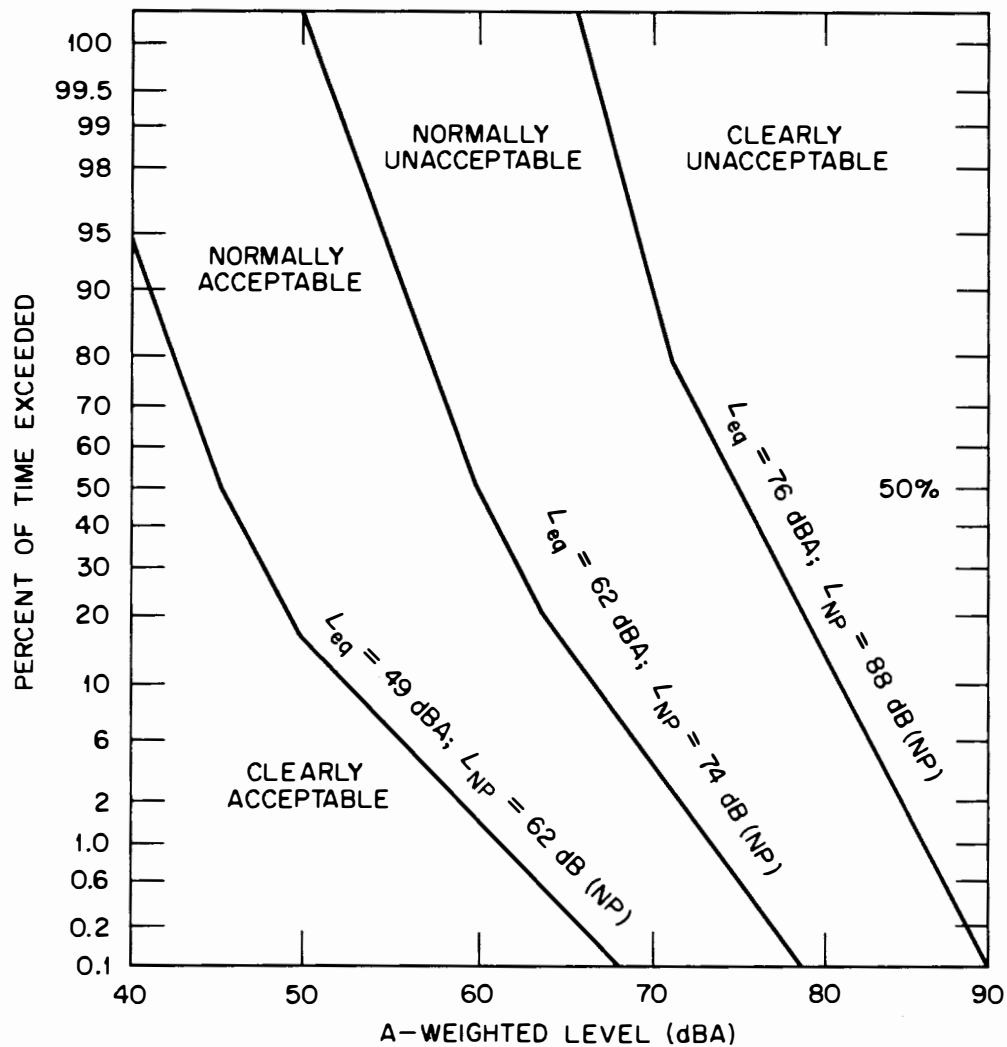


Fig. W.2. Guideline criteria relating noise pollution level to community noise acceptability. Source: U.S. Environmental Protection Agency, 1975.

4. Clearly unacceptable — The noise exposure at the site is so severe that the construction costs to make the indoor environment acceptable would be prohibitive and the outdoor environment would still be unacceptable: NPL greater than 88 dBA.

We must emphasize that these criteria have not been officially or unofficially adopted by HHS or any other government agency. They are presented here solely to enable the reader to interpret NPL values computed in this report.

The averages of noise annoyance potential were calculated on the basis of information obtained on (1) the number of each item of equipment typically present at a site (in a given phase), (2) the length of the duty cycles of this equipment, and (3) the average noise levels during operation.

For purposes of site characterization, the noisiest piece of equipment was assumed to be located 15 m (50 ft) from an observer, and all other equipment was assumed to be located 60 m (200 ft) from the observer. Ambient noise (levels depending on the surroundings of the site) was taken to be present in addition to the equipment noise. The construction noise model may be expected

Table W.2. Permissible train noise (dBA)
Best maintenance practice standards

	Existing	New (after 1979)
Rail cars ^a		
At speeds of 20 m/s (45 mph) or less	88	
At speeds of more than 20 m/s (45 mph)	93	
Locomotives ^a		
Stationary		
At idle	73	70
At other throttle settings	93	87
Moving	96	90
Switchyard retarders ^b	83	
Car-coupling operations ^b	92 ^c	

^a100 ft from source.

^bMaximum level at receptor site.

^cException: where 92 dBA previously exceeded coupling, speed cannot exceed 4 m/s (8 mph).

to yield at least a relative measure of the noise annoyance associated with each type of site and phase for the most adverse conditions likely to be associated with each phase.

Table W.3 shows NPLs calculated for each of five phases of construction pertaining to the relatively quiet (50 dBA) ambient conditions found in suburban environments.

The NPL values shown in Table W.3 obviously depend on the previously described model of the site. For this model, the average sound pressure level depends strongly on the one or two noisiest pieces of equipment, whereas the standard deviation depends largely on the numbers and duty cycles of the less noisy equipment and on the ambient noise level.

The attenuation of critical NPL levels with distance from sources is shown in Table W.4. Most of the construction will occur at locations far enough from receptors to expose them to acceptable NPL levels.

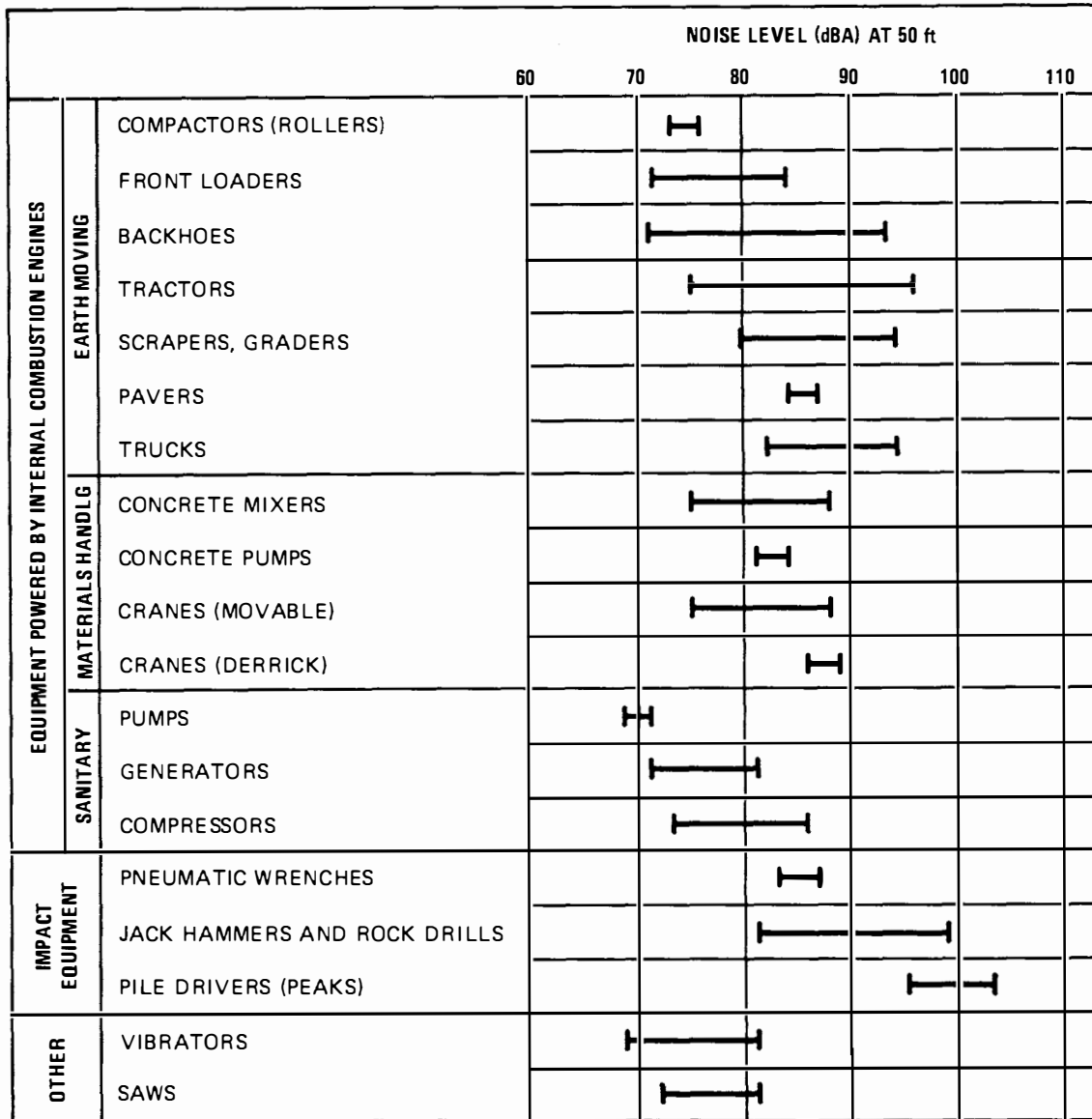
W.2.3 Blasting noise problems

Noise is an undesirable by-product of blasting. Air vibrations are generated by the blast and are propagated outward through the air under the influence of the existing topographic and atmospheric conditions. Three mechanisms are usually responsible for the generation of air blast vibrations: the venting of gases to the atmosphere from blown-out unconfined explosive charges, release of gases to the atmosphere from an exposed detonating fuse, and ground motions resulting from the blast. Unstemmed explosive charges in open boreholes allow venting of the gases to the atmosphere. However, partial confinement allows useful work to be done and results in reduction of the amplitude of the air blast over an open air explosion. Further confinement of the blast in the boreholes by the addition of stemming reduces the air blast through allowing a more gradual release of the gases by pushing out the stemming and through the broken burden. The air vibrations generated by ground motion resulting from the blast are small. The surface acts as a piston, moving the air above the point of detonation. Thus, the quality of air displaced by the ground motion is small compared with the volume of gas released during a blast.

Because the greatest amount of noise is generated by venting gases, the use of stemmed charges with a buried detonating fuse is a logical procedure to follow to reduce blast noise.

The use of a blasting mat over a borehole further reduces air vibrations to reasonable levels. The OSHA standards specify a limit of 140 dBA for construction workers in a blasting area. This level would normally attenuate to about 80 dBA at a distance of 305 m (1000 ft).

However, the rapid rise of gases managing to escape the borehole make blasting noise especially susceptible to meteorological conditions. The propagation velocity may increase with altitude as a result of the existence of a temperature inversion or of increased wind velocity at higher altitude, causing the blast waves to be refracted downwind to focal areas some distance from the blast.⁷



NOTE: BASED ON LIMITED AVAILABLE DATA SAMPLES.

Fig. W.3. Construction equipment noise ranges. Source: U.S. Environmental Protection Agency, December, 1975.

Legitimate damage claims may result when personal or property damage is caused by seismic or air blast waves from blasts. The advances in blasting technology during the past 25 years, including blasting procedures, damage criteria, knowledge of seismic wave propagation, monitoring instrumentation, and a more knowledgeable blasting profession, have minimized claims resulting from real structural damage. More and more blasting operators instrument their own blasts or subscribe to a consulting service to insure vibration levels below those necessary to cause damage. The occasional legitimate damage claim can result from many unknown causes, the best perhaps being that any damage criterion is a probability-type criterion.

Vibration levels that are completely safe for structures can be annoying and even uncomfortable for people. Predominant frequencies generated by blasting are commonly in the range of 6 to 40 cycles per second (cps). If a building is being vibrated to a particle velocity of 1.0 in./s, the building is considered safe, but the vibration level as viewed subjectively by people is intolerable. At a particle velocity of 0.2 in./s, the probability of damage to a building is nil, yet the vibration level is viewed as quite unpleasant or annoying by some people.

Table W.3. Typical ranges of noise levels at public works construction sites with a 50-dBA ambient typical of suburban residential areas

	Ground clearing		Excavation		Foundations		Erections		Finishing	
	I ^a	II ^b	I ^a	II ^b	I ^a	II ^b	I ^a	II ^b	I ^a	II ^b
Energy average dBA	84	84	88	78	88	88	79	84	84	84
Standard deviation	8	8	7	3	8	8	9	11	7	8
Noise pollution level	103	104	106	86	108	108	103	108	101	104

^aAll pertinent equipment present at site.^bMinimum required equipment present at site.**Table W.4. Attenuation of noise pollution level with distance**

NPL ^a (dBA)	Distance [m (ft)]	
	To NPL = 74 dBA	To NPL = 62 dBA
120	56 (185)	225 (740)
110	18 (60)	72 (235)
100	6 (20)	23 (75)

^aNoise pollution level.

A similar relationship exists with the noise associated with air blast pressures. The air blast pressure from most blasts is considered less than that which causes glass damage. However, the sound level near a blast is comparable to the maximum sound in a boiler shop or the sound level 1.2 m (4 ft) from a large pneumatic riveter. The sound level at 152 m (500 ft) compares with the sound generated at a distance of 1 m (3 ft) from a trumpet, auto horn, or an automatic punch press. It is completely understandable that the public reacts to blasting operations. No amount of objective data will convince a person who "feels" strong vibrations that the vibration level as measured was barely perceptible — a similar situation exists with noises and air blasts. Personal contact and strong efforts in public relations help to alleviate the problem but convince few. The only solution possible is to keep vibration levels and air blast pressures well below the safe vibration criteria and concentrate on noise abatement.

W.2.4 Mitigations

The typical range of construction noise has a maximum NPL of less than 110 dBA (Table W.3). This level attenuates to a normally acceptable level of 74 dBA at a distance of 18 m (60 ft) and a clearly acceptable level of 62 dBA within 72 m (235 ft). Most of the construction will be done far enough from receptors to expose them to normally acceptable NPL levels, but temporary barriers may be desirable in a few cases.

Blasting operations in the area require advance publicity. A reputable professional blasting contractor should be used, and the specifications should include the case of blasting mats.

W.3 OPERATIONAL NOISE

The proposed plant layout (Fig. W.4) contains several areas having multiple noise sources in each. The individual noise components from specific pieces of equipment and their composite noise levels for each area are given in Table W.5. This table is based on design data furnished by P&M/ET-78-C-01-3055/C-21500, Table 1 — "Noise," and interpreted by Dr. Pugsley and checked with Dr. Bradshaw of Stearns-Roger. As a conservative move, the highest value was used for variable level noise sources. The composite noise levels are rounded to the nearest whole number. Values shown with an asterisk in the table were estimated to operate 10% of the time, since no specific information was available; the L_{eq} computations for the area are based on this assumption.

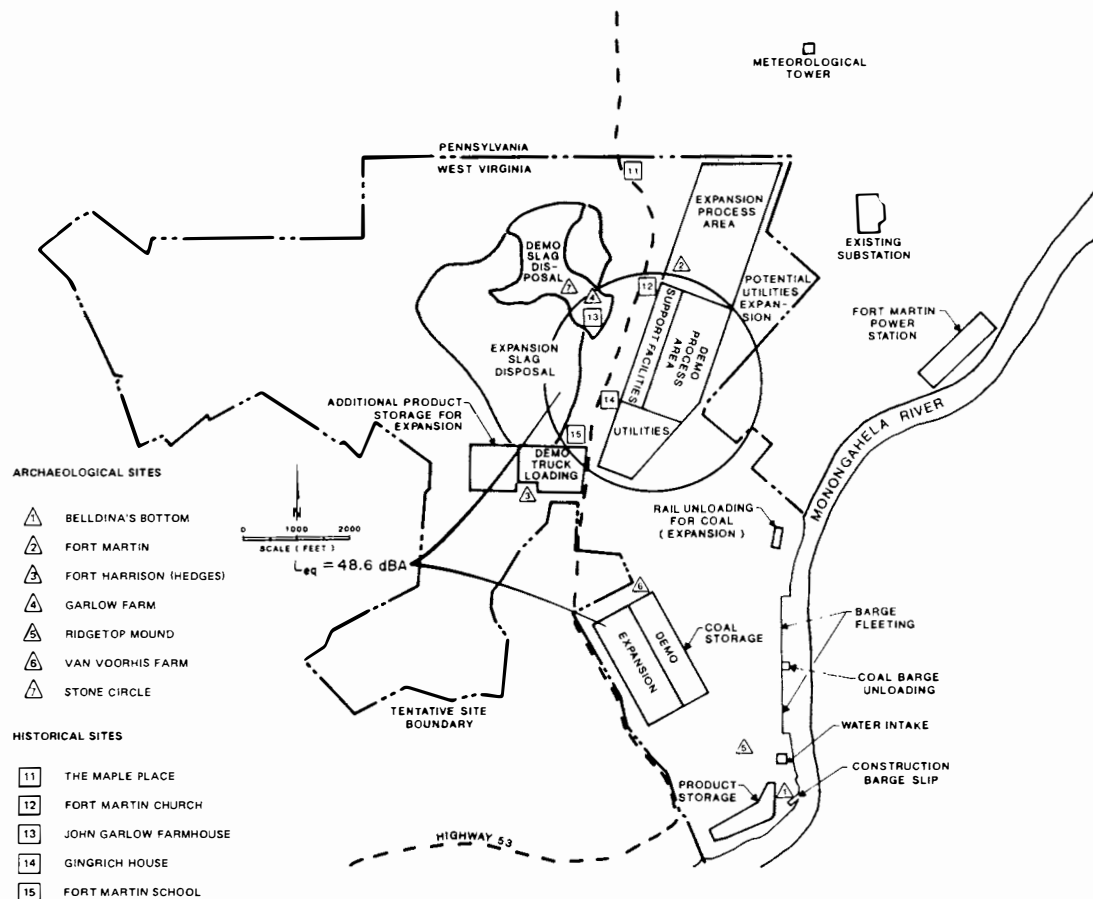


Fig. W.4. Plant layout with contour at $L_{eq} = 48.6 \text{ dBA}$ and $L_{dn} = 55 \text{ dBA}$.

W.3.1 Resulting noise levels

The contour in Fig. W.4 is an approximate boundary of the area exposed to noise levels greater than the mandated limit of $L_{dn} = 55 \text{ dBA}$. Estimated noise levels at the building indicated by numbered circles are (in dBA)

		L_{eq}	L_{dn}			L_{eq}	L_{dn}
1	Stone Circle	49	55	5	Gingrich house	56	62
2	Fort Martin	49	55	6	Fort Martin Church	55	61
3	Garlow farm	51	57	7	Fort Martin School	51	57
4	Garlow house	54	60				

The loudest noise source in the coal stockpile area will be a front loader bulldozer estimated at 95 dBA. Noise levels of 48.6 dBA will extend about 59 m (195 ft) from the area boundary when the bulldozer is operating along the perimeter.

W.3.2 Pipe cleanout noise

Before the plant becomes operational, there will be a single-event noise from a steam blast to clean out the pipes in the plant. The noise level is expected to be 105 dBA at 305 m (1000 ft) and last 2.5 min. This level will decrease to 99 dBA at 610 m (2000 ft) and 90 dBA at 1.6 km (1 mile).

Table W.5. Composite noise levels from plant areas

Map area number ^a	Unit number ^a	Unit name	Number of pieces of equipment	Noise level of each piece of equipment (dBA)	Area L _{eq} (dBA)
1	11	Dissolver plant	2 6 ^b 1 2 ^b	93 95 100 105	104
2	12	Hydrogen treating and recovery	8	93	102
4	21	Gasifier	3 2 1 ^b 2 ^b	93 100 128 104	118
5	22	Shift conversion	1 ^b	102	c
6	23	Hydrogen purification and compression	3 1 ^b	93 115	106
7	24	Syngas purification	1 ^b	105	c
8	25	Methanation	1 ^b	98	c
9	31	Low-pressure gas treating	1	93	93
10	32	Product gas	3	93	99
11	33	Sulfur recovery	2	93	98
15	44	Oxygen production, etc.	3 1 ^b 2 ^b	93 98 102	99
16	51	Steam generation	3	93	107
17	52	Water supply, treating and intake	1	93	93
18	53	Water reclamation	9	93	103
19	54	Cooling tower systems	5	93	101

^aFrom Fig. 2.2.^bValves that will operate an estimated 10% of the time.^cUsed in calculation for L_{eq} = 50 contour.

W.3.3 Mitigations

It may be feasible in the final design to provide sound barriers near the components producing the highest sound levels. Moving the louder functions to another part of the area would change the critical noise contour.

There is no apparent mitigating measure for the single-event pipe cleanout noise. Public education should minimize complaints. A brief evacuation from the area within 1.6 km (1 mile) should be recommended.

W.4 TRAFFIC NOISE

The traffic in the plant area will consist of:

1. Plant trucks hauling slag across highway 53: about 200 one-way trips per day or eight per hour is assumed as a worst case (Appendix C, Sect. C.4.1.9).
2. Commuter cars: 550 one-way trips per day. Assuming 40% of the work force on the day shift and 30% on each of the other shifts, the morning and evening peak hours would have 385 cars each.
3. Delivery trucks amounting to an added 8% of commuter traffic per day or 1% per hour during the normal work day: about eight trucks per peak hour.
4. Product shipment trucks estimated at 50 per day or two per hour (see Sect. 2).

This traffic amounts to a peak hour volume of 400 vehicles composed of 3 to 4% heavy trucks, depending on proximity to the slag-hauling traffic (l. above). Estimating this traffic to average 18 m/s (40 mph), the resulting L_{eq} would be about 63 dBA at 30 m (100 ft) and 65 dBA at 15 m (50 ft) from the highway.⁸

W.4.1 Mitigations

Although these noise levels meet the Federal Highway Administration standards,⁶ it is desirable to reduce the levels by any practicable means. Lowering the speed limit to 9 m/s (20 mph) would decrease sound levels about 5 dBA. Scheduling heavy truck traffic to avoid peak hour volume would lower peak hour sound levels 1 to 3 dBA.⁹

W.5 RAILROAD NOISE

Noise is generated by railroad operations in two basic locations: in yards and on lines. In railroad yards, trains are broken down and assembled and maintenance is performed. Line operations involve the sustained motion of locomotives pulling a string of cars over tracks.

W.5.1 Marshalling yard noise

The hump yard is an efficient system for disengaging cars from incoming trains and assembling them into appropriate outgoing trains. A locomotive pushes a string of cars up a small hill, known as a hump, allowing each car to roll individually down the other side through a series of switches onto the appropriate track, where a train is being assembled. As each car rolls down the hump, it is first slowed by the master retarder.

The slowing, or retarding, is accomplished by metal beams that squeeze the wheel of the rail car. After the cars leave the master retarder, they coast into a switching area that contains many tracks. As each car is switched onto a particular track, it is slowed by a group retarder. After a car moves out of a group retarder, it is switched onto one of many tracks in the classification area, where the car collides with another car.

The collision causes the cars to couple, forming a train. In some yards, the first car that moves into the classification area along a particular track is stopped by an inert retarder, so-called because the retaining beam is spring-loaded and requires no external operation. Inert retarders differ from the master and group retarders, which are controlled continuously by an operator or automatically by a computer.

All three of the retarding processes described produce noise. When the beam of a master or group retarder rubs against the wheels, a loud squeal is often generated. The most significant noise generated by inert retarders occurs when a string of cars is pulled through. If the inert retarders are short and exert small forces, they may generate noise that is negligible compared with the noise generated by the group retarders. Some yards are equipped with inert retarders that can be manually or automatically released when a string of cars is pulled through them, thereby preventing retarder squeal. There are no inert retarders in some yards so that an individual brakeman must ride some cars and brake them manually.

Noise is also produced when cars couple in the classification area of the yard. The impact points, and thus the origins of the noise, are scattered over the classification yard. The noise is impulsive and is sometimes followed by a thunder-like rumble audible for several seconds after the impact.

Locomotive engines generate noise as the locomotives move around or pass through yards. When the locomotives are not in use, their engines are often allowed to idle continuously (even overnight), which also results in significant noise. When the locomotives are in motion, their horns, whistles, and bells may produce noise for warning purposes.

Retarders generate noise ranging from 80 to 125 dBA at a distance of 15 m (50 ft). The maximum impulse noise (lasting a few tenths of a second) from coupling operations varies from 122 to 128 dBA at a distance of 3 m (10 ft).¹⁰ Regulations⁵ require levels of 83 to 92 dBA at receptor sites. The following table shows the distances required for attenuation to these sound levels.

Retarder noise level (dBA)	Distance to 83 dBA [m (ft)]	Coupling noise level (dBA)	Distance to 93 dBA [m (ft)]
90	2 (8)	122	9 (30)
100	8 (26)	124	11 (37)
110	25 (83)	126	14 (47)
120	80 (263)	128	18 (59)
125	143 (468)		

The EPA¹¹ has proposed new regulations for noise levels at the property line of marshalling yards, which are to be published about 1981. The proposal being considered is for $L_{eq} = 70$ dBA for all facilities and equipment after January 1, 1982, and $L_{eq} = 65$ dBA for hump yard facilities and equipment only after January 1, 1985.

W.5.2 Train noise along railroad lines

Line, or wayside, noise — the noise in communities from passing trains — is produced by many high-noise sources. The locomotive engine and its components, such as exhaust systems and cooling fans, and interaction of railroad car wheels with rails results in significant noise.

Wheel/rail noise is caused principally by impact at rail joints, giving rise to the familiar clickety-clack, and by small-scale wheel and rail roughness. A severe form of wheel roughness that generates high noise levels is caused by flat spots developed during hard braking. Also, wheels squeal on sharp curves and generate noise by flange-rubbing on moderate curves. The operation of such auxiliaries as refrigeration equipment also contributes to the overall noise level. Horns or whistles are sounded at crossings and are significantly louder than other wayside noises. In addition, some crossings are equipped with stationary bells that sound before and during the passage of trains.

Regulations limit the noise from locomotives to 96 or 90 dBA for units manufactured after 1979. Railway cars are limited to 88 dBA at speeds of 20 m/s (45 mps) or less and to 93 dBA at higher speeds.⁸

The additional freight generated by unit train shipment of products from the plant is estimated at less than 100,000 tons. This would amount to about 13% more freight traffic along the Monogahela Railroad.¹²

W.5.3 Mitigations

Noise abatement in yards can be effected by

1. parking idling locomotives in the center of yards, away from residences,
2. retarder lubrication,
3. use of ductile iron wheel shoes,
4. use of releasable inert retarders,
5. retarder control by computers, and
6. use of barriers for noise control.

Railroad line noise can be abated by

1. speed reduction,
2. ban on night operation,
3. use of larger locomotives at lower throttle,
4. engine shielding and muffling, and
5. rail welding.

W.6 SUMMARY

Construction of the plant will result in increased noise levels in the area. The increased levels will be in the normally acceptable range, except where construction is within 18 m (60 ft) of a sensitive receptor. Mitigations appear feasible in these areas (Sect. W.2.4).

Plant operation will raise noise levels above EPA guidelines. Receptors depicted in Fig. 2.2 by circles numbered 3, 4, 6, 7, and 8 will be exposed to levels greater than $L_{dn} = 55$. Some mitigation may be possible in the final plant design stage (Sect. W.3).

W.7 COMPUTATIONAL METHODS AND RESULTS

The computational methods used most in this appendix are described in W.7.1. The results of various noise levels are depicted in W.7.2.

W.7.1 Computational methods

The computation of L_{eq} from multiple sources in the same area requires the use of special rules.¹ The noise level from two equal sources of 50 dBA each is not 100 dBA but 53 dBA. With one source of 50 dBA and one of 55 dBA the combination produces 56.2 dBA. The correction factor to be added to the loudest source is taken from the equation

$$\text{Correction (dB)} = 10 \log \left[1 + 1/10^{0.1 (L_1 - L_2)} \right],$$

with L_1 and L_2 in decibels.

As another example, consider the L_{eq} resulting from five sources emitting 100, 98, 98, 93, and 93 dBA each. Here L_{eq} can be obtained by use of the following procedure:

$$\begin{array}{rcl} 100 - 98 & = & 2 \\ 102.1 - 98 & = & 4.1 \\ 103.5 - 93 & = & 10.5 \\ 103.8 - 93 & = & 10.8 \end{array} \qquad \begin{array}{rcl} 100 + 2.1 & = & 102.1 \\ 102.1 + 1.4 & = & 103.5 \\ 103.5 + 0.3 & = & 103.8 \\ 103.8 + 0.3 & = & 104.1 = L_{eq} \end{array}$$

In those areas where some noise sources will be intermittent, the following equation was used to calculate L_{eq} .

$$L_{eq} = 10 \log \left[1/n \sum_{i=1}^n 10^{L_i/10} \right].$$

Here n is the number of time units within which each sound level (L_i) is present.

As an example, six valves at 95 dBA and two at 105 dBA operate 10% of the time or 6 min/h. Their combined $L_i = 109.2$ dBA. In the same area two pieces of equipment operate along 54 min/h at 93 dBA each and one piece at 100 dBA. Their combined $L_i = 101.5$. The combination produces 109.9 dBA during 6 min each hour. Then

$$L_{eq} = 10 \log \left[\frac{6(10^{10.99}) + 54(10^{10.15})}{60} \right]$$

$$L_{eq} = 103.5 \text{ dBA}.$$

The resulting L_{eq} for each area in Fig. W.4 was used to the nearest decibel.

For $L_{dn} = 55$, use the same procedure with 15 h at $L_i = 48.6$ dBA and 9 h at $L_i = 58.6$ dBA. This compensates for the 10 dB "penalty" between 10 PM and 7 AM.

To compute the attenuation with distance, consider the sound in an area as emanating from a single source. For simplicity, assume no reflective or absorptive surfaces so that the spherical waves are undisturbed. This is a reasonable assumption for SRC-II after the site is graded for construction. Little, if any, absorption or reflection within the site will affect noise levels emanating to the outside community. Since the sphere radii and circumferences increase with distance, the sound level decreases. The result is described by the equation

$$L = L_0 - 20 \log d - 0.6$$

or

$$\frac{L_0 - L - 0.6}{20} = \log d$$

To find the distance to a point where $L = 50$ dBA, when $L_0 = 111$ dBA,

$$\log d = \frac{110 - 50.6}{20} = 3.02 ,$$

$$d = 1047 \text{ feet .}$$

The contour in Fig. W.4, where $L_{eq} = 48.6$ dBA and $L_{dn} = 55$ dBA, was placed at distances where the sound level from a single source is attenuated by distance from the source to 48.6 dBA. The predominant noise comes from the gasifier complex, so the contour is about 838 m (2750 ft) from the center of this area. Attenuated noise levels from other areas were well below 48.6 dBA at points along the contour so that no significant correction factors needed to be added. This contour depicts the centerline of a rather diffuse noise zone rather than a sharp line of discontinuity between higher and lower sound levels.

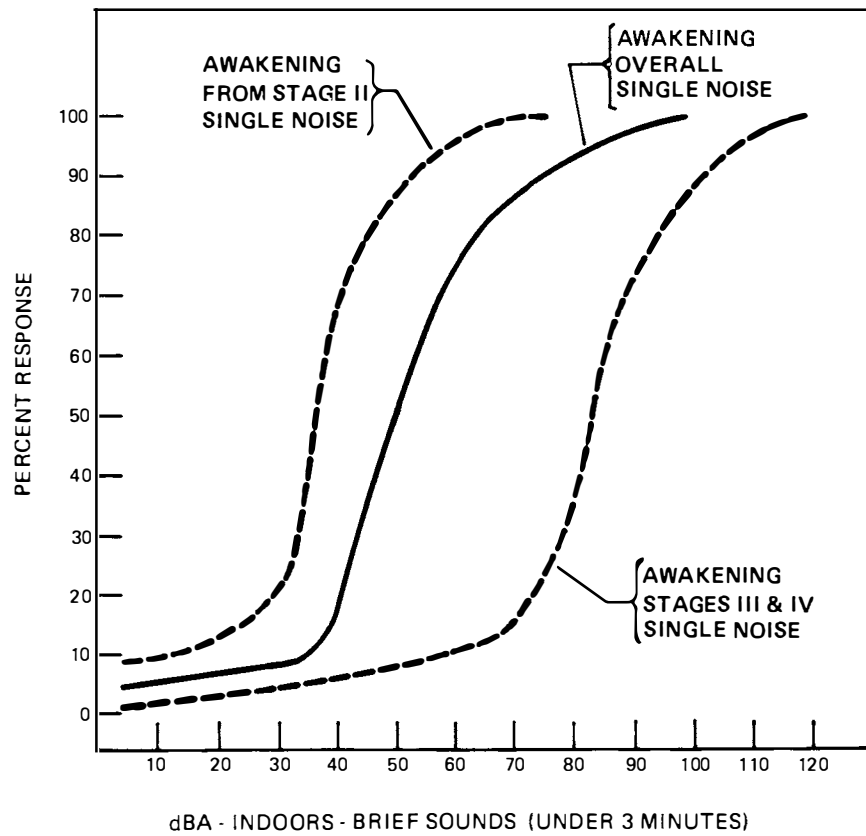
W.7.2 Results of noise problems

Some generalized results of noise level problems in a typical community are shown in Figs. W.5 through W.7.

W.8 CONTACTS AND REFERENCES

Persons contacted for information needed during this analysis include:

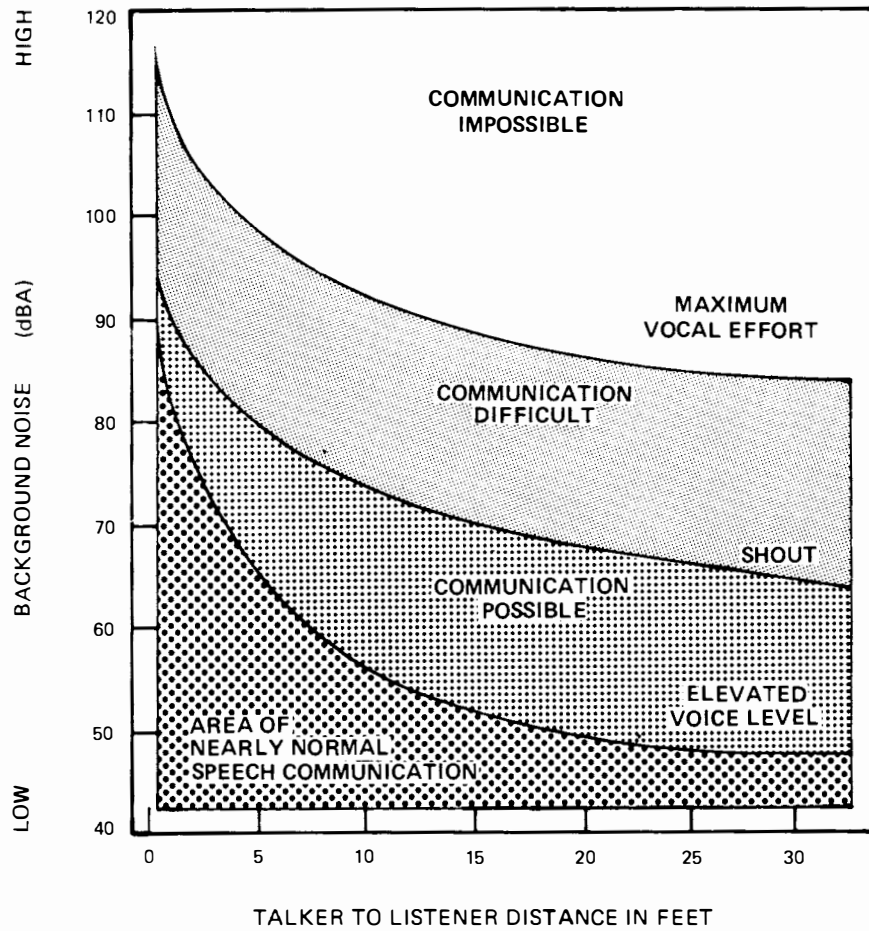
Robert DeVault, Oak Ridge National Laboratory;
 Ray Moxley, Pittsburg & Midway Coal Mining Company;
 Dr. E. B. Pugsley, Stearns-Roger; and
 Dr. W. N. Bradshaw, Stearns-Roger.



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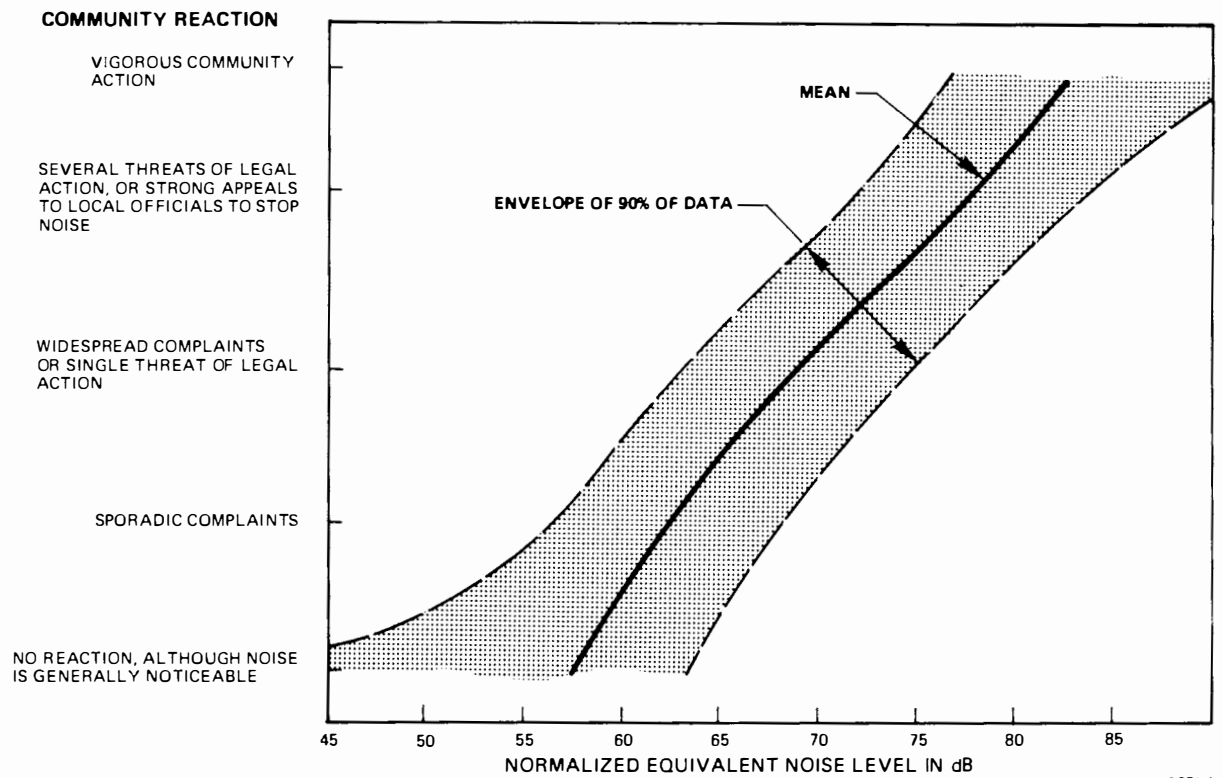
Fig. W.5. Sleep interference as a function of the intrusion of noise on normally rested young adults who are unacclimated to the noise level.

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2563-A

Fig. W.6. Quality of verbal communication in relation to distance between speaker and listener.



2571-A

Fig. W.7. Community reaction to intrusive noise.

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12. U.S. Department of Transportation, United States Transportation Zone Maps, Federal Railroad Administration, October 1975.

Appendix X

DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ENVIRONMENTAL POLICY ACT COORDINATION

- Ward, R. D., & B. A. Schmitt. 1999. The evolution of the concept of a species. *Journal of the History of Biology* 32: 1301-1317.
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THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

September 17, 1980

Honorable Douglas M. Costle
Administrator
United States Environmental
Protection Agency
Washington, D.C. 20406

Dear Mr. Costle:

I want to extend my appreciation for your expression of the Environmental Protection Agency's cooperation and support for the Department of Energy's synthetic fuel demonstration program. We encourage and welcome the Environmental Protection Agency's efforts to expedite environmental guidance, reviews, and permits. The development and commercialization of synthetic fuel technologies will necessitate a continued close and effective working relationship between the Environmental Protection Agency and the Department of Energy.

I am advised that interactions between the Environmental Protection Agency and the Department of Energy have begun in connection with the development of generic environmental guidance documents for synthetic fuel technologies. We view this process as extremely critical since these guidance documents will play a major role in shaping environmental compliance requirements for future commercial synthetic fuel facilities. We believe that environmental guidance for synthetic fuel technologies should reflect a range of best available control systems and concepts rather than one particular system or concept that may not be universally cost-effective or technically applicable for individual facilities.

In your letter you expressed concern about the coordination of environmental review and regulatory requirements with the development of the proposed SRC-II project in Morgantown, West Virginia. As you know, this project has major importance to the President's synthetic fuel program. It is expected to resolve many of the remaining uncertainties with regard to the technical feasibility, environmental acceptability and economic competitiveness of the solvent-refined coal technology.

Conceptual design of the SRC-II project is virtually complete. Detailed final design of the facility should commence on a full-scale basis in the near future and is scheduled for completion by March 1983. As is common in the process industries, facility construction will not await completion of final facility design and is scheduled to begin in the spring of 1981 with an estimated completion date of August 1984. This process should permit the design of appropriate environmental controls to proceed concurrently with final, detailed design of the overall project and to be incorporated in a timely manner into the construction schedule. We look forward to working closely with the Environmental Protection Agency in the design of such controls and to expedite requisite environmental permits.

Page 2

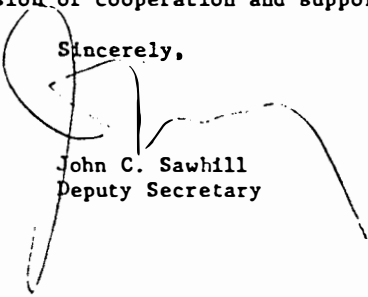
With respect to our strategy for compliance with the requirements of the National Environmental Policy Act (NEPA), we plan to issue a final environmental impact statement with the best available information prior to any decision to proceed with major detailed design efforts and to commence construction of the SRC-II facility. In our view, it is appropriate to complete this final environmental impact statement prior to any significant financial commitments to the SRC-II project, such as would be incurred by the completion of final design, projected to cost approximately \$200 million. Utilizing a tiering approach, we would, of course, perform supplementary NEPA reviews as necessary, to address significant environmental impacts not within the scope of the final environmental impact statement. For example, further NEPA review would be required if environmentally significant new information relevant to the selection of environmental control equipment arises as a result of further design efforts. In addition, as new information becomes available which we believe would be of interest to EPA, we will promptly share it with you.

In addition, in accordance with the terms of the cost-shared contract, the Department of Energy will prepare appropriate NEPA documentation prior to any transfer of the demonstration facility to the industrial partner.

It is my intention that Department of Energy staff continue to work closely with the Environmental Protection Agency Headquarters and Regional representatives on resolving environmental issues concerning the synthetic fuels technology area generally and the proposed SRC-II project specifically.

Thank you again for your expression of cooperation and support.

Sincerely,



John C. Sawhill
Deputy Secretary

SEP 17 1980

MEMORANDUM

Meeting Between the Department of Energy
and the
Environmental Protection Agency
on SRC-II

MEETING REPORT: DOE/EPA-SRC-II EIS

DATE: September 15, 1980

PLACE: Room 4E-096 DOE, Forrestal Building

TIME: 2:00 p.m. - 3:30 p.m.

ATTENDEES: See attached

Over the past several weeks EPA's comments on the SRC-II draft EIS have generated much concern on the part of DOE officials. Therefore, Key officials of both agencies met to address outstanding issues. It was made clear from the outset that both agencies are strongly committed to the development of a synthetic fuels industry in an environmentally sound manner. With respect to the issues raised on SRC-II, the following agreement was made.

AGREEMENT

1. Regarding EPA/DOE closer coordination

DOE invited EPA to work closely with DOE's Fossil Energy Environmental Task Force which is currently coordinating five synthetic fuel demonstration projects. EPA accepted this invitation.

2. Regarding applying NEPA to the design stages of the project

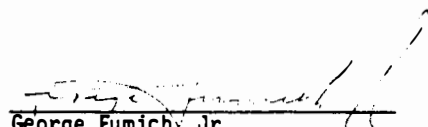
EPA supports DOE's NEPA strategy as outlined in the attached letter from John Sawhill to Douglas Costle and believes that the information gaps EPA identified in commenting on the DEIS will be remedied by the FEIS and supplemental reports which DOE will make available to the public. EPA does not believe that DOE needs to issue a revised DEIS before it issues the FEIS.

3. Regarding effective monitoring

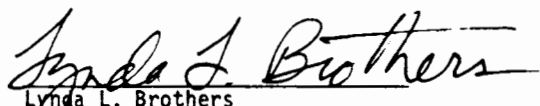
The accuracy of analyses and effectiveness of mitigating measures must be tested by a comprehensive monitoring program throughout construction and operation of the demonstration project. DOE and the industrial partners are committed to such a program and will assure that EPA and the public are fully apprised of its results.

4. Regarding applying NEPA at the commercialization stage of the project

DOE has signed a cost-shared agreement with the industrial partners which now assures that DOE will prepare appropriate NEPA documentation prior to any transfer of the demonstration facility to the industrial partners. EPA agrees that the above commitment satisfactorily addresses one of the major concerns EPA expressed when commenting on the DEIS.


George Fumich, Jr.
Assistant Secretary
for Fossil Energy, DOE


William N. Hedeman, Jr.
Director
Office of Environmental Review
Environmental Protection Agency


Lynda L. Brothers
Deputy Assistant Secretary
for Environment, DOE

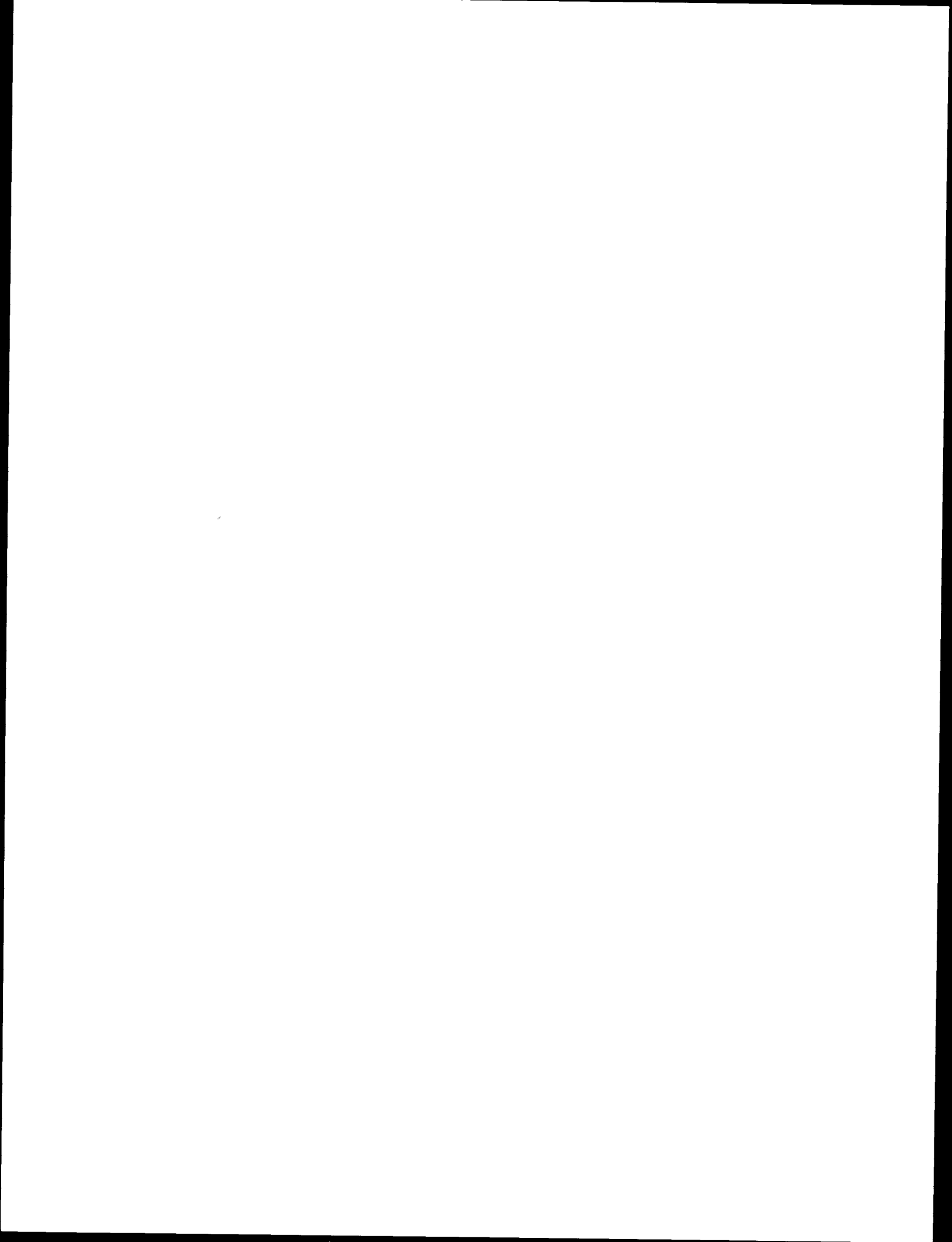
Attachments

LIST OF ATTENDEES

DOE/EPA MEETING SRC II

SEPTEMBER 15, 1980

<u>NAME</u>	<u>ORGANIZATION</u>	
Larry M. Joseph	DOE/FE	353-5964
Steve Greenleigh	DOE/OGC	252-6947
Bob Stern	DOE/EV	252-4600
Bill Hedeman	EPA/OER	755-0777
Lynda Brothers	DOE	
Tom Shëckells	EPA/OER	755-0777
Joe McCabe	EPA/OER	755-0780
George D. Pence	EPA Region III	215-597-3654
Tobey Pierce	OER/EPA	755-0780
Barbara J. Bramble	DOE/OGC/CEB	395/4616
R. S. Davis	EPA-3	597-7188
Steven A. Torok	EPA Region III	215-597-6334
Tom Gouggon	EPA/OPE	755-2733
Don Ryan	EPA/OPM	755-0933
Roger LeGassie	DOE/FE	252-6660
George Fumich, Jr.	DOE/FE	252-6660
Edward J. Lievens, Jr.	DOE/FE	353-3107
John F. Pearson, Jr.	DOE/Oak Ridge	615-576-1051
Martin L. Rogowsky	DOE/FE	252-6503
Carol Borgstrom	DOE/EV	252-4600
Jim Johnson	DOE/FE	353-2983
Mary Shaughnessy	DOE/EV	252-4610
Phil Ross	EPA/Legislation	755-0544
Bill Coleman	EPA/Legislation	755-0484
Peter Hecht	EPA/OER	755-0770



Appendix Y
HEALTH EFFECTS

Appendix Y.1
SRC-II STUDY PROGRAM

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for ensuring the integrity of the financial system and for providing a clear audit trail. The document also highlights the need for transparency and accountability in all financial dealings.

In the second part, the focus is on the role of the central bank in regulating the money supply and interest rates. It explains how these tools are used to maintain price stability and to support the overall economic growth. The document also discusses the challenges faced by the central bank in balancing these objectives.

The third part of the document deals with the financial system's response to external shocks. It describes how the system can be resilient to such shocks and how the government can provide support when needed. The document also discusses the importance of international cooperation in addressing global financial issues.

Finally, the document concludes by emphasizing the need for continuous monitoring and evaluation of the financial system. It calls for a proactive approach to identifying and addressing potential risks and challenges. The document also stresses the importance of public participation in the financial system and the need for a strong regulatory framework.

PNL-3517
UC-90

SOLVENT REFINED COAL-II
(SRC-II) DETAILED
ENVIRONMENTAL PLAN

Prepared by Staff of the
Coal Liquefaction Environmental
Research Program

October 1980

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

FOREWORD

This document describes a detailed plan to aid development of an environmentally acceptable solvent refined coal (SRC-II) conversion process. Most of the document was prepared by the staff of the Pacific Northwest Laboratory (PNL) under the direction of the Coal Liquefaction Environmental Research Program (CLERP) office. Other organizations that contributed include:

Environmental Research and Technology, Inc.

pp. 9-23 SRC-II Process, (excerpted from "Solvent Refined Coal (SRC-II) Technology: Materials for Environmental and Health Characterization." Environmental Research and Technology, Inc., July 1980.

Pittsburg & Midway Coal Mining Co.

p. 59 Eye Irritation, Dermal Sensitization, Aspiration Hazard

pp. 60-63 Industrial Hygiene, Phase I

pp. 83-84 Industrial Hygiene, Phases II-IV

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EXECUTIVE SUMMARY: SOLVENT REFINED COAL-II (SRC-II)
DETAILED ENVIRONMENTAL PLAN

This document describes environmental research which will:

- aid in the development of an environmentally acceptable SRC-II process, and
- provide data for environmental assessment of the process.

The document provides a management plan which involves the cognizant offices of the Department of Energy (Assistant Secretary for the Environment and Assistant Secretary for Fossil Energy (ASFE), Oak Ridge Operations office), the developers of the SRC-II process, and environmental research groups. The SRC-II process is described, criteria for selection of samples to undergo environmental analyses are given, and approximate timelines are presented for obtaining pertinent samples.

At this time, the SRC-II process is at the pilot-plant stage of development and a demonstration facility is scheduled to begin operation in 1984. Since design criteria may change, the environmental research described in this document is organized in four phases which correlate with and will provide information early in process development.

Phase I research (screening) evaluates samples from existing SRC-II facilities (pilot, process demonstration unit [PDU], bench) which may bracket potential demonstration/commercial practice in terms of physical and chemical criteria. The samples are being subjected to a battery of short-term biomedical and ecological assays. Chemical fractionation and analysis are being performed to determine compounds and compound classes of potential concern. In some cases, chemical fractionation/manipulation is required to provide materials amenable to biological and ecological testing. Phase I research provides a first estimate of potential environmental properties of SRC-II materials. As such, Phase I aids in:

- setting research priorities for the second phase of work which involves longer-term, more-extensive biomedical and ecological assays and chemical analyses;
- providing initial data on materials and chemical entities that may require ameliorative action during process development;
- providing first, qualitative analyses for assessing environmental risk to be expected from deployment of the SRC -II process.

Phase II (baseline) research will evaluate SRC-II materials which are considered most representative of potential demonstration/commercial practice. These materials will be subjected to longer-term, more-extensive biological and ecological analyses relative to effects and environmental fate. Chemical fractionation and analyses will again be used to: 1) provide materials amenable to bioassay, and 2) determine compounds and compound classes of concern. Results from this research phase will provide:

- a reasonable estimate of which materials of concern may require regulation;
- correlation analyses between short-term, inexpensive, in vitro and selected in vivo assays (Phase I) and longer-term, more expensive, in vivo assays and ecological studies (Phase II);
- a basis for development of control technologies and management procedures which may ameliorate environmental risk;
- a second and more quantitative assessment of potential environmental risk.

Phase III research will examine effects of process modification, control technologies and changing operational conditions on potential environmental properties of SRC-II materials. Short-term biological and ecological analyses (Phase I), which have been shown to correlate with longer-term analyses (Phase II), will be used in Phase III. Integrated chemical fractionation and analysis methods (selected in Phase I), will be used to determine compounds and compound classes of environmental concern. Data from Phase III will provide:

- a basis for determining effectiveness of control technology, process modification, etc. relative to decreasing potential environmental effect,
- a third analysis of environmental risk which would consider effects of altered plant operations.

Phase IV research (onsite monitoring) will develop methods and initiate environmental monitoring for effects at the SRC-II demonstration facility and potential commercial sites. Data from Phases I, II and III may provide indicators of biological and ecological effects, and a basis for assays for potentially harmful chemical entities which should be monitored in the work-place and local environments. Phase IV research efforts will include intensive studies of environmental fate and transport for SRC-II materials. Data from demonstration facility monitoring should allow:

- development of more-effective environmental management procedures in the areas of waste disposal and industrial hygiene, for both the demonstration and commercial SRC-II facilities;
- quantitative environmental risk assessment which is more appropriate to a commercial SRC-II process.

This document also describes industrial hygiene programs which must occur throughout SRC-II process development. Present studies concerning potential end-use of SRC-II materials are also discussed. Since end-use of SRC-II products is still under consideration, environmental effects relevant to end-use will be considered in later versions of this environmental program. It is anticipated that research on end-use, especially that involving utilization of SRC-II materials as refinery and petrochemical feedstocks, will proceed in phases similar to those already described. Efforts to assess control technologies will be described in a separate document.

Summaries are provided of ongoing efforts and results to date on research in Phases I, II and III. The current program is defined most specifically in Phase I, with decreasing levels of specific description in Phase II, and little specificity in Phases III and IV. Phases III and IV are contingent on process development and results of Phases I and II. Therefore, the plan will be routinely updated to more specifically define later-phase research efforts. Studies suggested in the plan are consonant with the Environmental Concerns and Requirements stated in the Environmental Development Plan for Coal Liquefaction and in the Program Environmental Plan for SRC processes.

INTRODUCTION

Three coal liquefaction processes are being developed by industry, with the aid of the U.S. Department of Energy (DOE), and may be ready for commercialization by the 1990s. These include the Solvent Refined Coal-II (SRC-II), H-coal, and donor solvent processes. Another SRC process (SRC-I), which produces a low-sulfur, low-ash, solid fuel for use in electric power production, is also expected to undergo commercialization within the same time frame.

SRC-I and -II are currently in a more advanced stage of development than are the H-coal or donor solvent processes. Demonstration facility designs are being prepared for both SRC options, and construction of demonstration facilities will be initiated by 1981. Both process options are being studied at a 50-ton/day, pilot plant in Ft. Lewis, WA. The SRC-I process is also being evaluated at a 6-ton/day pilot plant in Wilsonville, AL. H-coal and donor solvent pilot plants were scheduled for operation in 1979-1980 and 1980-82, respectively, and large-scale process demonstration unit (PDU)/pilot plants for these processes recently became available for research on potential environmental effects.

In the spring of 1978, the Environmental Coordinating Committee for Coal Liquefaction of the Office of the Assistant Secretary for the Environment (ASEV) asked the Pacific Northwest Laboratory (PNL) to prepare environmental research plans for the solvent refined coal processes (SRC-I and II). In the fall of 1978, discussions were held with Assistant Secretary for Energy Technology (ASET) personnel and personnel representing operators (the Pittsburgh & Midway Coal Mining Co. [P&M] and Gulf Mineral Resources Co.) of the SRC pilot plant. These companies may also be responsible for operation of the SRC-II demonstration facility. Through a series of meetings and further discussions, a joint effort was begun among personnel representing process developers and PNL to initiate environmental research and integrate process information with the environmental research program. This document is a result of these joint efforts and of research experience on the SRC-II process.

PROGRAM ORGANIZATION AND MANAGEMENT

The current program represents research in progress at PNL, under the aegis of ASEV/DOE; P&M efforts at the site of the potential SRC-II demonstration facility; and P&M's work relative to SRC-II research and development at the Ft. Lewis pilot plant and the Merriam, KS PDU. The latter programs are also sponsored by ASFE/DOE under program offices for demonstration facilities and research and development, respectively.

The organization of SRC coal liquefaction environmental programs at PNL is shown in Figure 1. The SRC-II program is administered through PNL's Coal Liquefaction Environmental Research Program (CLERP). Personnel report administratively to Drs. H. Drucker and S. Marks of the PNL-DOE Program Office. Drs. Drucker and Marks provide administrative support in the organization-wide effort required for implementation of this plan. Dr. Drucker serves as manager of coal liquefaction research at PNL, and will be aided in his activities by an associate manager, Dr. R. H. Gray. This coordinating group will serve to integrate research and reporting activities for the research tasks that presently comprise the PNL SRC program and other coal liquefaction environmental activities. The group will also function as liaison for program/task/project development with cognizant offices of DOE.

Three tasks in the PNL program (chemical characterization and monitoring, biomedical evaluation, and ecological evaluation), which are defined by present DOE-ASEV funding documents, will be performed at PNL. One task (biomedical and environmental assessment) is not expected to receive funding until FY 1981. This task will involve input from the three PNL departments presently participating in the program (Biology, Ecological Sciences, and Physical Sciences), and two other PNL departments (Atmospheric Sciences, and Water and Land Resources). PNL will provide source-term data for determining dose and effects to ecosystems and dose to occupationally and environmentally exposed human populations. Evaluation of the SRC-II process relevant to risk analyses will be provided by Environmental Research and Technology, Inc. (ERT), contracting to the Fossil Energy Division of DOE. Science Research Systems, Inc. will aid in extrapolating dose-effect relationships to man, as measured in experimental systems. PNL will have primary technical and managerial responsibility for the SRC-II environmental assessment.

Task leaders representing key program elements will develop programs applicable to determination of environmental effects of demonstration and commercial SRC-II facilities. Research will provide data relevant to the environmental concerns and requirements stated in the Coal Liquefaction Environmental Development Plan and in the SRC-II Program Environmental Plan.

A technical advisory committee (TAC) will be established to aid in technical review and in setting research priorities for environmental studies. The TAC will include senior PNL scientists from programs other than coal liquefaction, and consultants drawn from outside PNL. This committee will meet twice yearly to provide independent review of technical progress, quality, and priorities.

A major biomedical/environmental research program, funded by ASFE, is also being conducted on SRC-II under the P&M pilot-plant contract. The PNL

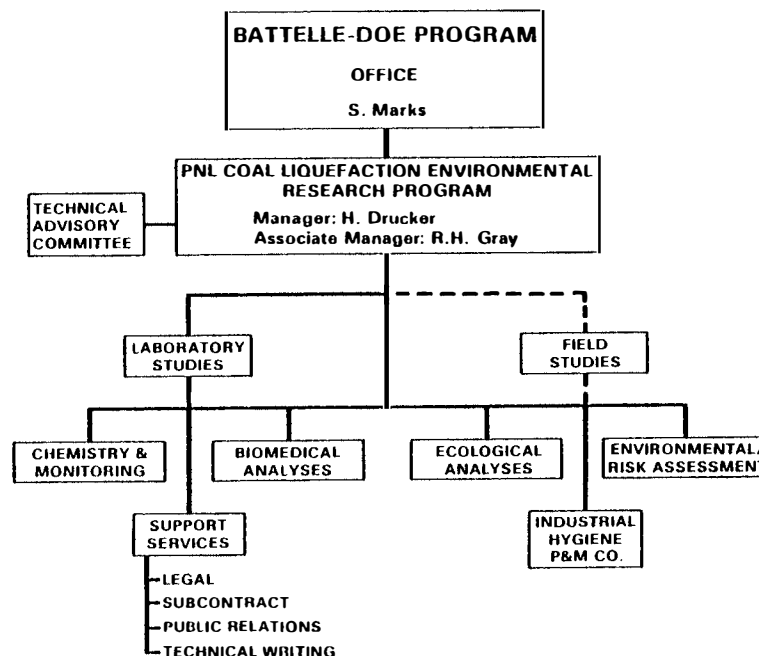


Figure 1. SRC Organization at Pacific Northwest Laboratory (PNL)

and P&M programs were designed to complement each other and to avoid duplication of effort.

PNL research at the SRC-II demonstration facility will be coordinated with the P&M Demonstration Project and the office of Dr. J. Reafsnnyder, Oak Ridge Operations (ORO, the DOE field office with overview responsibilities for SRC operations). The research will also involve collaboration with personnel of Stearns-Roger, Inc., Consulting Engineers, acting for the P&M Demonstration Project, and personnel of Oak Ridge National Laboratories (ORNL), acting as consultants to ORO.

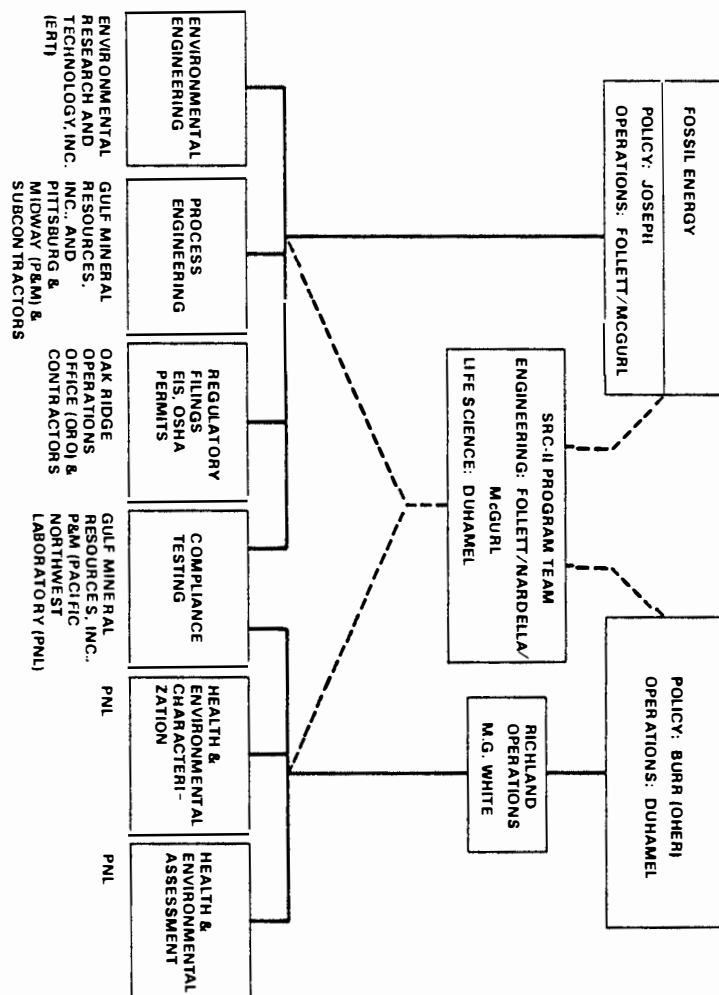
The PNL program requires extensive engineering analyses of SRC-II demonstration facility designs, and of smaller-scale facilities to develop operational conditions for small-scale units which might yield samples relevant to demonstration and commercial practice. Engineering analyses will be performed by P&M and ERT personnel. PNL staff will participate in these efforts in order to obtain representative samples and establish research priorities.

Provision is made by the organization outlined in Figure 2 for: 1) integration of environmental research performed through the major program elements (PNL, P&M pilot-plant operations and P&M demonstration project), and 2) communication among DOE personnel responsible for project management and these elements.

An SRC-II Environmental Program Team (EPT), was established to aid in developing and maintaining a coordinated research effort (see organizational scheme, Figure 2) on the environmental acceptability of the SRC-II process. The EPT is composed of managers representing major program elements. Committee chairmen are representatives of ASFE and ASEV. The committee will also have permanent representatives from ORO and the technology developers. Suggested responsibilities of the ad hoc committee are to:

- aid in integrating SRC-II process development with environmental research;
- maintain ongoing overview of SRC-II environmental research and minimize undesirable duplication of effort;
- serve as an informal scientific and peer review mechanism for reports and communications on SRC work. (Note: The committee will be advisory and informational, not a clearance or approval mechanism.);
- inform DOE-ORO of study results and future plans, and aid in providing information for use in the permitting, licensing, and regulatory processes for development of the SRC-II demonstration program;
- aid the DOE Environmental Coordinating Committee and the DOE Coal Liquefaction Commercialization Task Force in analyzing available information;
- advise on the need for and arrange informational meetings among scientists working on SRC-II programs, both on a regularly scheduled and as-required basis.

Figure 2. Organization of Environmental Program Team (EPT)



Reports generated by the research programs and required under the terms of contractual obligations to DOE will be submitted in draft form to the committee for information and comment.

To assure that pertinent information is received in a timely fashion by all program participants, the following report/meeting schedule is suggested:

1. short, monthly, highlight reports to all pertinent participants in the program, emphasizing significant research results;
2. quarterly reports on program performance, including research status and information relevant to task completion and proposed timelines (to be submitted as public documents);
3. semiannual meetings involving key scientists in the program. These meetings should be held under the aegis of the EPT to provide for continuing, informal, critical review of work in progress.

The schedule described is in addition to reports and meetings required under terms of contracts between DOE and elements of the research program.

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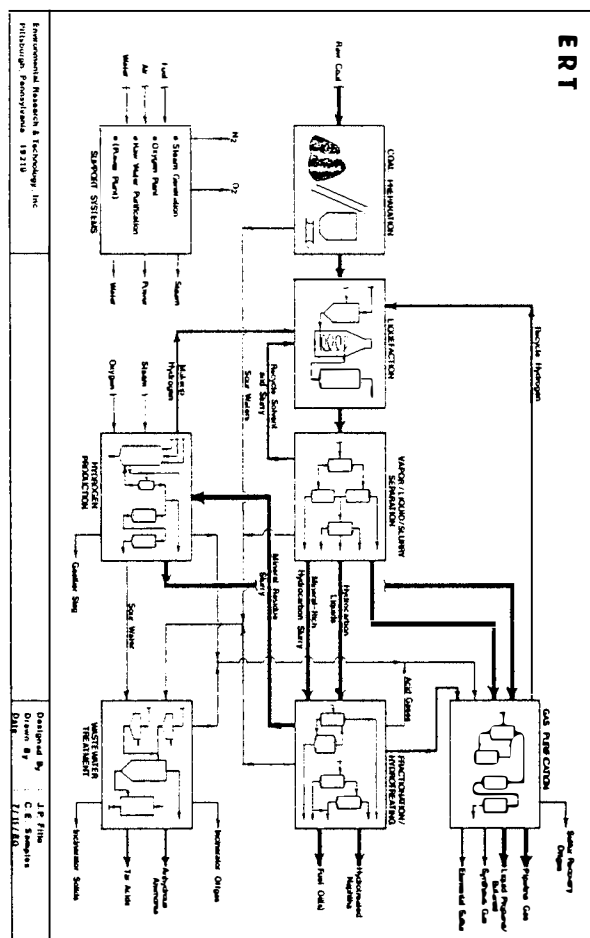
COAL LIQUEFACTION

The SRC-II demonstration facility is designed to process 6000 tons per day of high-sulfur bituminous coal. Pulverized and dried coal is mixed with recycled, process-derived hydrocarbon solvent and mineral-rich slurry. The feed slurry is pumped to the system pressure of ~2000 psi, mixed with hydrogen-rich gas, and heated in a fuel-fired preheater before entering the dissolver reactor. Coal dissolution and depolymerization reactions mostly occur in the preheater. Hydrocracking of heavy coal liquids and final conversion to products occur in the dissolver. Portions of coal-bound N, S, and O are converted to NH_3 , H_2S , and H_2O , respectively. Smaller amounts of HCN, CO_2 , and CS_2 are also produced. Unreacted coal mineral matter, liquid and gaseous products, and gaseous contaminants exit from the dissolver at ~860°F and proceed to cooling and phase separation.

Dissolver effluent is partially quenched with a process-derived middle-boiling-range oil from the high-pressure separation section. Noncondensable gases containing unreacted hydrogen, carbon oxides, light hydrocarbons and acid gases are removed through the high-pressure section of the system and proceed to gas purification. The mineral-rich hydrocarbon slurry is removed through the low-pressure section of the system. A significant fraction of the slurry is combined with hydrocarbon solvent and recycled to prepare the feed coal slurry. The remainder of the slurry is sent to vacuum distillation. Three intermediate hydrocarbon liquid streams leave the system and proceed to atmospheric fractionation. Sour waters, from both high- and low-pressure systems, proceed to wastewater treatment for byproduct recovery.

The fractionation system separates liquid products from other coal-derived hydrocarbons and the mineral-rich hydrocarbon slurry. High-boiling-range distillate is removed from the mineral-rich hydrocarbon slurry in a two-stage vacuum distillation system. An atmospheric distillation system

Figure 3. Schematic of the SRC-II Demonstration Facility Process



produces light and heavy fuel oils, and separates butane and lighter hydrocarbons from the raw naphtha. Raw naphtha is subsequently hydrosulfurized onsite.

HYDROGEN PRODUCTION

A source of hydrogen is required for coal liquefaction and naphtha hydrotreating. Hydrogen is most economically obtained by gasification of the mineral residue slurry. Molten residue, steam and oxygen are fed at high pressure to the proprietary Texaco partial oxidation gasifier. Heavy hydrocarbons in the mineral residue slurry are gasified at high temperature and residual coal mineral matter is converted to molten slag. Synthesis gas is partially quenched and molten slag is solidified in the lower portion of the gasifier. Synthesis gas is catalytically converted to hydrogen via the water-gas shift reaction. Excess synthesis gas is used for plant fuel. Solidified slag is sluiced from the base of the gasifier for subsequent dewatering and disposal.

ENVIRONMENTAL CONTROL SYSTEMS

Gas Purification

Acid gases are generated during liquefaction and gasification processing and must be recovered and treated prior to reuse or venting of process-derived gaseous streams. Acid gases are recovered from hydrogen-rich recycle gas, synthesis gas and make-up hydrogen from gasification, and low-pressure light hydrocarbon gases from fractionation, using either aqueous diethanol amine (DEA) solution or Benfield (i.e., aqueous potassium carbonate solution) systems. The Benfield system is used exclusively on gasifier-derived gas streams. Elemental sulfur is recovered from acid gases, including streams from raw naphtha hydrosulfurization and sour water ammonia recovery, using the Claus process in conjunction with a Shell Super-SCOT tailgas cleanup system. SCOT unit tailgas is incinerated and vented to the atmosphere.

Wastewater Treatment

The design for wastewater treatment in the SRC-II demonstration plant specifies zero discharge. This is achieved by collecting and treating all waste waters from the plant area (i.e., those which are process-derived, and run-off from storage and process areas) for reuse in the process. By-product ammonia and tar acids are recovered from liquefaction waste waters. All plant waste waters undergo varying levels of physical and/or chemical treatment (e.g., pH neutralization, solids/organics removal) prior to evaporation, followed by incineration of treatment sludges and evaporator brines. Evaporator distillate is processed through a wet cooling-tower system prior to reuse. Solid incinerator residues are disposed on site; incinerator offgas is vented to the atmosphere.

Solid Waste Handling

Solid wastes generated by the SRC-II demonstration facility are currently slated for disposal in a secure, on-site landfill. The largest amount of solid waste is ~800 tons per day of slag, generated during gasification of mineral residue slurry. Incineration of wastewater treatment sludges and brines produces about 100 times less solid than the slag.

PRODUCTS

Major products from the SRC-II demonstration facility are fuel oils suitable for use by the electric utility industry. Both light (i.e., ~350°- to 550°-boiling-range hydrocarbons) and heavy (i.e., ~550°- to 900°-boiling-range hydrocarbons) fuel oils are produced individually from fractionation, and can be blended on site to produce a full boiling range fuel. Fuel oils will be stored on site and shipped in bulk by rail.

Product naphtha (i.e., C₅ to 350°F-boiling-range hydrocarbons) is produced for use in-plant and/or as a refinery feedstock. Raw naphtha from fractionation is hydrotreated for stability against oxidation and to remove sulfur as H₂S. Naphtha will be shipped by tank truck.

The final set of products includes synthetic natural gas (SNG), liquefied propane and mixed butanes. These are derived from the gas purification section of the demonstration facility. Butane and lighter hydrocarbons, recovered from product fractionation and recycle hydrogen upgrading, are fractionated to produce liquefied gases. Synthesis gas in excess of that required to fulfill plant fuel requirements is purified and catalytically methanated. Ethane and lighter hydrocarbons from recycle hydrogen upgrading and liquefied product fractionation are also processed by methanation. SNG is shipped by pipeline; liquefied gases, by tank truck.

SUPPORT SYSTEMS

Numerous systems are required to maintain operation of the demonstration facility, including coal storage and handling, steam generation, an oxygen source and raw make-up water treatment. Electric power will be supplied by the local utility. An elevated flare system is also required for combustion of hydrocarbon materials during emergencies. However, due to the complex nature of coal-derived hydrocarbons, a controlled combustor system is specified to ensure complete combustion of emergency releases.

TABLE 1. Sources, Availability, and Relevance of SRC-II Pre-Demonstration-Facility Materials for Biomedical and Ecological Testing.

Pre-Demonstration-Facility Testing Source		Relation to Demonstration-Facility Materials and Configuration		Material Availability
Materials		PROCESS INTERMEDIATES		
SRC-II pp(a)	Coal Slurry	Slurry composition may differ due to contrasts with demonstration-facility vapor/liquid/slurry separation system configuration. Heavy distillate used as slurry pump seal flush. Fractionation configuration different; distillate boiling ranges are variable and may not correspond exactly with demo specifications (b): 		

(a) SRC-II pp: 30 ton per day SRC-II pilot plant in Fort Lewis, WA.

(b) Demonstration-plant specifications are those defined in the Phase Zero detailed conceptual design.

SOURCES, AVAILABILITY, AND RELEVANCE OF MATERIALS

SRC-II materials to be used for initial biomedical and ecological assay must currently be obtained from small, sub-commercial-scale facilities and be representative of materials anticipated from larger-scale facilities. The relationship of pre-demonstration-scale materials to those projected for the demonstration facility varies. In some cases, representative materials can be directly identified. In other instances, while demonstration-scale analogs cannot be rigorously identified, they can be reasonably simulated. Similarities in physical plant configuration or chemical characteristics of materials from existing facilities can be exploited. Sometimes it is not possible to generate an analogous material. Regardless of the source, the relevance of each material to projected demonstration facility operations must be assessed to accurately interpret the biomedical and ecological database that is generated.

Sources, availability, and relevance of pre-demonstration-scale materials for biomedical and ecological testing are shown in Table 1. Correspondence of these materials with characteristics of projected demonstration facility materials is discussed with respect to the "Phase Zero" design and options for the detailed demonstration-facility design.

SOURCES OF MATERIALS

Biomedical and ecological testing programs will utilize relevant materials from PDU-, pilot- and eventually demonstration-scale units. Thus, needs for environmental control can be defined early in process development and maximum and effective control can be implemented before design reaches commercial scale.

Three major facilities are currently available to provide materials for biomedical and ecological testing, including:

1. SRC-II Pilot Plant - 30-ton-per-day coal liquefaction facility, located in Fort Lewis, WA; operated by P&M.
2. P99 - 1-ton-per-day coal liquefaction PDU, located in Harnsville, PA; operated by Gulf Research and Development Company.
3. Texaco Pilot Plant - 12-ton-per-day partial oxidation gasifier, located in Montebello, CA; operated by Texaco Development Corporation.

Additional PDU- and pilot-scale facilities are needed, and should be made available for generating relevant SRC-II materials. These include units for hydrotreating, refinery upgrading, by-product recovery, wastewater treatment and end-use applications. By-product recovery units should be available following definitive choice of options for the demonstration facility. Wastewater treatment could include evaporator/incinerator, physical/chemical treatment and biological treatment systems, and is partially dependent upon options pursued in detailed demonstration facility design.

TABLE 1. (continued)

<u>Pre-Demonstration-Facility Testing Source</u>	<u>Materials</u>	<u>Relation to Demonstration-Facility Materials and Configuration</u>	<u>Material Availability</u>
Texaco PP ^(d)	Process Waters	Correspondence between pilot- and demonstration-facility systems cannot be identified here due to proprietary nature of demonstration plant design.	1Q 1980
<u>ENVIRONMENTAL CONTROL SYSTEM MATERIALS</u>			
Byproduct Recovery Pilot Units	Treated Waters Absorber Solutions	Ammonia and tar acid recovery systems to be finalized for detailed demonstration-plant design.	Materials are currently unavailable.
SRC-II PP	Stretford Solution	Potential utilization in demonstration plant not similar to pilot plant, application not specifically defined.	4Q 1980 and later.
Biotreatment Bench Units	Treated Process Waters	Biological treatment system not specified in Phase Zero demonstration plant design, but retained as option. All significant demo-related sour-water streams not available from existing pilot and PDU facilities.	Bench unit tests must be defined.
<u>SOLID WASTES</u>			
Texaco PP	Gasifier Slag	Correspondence between pilot and demonstration plant systems not identified here due to proprietary nature of demonstration plant design. Kentucky 9/14 coal not currently planned for use in the demonstration plant.	Slag from gasification of Kentucky 9/14 coal-derived vacuum bottoms produced 1Q 1978. Slag from gasification of Powhatan #5 coal-derived vacuum bottoms produced 1Q 1980.

^(d)Texaco PP: 12-ton-per-day Texaco pilot plant gasifier in Montebello, CA

TABLE 1. (continued)

<u>Pre-Demonstration-Facility Testing Source</u>	<u>Materials</u>	<u>Relation to Demonstration-Facility Materials and Configuration</u>	<u>Material Availability</u>
p99 ^(c)	Process Water	Process water recycled as a dissolver effluent quench which is different from demonstration-facility configuration and may affect composition.	All materials, 4Q 1980 and later.
	Coal Slurry Recycle Slurry	Slurry composition may differ due to contrasts with demonstration-plant vapor/liquid/slurry separation system configuration. Mineral oil used as slurry pump seal flush.	
	Raw Naphtha 400°F Distillate Vacuum Bottoms	Fractionation corresponds better to demo system than to pilot plant, but provides only ~400°F and ~400°F distillates. Vacuum flash system operation flexible, can achieve up to ~1000°F endpoint on 400°F distillate.	
	50°F Boiling Fractions	Reactor configuration (i.e., diameter, length/diameter ratio) variable, can investigate effects on product yields. Prepared by controlled fractionation of 400 to 975°F distillate into 50°F boiling cuts.	3Q 1980
	Process Water	Water quench corresponds better than pilot plant with demonstration facility configuration, can vary use of fresh makeup water.	4Q 1980 and later.

^(c)p99: 1-ton-per-day SRC-II P99 PDU in Harmarville, PA

TABLE 1. (continued)

Pre-Demonstration-Facility Testing Source	Materials	Relation to Demonstration-Facility Materials and Configuration	Material Availability
SRC-II PP	Middle/Heavy Distillate Blend	Blend based on pilot-plant product yields different from blend defined to achieve demonstration-facility liquid product specifications.	Distillates available for blending 2Q 1980.
P99	Fuel Oil	Consists of 400°F ⁺ boiling distillate representative of P99-produced product.	4Q 1980 and later.
<u>END-USE MATERIALS</u>			
Boiler, Combustor, Turbine PDUs	Combustion Particulate and Off-gases	Performance and environmental characteristics in end-use testing systems are satisfactory to date. Performance of slurries, distillates and vacuum bottoms in a controlled combustor system (i.e., part of demonstration-facility emergency flare system) needs to be identified.	Additional end-use testing studies must be defined.
Hydrotreating Pilot Units	Upgraded Fuel Oil	Hydrotreating of product fuel oils not planned for demonstration facility.	Fuel-oil blend tested by UOP, 1979. Further fuel-oil hydrotreating studies being investigated.
Refinery Upgrading Pilot Units	Refined Fuel Oils	Extensive use of demo-produced fuel oils as refinery feedstocks not planned, but to be investigated for potential end use of commercially produced materials.	Fuel-oil upgrading studies being investigated.

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TABLE 1. (continued)

Pre-Demonstration-Facility Testing Source	Materials	Relation to Demonstration-Facility Materials and Configuration	Material Availability
Evaporator/Incinerator PDUs	Incinerator Solids	All significant raw and treated demo-related sour-water streams not available from existing pilot and PDU facilities.	Incinerator testing studies must be defined.
Biotreatment Bench Units	Biotreatment Sludge	Biological treatment system not specified in Phase Zero design but is an option for the commercial facility. All significant sour-water streams not currently from existing pilot plants and PDUs.	Bench unit test must be defined.
<u>BYPRODUCTS</u>			
Byproduct Recovery Pilot Units	Ammonia Tar Acids	Ammonia and tar acid recovery systems to be finalized for detailed demonstration facility design.	Studies must be defined.
SRC-II PP	Stretford Sulfur	Potential utilization in demonstration facility not similar to pilot plant, application not specifically defined.	4Q 1980 and later.
<u>PRODUCTS</u>			
Upgrading Pilot Units	Hydrotreated Naphtha	Raw naphtha boiling ranges for SRC-II pilot plant and PDU variable with respect to demonstration facility (i.e., C ₅ -350°F. Hydrotreating levels typical of demonstration plant must be identified.	Hydrotreatment studies must be defined.

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PROCESS INTERMEDIATES

Certain intermediate process materials can be obtained directly from operating SRC-II facilities. Coals representative of those slated for use in the demonstration facility can also be obtained. Coal slurry, recycle slurries, mineral residue slurry (i.e., vacuum bottoms) and raw naphtha can be obtained from both the SRC-II pilot plant and P99.

Intermediate hydrocarbon streams in the demonstration facility that lack direct pre-demonstration analogs include dissolver effluent, low- and high-pressure hydrocarbons (i.e., three streams), effluent separator quench, recycle solvent, fractionator recycle (i.e., slurry pump seal flush), and lean and rich scrubber oils (i.e., for removal of hydrocarbons from recycle hydrogen). Although the chemical and physical nature of each stream is not precisely represented, raw naphtha, middle distillates and heavy distillates from the SRC-II pilot plant can represent the boiling range and chemical composition of these demonstration facility materials. Precise boiling-range fractions (i.e., in 50°F increments) of raw naphtha and distillates prepared from 400°F distillate from the P99 can be characterized. These materials were prepared to evaluate chemical, physical and thermodynamic properties, and are currently available for biomedical and ecological testing.

Process waters analogous to SRC-II demonstration facility operations can be generated only to a limited extent. Although sour waters from coal liquefaction can be obtained from the SRC-II pilot plant and P99, they may not be representative of demonstration facility operations. Analogs of gasifier sour waters can be obtained from the Texaco pilot plant.

Materials from the SRC-II pilot plant may differ from demonstration facility streams for three reasons:

1. Dissolver configuration - Dimensional differences (i.e., diameter, length/diameter ratio) between pilot- and demonstration-facility dissolver reactors may affect yields of specific coal-derived chemical components.
2. Vapor/liquid/slurry separation - Because the physical configuration and operation of pilot and demonstration facility systems differ, they may affect the compositions of both recycle slurry (and therefore, coal slurry) and process water.
3. Fractionation - Inefficiencies in operation of the pilot plant's vacuum flash system result in a portion of heavy distillate going to the vacuum bottoms. Typically, naphtha and distillate boiling ranges do not correspond exactly in pilot and demonstration facilities.

The differences listed above are important if they alter the chemical, biomedical or ecological properties of specific materials. Materials have been obtained from the SRC-II pilot plant during the first quarter of 1978 and the second quarter of 1980. Additional materials generated using various coals at different process conditions will be available for characterization throughout demonstration facility construction.

Differences between P99 and demonstration-facility materials may also result from differences in separation and fractionation systems. In particular, use of mineral oil as the slurry pump seal flush affects coal slurry composition. Although the water quench system corresponds more closely with that for the demonstration facility, compositional differences may occur due to lack of specific wastewater streams (e.g., from fractionation, hydrodesulfurization). The fractionation system is limited in that only two boiling-range fractions are separated (i.e., naphtha and 400°F boiling-range distillate). However, the vacuum flash system is sufficiently flexible to produce virtually any heavy distillate with an endpoint <1000°F. The P99 is generally suited for performing controlled studies to evaluate effects of coal type, reaction conditions, reactor configuration and distillate endpoint. Materials for environmental and health testing will be available from late 1980 through at least 1983. The 50°F boiling-range fractions of 400°F distillate are currently available from the Hammarville, PA facility.

Process waters, produced during gasification of vacuum bottoms derived from Powhatan No. 5 coal (i.e., produced from the SRC-II pilot plant) in the Texaco gasifier, were recently characterized by Hydrosience, Inc. The proprietary nature of the Texaco process precludes discussion of the pilot-plant samples' relevance. Specific plans for further testing of vacuum bottoms in the Texaco gasifier have not been defined.

ENVIRONMENTAL CONTROL SYSTEM MATERIALS

By-product recovery systems, including ammonia and tar acid recovery from liquefaction process waters and elemental sulfur from acid gases, are sources of environmental control system materials. In general, materials include treated process waters and absorption solutions for which pre-demonstration-scale analogs can be identified. Environmental issues include not only system performance, but removal and/or buildup of trace contaminants (i.e., metals, organics, inorganics) from coal-liquefaction-derived acid gases and waste waters. In the cases of physical/chemical treatment, completely analogous effluent, evaporator distillate, oil wash and acid gas recovery solutions are difficult, if not impossible, to obtain. If a Stretford system is specified for sulfur recovery, an analogous system is currently in operation at the SRC-II pilot plant.

Relevance of these materials depends on availability of process waters for treating and the definition of specific treatment methods for the demonstration facility. Typically, not all major contributing process streams are available for integrated treatment system testing (i.e., byproduct recovery, physical/chemical separation, evaporation). However, selected process waste waters are available from the SRC-II pilot plant, P99, and the Texaco gasifier for treatment in relevant demonstration facility systems. Process wastewater should be available from late 1980 through demonstration facility construction.

Treatment methods to be defined during detailed demonstration facility design include byproduct recovery systems and specific wastewater treatment schemes. Although Chem Pro and Phosam W were specified in the conceptual design, final choice of the specific process has not been made. Selexol is being considered as an alternative to the Benfield system for acid gas recovery in hydrogen production. Biological treatment, which was not included

in the conceptual design, is now being considered in the detailed design. Bench-scale test units are available for performing these studies. Testing of evaporation systems will be necessary when specific input waste waters have been defined. Materials for biomedical and ecological testing will probably be available between 1981 and 1983, and will depend on choice of treatment.

Flare And Controlled Combustion

The demonstration facility flare system is of particular interest from a biomedical and ecological standpoint. A reliable flare system must be available to insure complete combustion of complex, coal-derived hydrocarbons (i.e., gaseous, liquid and slurry streams), and to minimize potential emergency releases. Since a controlled combustor system is specified for the demonstration facility, the performance characteristics of the full range of coal-derived materials (i.e., naphtha, distillates, slurries) must be identified. This may be particularly important in the case of the combustion of slurries containing significant levels of solids. Conventional and trace pollutant emissions from these systems must be quantified. Combustor systems are available for testing, and studies must be defined.

SOLID WASTES

The major solid waste expected from the demonstration facility (i.e., 98⁺ percent of the total) is slag from gasification of mineral residue slurry. This material has been obtained from the Texaco pilot plant on two occasions: 1) during the first quarter of 1978 from gasification of Kentucky No. 9/14 coal-derived vacuum bottoms, and 2) during the first quarter of 1980 from gasification of Powhatan No. 5 coal-derived vacuum bottoms. Extensive leach testing has been performed by ORNL on the former materials. Results suggested the material is nontoxic according to Resource Conservation and Recovery Act (RCRA) criteria. If true, and results are similar for the Powhatan coal-derived slag, waste disposal could be substantially simplified. However, additional biomedical and ecological testing is still necessary, and can commence as soon as proprietary rights agreements are executed with Texaco Development Corporation.

Solids are generated during incineration of wastewater treatment sludges and evaporator brines, and may also be generated during potential biological treatment. Evaporator/incinerator and biological treatment system testing is not currently scheduled. Representative wastewater streams and detailed design bases for the demonstration facility are needed to design treatment studies for generation of relevant solid-waste materials (i.e., inorganic salts and/or biological treatment sludge). Toxic properties of solid wastes slated for disposal must be identified prior to demonstration facility operation.

BY-PRODUCTS

Pre-demonstration-scale analogs of ammonia and tar acid byproducts are not currently available. Definition of specific systems will occur during the early stages of detailed design. The demonstration facility's sulfur recovery

system may be changed from Claus to Stretford. If so, elemental sulfur will be available for testing from the SRC-II pilot plant.

PRODUCTS

Distillate fuel oils and raw naphtha can be obtained for biomedical and ecological testing. Light and heavy fuel-oil analogs include middle and heavy distillates, respectively, from the SRC-II pilot plant. These materials were obtained in the first quarter of 1978 for biomedical and ecological screening studies. More-representative materials (i.e., coal feedstock and pilot-plant process conditions) were obtained in the first quarter of 1980 and are being analyzed. The relevance of these materials hinges on whether they correspond with final demonstration-facility material specifications (e.g., boiling-point ranges), particularly in the case of heavy distillate, where pilot-plant material is limited to a maximum endpoint of ~850°F.

A full-boiling-point-range fuel oil can be synthesized by blending middle and heavy distillates from available SRC-II pilot plant materials. The blending ratio for this fuel oil must be specified, but is likely to be based on weighted boiling-range specifications for demonstration-facility fuel oil. Additional quantities of product distillates should be available from late 1980 through demonstration facility construction.

The P99 facility is particularly suited for generating SRC-II materials. Although the unit currently produces only 400°F and 400°F distillates, future modifications may enable generation of middle- and heavy-boiling-range fractions. Product materials should be available from the P99 from late 1980 through 1983.

Raw naphtha from the SRC-II pilot plant was obtained during the first quarters of 1978 and 1980 for biomedical and ecological testing. Further characterization must be performed on a relevant product material that has been hydrodesulfurized. Hydrotreatment studies must still be defined, at levels expected for the demonstration facility, before product naphtha characterization can begin.

Major options in the demonstration-facility design may significantly affect the final product slate. Options hinge on the precise utilization and specifications of mineral residue slurry for hydrogen production. Naphtha, synthesis gas and liquefied propane/butanes are all potential plant fuels, and availability of synthesis gas is crucial to their eventual utilization. Lowering the endpoint on heavy fuel oil (e.g., from 900 to 850°F) decreases fuel oil product and provides an additional increment of mineral residue slurry for gasification. This would result in availability of more synthesis gas for plant fuel and/or methanation (and thereby enable marketing of additional naphtha product), and may have significant impact on the chemical and biological properties of heavy and full-boiling range fuel oil products. The fuel balance, and ultimately the final product slate, are currently being optimized for the detailed demonstration-facility design.

END-USE MATERIALS

The primary end use for demonstration facility fuel oils is in electric utility applications. Results to date indicate satisfactory performance, both operationally and environmentally, for conventionally regulated pollutants (i.e., SO₂, NO_x, CO, particulate, and volatile hydrocarbons). Various applications (e.g., package boilers, fired-tube boilers, turbines) have been investigated, in addition to studies of novel burner configurations to mitigate environmental emissions. Due to differences between petroleum- and coal-derived distillate fuels, characteristics of trace contaminant emissions need to be identified (i.e., gaseous and particulate-borne trace metals and heavy hydrocarbons). End-use testing facilities are available for characterization, and studies must be defined. Distillates from the SRC-II pilot plant can be obtained from late 1980 through demonstration facility construction.

Alternative end uses for SRC-II products are as refinery feedstocks. Demonstration-facility naphtha product is already being considered for use as a feedstock for catalytic reforming. Although more applicable to the SRC-II commercial facility, fuel oils (properly hydrotreated) could be used as feedstocks for refinery processes such as hydrocracking and fluidized bed catalytic cracking. Previous studies conducted by Universal Oil Products (UOP), Chevron and the Bartlesville Energy Technology Center (BETC) during 1978 and 1979 on various distillates from the SRC-II pilot plant showed that these materials could be treated (although under more severe conditions than petroleum-derived distillates). Limited screening studies by BETC and PNL suggest that a reduction in biological activity of these coal-derived distillates is possible.

STUDY PLAN

The SRC-II Study Plan will be performed in four phases which chronologically overlap. Phase I research (screening) will evaluate materials from existing SRC-II facilities (bench, PDU, pilot) which may bracket potential demonstration or commercial practice in terms of physical and chemical properties. These materials will be subjected to a battery of short-term biomedical and ecological assays. Chemical fractionation and analysis will be performed to determine compounds and compound classes of potential concern. In some cases, chemical fractionation is required to provide materials amenable to biomedical and ecological testing. Phase I research provides a first estimate for potential environmental properties of SRC-II materials, thereby:

- setting research priorities for Phase II, which involves longer-term, more-extensive bioassays and chemical analyses of environmental fate;
- providing initial data on materials that may require ameliorative action during process development;
- providing a first, qualitative analysis for assessing environmental risk anticipated from utilization of the SRC-II process.

Phase II research (baseline) will evaluate SRC-II materials which are considered most representative of potential demonstration or commercial practice. These materials will be subjected to longer-term, more-extensive biomedical and ecological analyses relative to effects and environmental fate. Again, chemical fractionation and analyses will: 1) provide materials amenable to bioassay, and 2) determine compounds and compound classes of concern. Results from this research phase will provide:

- a reasonable estimate of the materials of concern which may require regulation;
- correlation analyses between short-term, inexpensive, in vitro and selected in vivo assays (Phase I) and longer-term, more-expensive, in vivo assays and ecological studies (Phase II);
- a basis for development of control technologies and management procedures which may reduce environmental risk;
- a second and more quantitative assessment of potential environmental risk.

Phase III research will examine the influence of process modifications, control technologies and changing operational conditions on potential environmental effects of SRC-II materials. Short-term biomedical and ecological analyses (Phase I) which correlate with longer-term analyses (Phase II) will be used in Phase III. Integrated chemical fractionation and analysis methods (as indicated in Phase I), will be used to determine compounds and compound classes of environmental concern. Data from Phase III will provide:

- a basis for determining effectiveness of control technology, process modification, etc. relative to decreasing potential environmental effect;
- a third analysis of environmental risk to consider effects of altered plant operations.

Phase IV research (onsite monitoring) will develop methods and initiate environmental monitoring to study effects at the SRC-II demonstration and commercial facility sites. Data from Phases I, II and III may provide indicators of biomedical and ecological effects, and a basis for assays for potentially harmful chemical entities which should be monitored in the workplace (i.e., by (P&M) and local environment. Phase IV research efforts will include intensive studies of environmental fate and transport of SRC-II materials. Data from demonstration facility monitoring should allow:

- development of more-effective environmental management procedures, for waste disposal and industrial hygiene, at demonstration and commercial SRC-II facilities;
- quantitative environmental risk assessment more appropriate to a commercial SRC-II process.

The chronological overlap of research phases is due to a number of factors. Materials (products, wastes, etc.) of potential biomedical and ecological concern may be available in forms considered most representative of potential demonstration or commercial practice in Phase I. This would allow concurrent Phase I and II analyses. Certain materials (i.e., process waters) may not be available in forms considered appropriate for screening until Phase II, which would change the timing of all phases of research on these materials. Little is known about compounds and compound types potentially responsible for specific biomedical or ecological effects. Therefore, Phase IV monitoring will include sample collection, archiving, and later analysis for specific compounds and compound classes shown in Phases I, II and III to cause significant biomedical or ecological effects. Sample collection will be concurrent with Phase I efforts. Finally, method development may be necessary before comprehensive studies can be initiated (e.g., for Phase II bioaccumulation, multispecies, and fate and transport studies).

Work will proceed as follows. Materials representing the range of materials that may be produced by demonstration or commercial facilities will be analyzed in Phase I. Tentative identification will be made of compounds and compound classes of concern, and appropriate laboratory studies on bioaccumulation and environmental fate and transport of these agents will be initiated early in Phase II. As materials considered most representative become available, Phase II biomedical and ecological analyses will begin, and results from Phase I and II assays will be correlated. This should result in a battery of inexpensive, quick assays which can be used in Phase III to evaluate effects of process modification and control technology applications. Data from all phases will be used in designing appropriate site-monitoring methods to determine levels of compounds and compound classes known or suspected to cause biomedical or ecological effect. The data will also be used, in Phase IV studies, as a basis for determining whether biomedical or ecological effects may result from demonstration facility operations.

SAMPLE COLLECTION AND STORAGE

Sampling of coal liquefaction materials involves three operations: collection, storage, and distribution. Collection is engineering-dependent. As processes change, or modifications are made to the facility, collection points and the selection of materials to be collected will change. Current emphasis is on collecting materials from processes operating under conditions representative of those anticipated for the demonstration facility. The section entitled, "SRC-II Process" (pp. 9-23) describes engineering strategies for obtaining representative samples for Phases I and II. A general description of materials which might be assayed in Phase III is also provided. Potential time-lines for sampling are shown in the section on Cost and Time-Lines.

Samples that must be stored for current and subsequent investigation will be limited primarily to those: a) for which long-term characterization may be required, b) which will be used in extensive biological or ecological testing, or c) which are representative of well-defined process conditions and, as such, can be utilized to develop a data base that relates to a series of process variables. Storage facilities must be adequate to maintain sample integrity. Large quantities of selected materials must be maintained for biomedical and ecological testing, and chemically analyzed throughout the study to eliminate a potential source of interpretive error.

Distribution requires cataloguing and control of source materials to assure that their location and use is documented. Samples collected from an SRC facility will be distributed to authorized investigators at PNL, or at the laboratories of subcontractors included in the program. Additional distribution or use of PNL-catalogued materials will be at the request of DOE through the appropriate ASEV and ASFE program offices. Administrative control will include maintenance of records concerning sample availability, sample distribution, status of work being done, and names and locations of the responsible investigators.

SAMPLE COLLECTION

Sample collection will be limited to materials (products, process streams, solid and liquid wastes, fugitive emissions) which are representative of anticipated demonstration facility operating conditions. Selection of appropriate samples will be made by PNL in concert with ERT, P&M, and Gulf Mineral Resources Co. SRC-II materials selected for biomedical and ecological investigations are shown in Table 2.

Sample collection, usually in containers provided by PNL, will be performed by P&M and witnessed by appropriate PNL personnel. In general, projected sample use dictates collection procedures. Liquid samples for chemical characterization of organic constituents or Phase II biomedical testing are collected either in 1-gallon glass bottles with teflon-lined caps or in 6- or 15-gallon, teflon-lined, stainless steel drums. Larger samples for long-term ecological investigations are collected either in multiple 15-gallon, teflon-lined, stainless steel drums or in 55-gallon, polymer-coated steel drums (provided by P&M). Small-volume samples are returned immediately to PNL and, after cooling, are blanketed with N₂ in the headspace above the liquid.

TABLE 2. SRC-II Materials for Biomedical and Ecological Investigations

LIQUIDS

Raw Naphtha
Hydrodesulfurized Naphtha
Middle Distillate
Heavy Distillate
SRC-II Liquid Products
Process Feed Water
Process Water
Treated Effluent Water

SOLIDS

Coal Slurry
Raw Sulfur
Stripper Tower Bottoms
Vacuum Bottoms
Gasifier Slag, coarse
Gasifier Slag, fine
Wastewater Incinerator Solids

Large-volume (55-gal) samples are generally stored on-site at the pilot plant prior to shipment to PNL. These samples are also blanketed with N₂ after cooling and prior to shipment. Samples taken primarily for inorganic analysis are collected in perfluoroethylene (PFE), 1-liter bottles.

Samples of solid materials are generally collected in metal, slip-top cans (sizes vary from 1 quart to 5 gallons, depending on end use). If these samples are to be analyzed for metal content, they are collected in plastic-lined metal containers. Solid samples for chemical characterization will be collected in 5-kg blended lots. For biological and ecological testing that requires leaching studies, samples will be collected in 50-gallon, plastic-lined, steel or fiber drums.

Currently, we do not plan to collect air or aerosol samples. If future research requires collection of gaseous materials, procedures will be as follows: Vent gases would be collected, generally as grab samples, in PFE-lined, stainless steel gas bottles. Ambient plant vapors would be collected on polymeric adsorption traps (TENAX and XAD-2, or XE-347, depending on results of laboratory studies which would be performed if vapor sampling is contemplated), or charcoal. Ambient particulate samples would be collected on clean glass-fiber filters using HIVOL techniques. Data from HIVOL cascade impactors would give size distribution of collected particles and provide total particulate concentration in a given gas volume. If metal speciation experiments on vent gases are needed, adsorbent traps, specific for the metal species of interest, would be used for collection. Generally, vent gas and ambient gas samples would be collected primarily for chemical characterization studies. However, ambient-air samples might be taken from areas around the pilot plant where workers may be exposed to fugitive emissions or to emissions generated during certain in-plant operations; for example, fumes emanating from certain maintenance operations and cleanup procedures. These efforts may aid development of improved site and personnel monitors for compounds and compound classes of biomedical concern.

SAMPLE STORAGE AND QUALITY CONTROL

PNL-acquired samples are generally stored at 4°C until all studies are completed. Liquid samples are stored under N₂. Large-quantity liquid samples (6 gallons or more) are thoroughly mixed and are subsampled immediately after receipt to provide a 250-ml aliquot that is used to monitor sample stability during storage. Large-volume samples are also thoroughly mixed prior to any subsequent subsampling. The sample handling protocol and analysis procedures to evaluate sample stability are given in Table 3. Basically, the procedure consists of periodic analyses to determine gross changes in chemical composition or physical properties. Changes in of minor or trace constituents will not be detected. However, the analyses do provide an adequate, general, chemical characterization and a data base for comparison, should a re-examination of materials distributed for biomedical or ecological studies be necessary.

DATATRIEVE - DATA MANAGEMENT SYSTEM

A computerized data management system (DATATRIEVE) on the PNL Biometrics Computer Center's PDP 11/70 has been designed to record and monitor location and use of materials received and distributed to the chemistry, biology, and ecology research programs. The system utilizes a set of interactive DATATRIEVE procedures to store information as it becomes available and to generate reports as required.

The system is centered around codes which identify materials and tests; each material or combination of materials is identified by a unique MATERIAL CODE; each test is identified by a unique TEST CODE. The codes are used by DATATRIEVE to store and retrieve the status of a test, or to procure an audit trail for each material.

Two files, labeled TEST CODE DICTIONARY and SOURCE MATERIAL CODE DICTIONARY, have been established so that investigators may cross-reference codes

TABLE 3. Protocol for Analyses to Observe Stability of Research Materials During Storage

1. Receive sample in teflon-lined, stainless-steel barrel.
2. Mix thoroughly and subsample 500 ml into a brown glass bottle with a teflon-lined cap (alternate: teflon-lined, stainless steel bottle). Blanket stock sample and subsamples with N₂.
3. Store both samples under identical conditions in chilled facility at approximately 4°C.
4. Perform initial and intermittent long-term characterizations on small subsamples.
5. Analyses will include:
 - a. density,
 - b. boiling point curve,
 - c. capillary column gas chromatography; SE-52; splitless injection; flame ionization detection (FID); initial temperature, 35°C. Quantify major peaks.
 - d. high-performance liquid chromatography (HPLC) separation, ternary gradient on NH₂ column or binary gradient on C-18 column. Quantify major peaks.
 - e. molecular weight distribution by HPLC on steric exclusion column. Quantify distribution pattern.
6. These analyses will be performed on each material semiannually for 1 year and annually thereafter.
7. At each major sampling of material (for ecological, biological or chemical research) from the large reservoir, these same characterizations will be performed, unless these analyses have been completed within the previous 6 months.
8. A data file will be maintained and updated for each research material in the inventory.

with their English equivalents. Table 4 is a partial list of material codes and their English equivalents, contained in the SOURCE MATERIAL CODE DICTIONARY. Table 5 is a partial list of test codes and their English equivalents, contained in the TEST CODE DICTIONARY.

The SOURCE MATERIAL AUDIT FILE contains a record of transactions on each material or material combination. Each record contains, as a minimum, the material code, material accession number, and date the material was sampled. The material accession number, consisting of the log book and page number, refers to the chemistry ledger, where additional information may be found. The accession number also includes a batch number that has been assigned to distinguish different samples of the same material type. When a material is received from off-site, the date of receipt and a transaction remark, indicating the amount received and the current amount of material in storage, is also recorded. When a material is assigned for biological or ecological study, the following information is recorded: date of assignment, initials of the investigator assigned the material, the number of the investigator's log book where additional information can be found, and a transaction remark that indicates the amount assigned and the total amount currently in storage. Table 6 is a sample audit report (for one material), which can be generated at any time.

The TEST STATUS FILE contains the status of each test on each material. Test status is identified by test code, material code, material accession number, investigator's initials, proposed test start date, actual start date, completion date and the log book containing test results. Investigators are required to provide information on a quarterly basis. The TEST STATUS FILE can be updated at any time to reflect the current test status. Reports can be generated in two ways:

- 1) for each test category, to identify the status of individual tests on all materials; and
- 2) for each test material, to identify the status of all tests applied to that material.

Tables 7 and 8 are examples of the two types of reports that may be generated.

TABLE 4. A Partial List of Source Materials and Their English Equivalents

<u>MATERIAL CODE</u>	<u>MATERIAL NAME</u>
II-AP	II-Ambient Particulates
II-AV	II-Ambient Vapors
II-CS	II-Coal Slurry
II-FD	II-Fuel Oil
II-FOA	II-Fuel Oil Acid
II-FOAT	II-Fuel Oil Acid Tar
II-FOB	II-Fuel Oil Basic
II-FOBT	II-Fuel Oil Basic Tar
II-FDN	II-Fuel Oil Neutral
II-FONT	II-Fuel Oil Neutral Tar
II-FOB	II-Fuel Oil PNA
II-GB	II-Gasifier Bottoms
II-GFA	II-Gasifier Fly Ash
II-HD	II-Heavy Distillate
II-IS	II-Incinerator Solids
II-MD	II-Middle Distillate
II-N	II-Naphtha
II-STB	II-Stripper Tower Bottoms
II-VB	II-Vacuum Bottoms

TABLE 5. A Partial List of Test Codes and Their English Equivalents. (This list represents only some of the major test categories.)

TEST CODE	TEST NAME
B1	Cellular Studies
B1A	Microbial Mutagenesis (Ames' Assay)
B1B	Mammalian Cell Toxicity and Transformation
B1C	Mutagenic Studies in Chinese Hamster Cells
B1D	Yeast Mutagenesis
B1E	Unscheduled DNA Synthesis
B1F	Chromosomal Abnormalities
B2	Oral Studies
B2A	Acute Toxicity
C1	Initial Chemical Characterization
C1A	Inorganic Element Analysis
C1B	Speciation Measurements
C1C	Solid Waste Aqueous Leaching
C1D	Extraction of Solid Wastes with Solvents
C1E	Simulation Diagenesis Investigations
C1F	Initial Organic Analysis
C2	Organic Class Fractionation and Bio/Eco Assay
C2A	Fractionation
C2B	Identification of Biologically Active Agents
E1	Liquids
E1A	Acute Screening
E1B	Chronic Screening
E1C	System Level Screening
E1D	Field Validation
E2	Solids
E2A	Field Lysimeters
E2B	Comparative RCRA Bioassay
E2C	SRC-I Solid Product Spills
E2D	Residual Fate and Behavior

TABLE 6. Sample Source Material Audit Report for One Material

MATL CODE	MATL ACCESSION	DATE SAMPLED	TRANSACTION DATE	INV INT	TEST CATEGORY	INV LOG BOOK	TRANSACTION REMARK
II-F0	145300100	781112	781212				4.0 L received by stores, 4.0 L total in storage
	145300101	781112	790101	XXX	1A	3333	1.2 L given to XXX/B10, 2.8 L total in storage
	145300102	781112	790223	XXX	2B	2555	1.5 given to XXX/ECO, 1.3 L total in storage
	145300102	781112	790301	XXX	2A, 2B	3529	1.0 L given to XXX/ECO, 0.3 L total in storage

NOTE: The report above illustrates only format.

TABLE 7. Test Status Report Arranged by Test Category to Identify the Status of Individual Tests on all Materials

DEPT	TEST	MATL CODE	MATL ACCESSION	INV INIT	PROPOSED DATE	START DATE	FINISH DATE	LOG BOOK
B	1A	I-MR	145303200	XXX	790101	790201	790210	2341
		I-S	123512301	XXX	790915			2450
		I-WS	134201112	XXX	790520	790525	Canc.	2341
		II-MD	342300101	XXX	790701	790701		2351
	4A	II-HD	134212900	XXX	790801			2351
		II-MD	342300102	XXX	790901			2351

NOTE: The report above illustrates only format.

TABLE B. Test Status Report Arranged by Test Material to Identify the Status of all Tests Applied to that Material

DEPT	TEST	CODE MATL	MATL ACCESSION	INV INIT	PROPOSED DATE	START DATE	FINISH DATE	LOG BOOK
B	1A	I-MR	145303200	XXX	790101	790201		2341
	1A	I-S	123512301	XXX	790915			2450
	1A	I-WS	234201112	XXX	790520	790525	Canc.	2341
	1A	II-HD	134212900	XXX	790801			2351
	1A	II-HD	342300101	XXX	790701	790701		2351
	4A		342400102	XXX	790901			2351

NOTE: The report above illustrates only format.

PHASE I

The following sections describe short-term studies which utilize a battery of submammalian and mammalian cell in vitro assays for genotoxicants and acute and chronic toxicity assays for potential ecological effects. The sections also describe chemical methods of fractionation and extraction used to provide samples for in vitro bioassays and ecological studies, and methods for determining compounds and compound classes causing effects. This section is divided into:

- studies on liquid process streams and products,
- studies on solid process streams and effluents, and
- studies on process waters.

Short-term assays and accompanying chemical analyses provide a first and approximate estimate for the genotoxic and ecological effects of SRC-II materials. As such, they will be used as one criterion to select materials for longer-term animal bioassays and ecosystem studies to be performed in Phase II. A range of assays will be employed since it is possible and, indeed, probable that no single assay will correlate with results from Phase II animal bioassays or ecosystem studies. Because of their relative speed and low cost, in vitro assays and acute and chronic ecological assays are the likely methods for correlating genotoxic and ecological effects with specific chemical compounds and compound classes in SRC-II materials. Correlation is of vital importance: Phase I tests which correlate with Phase II tests will be the methods of choice for determining effects of SRC-II process and control technology changes on biomedical and ecological properties of SRC-II materials (studies to be performed in Phase III). Results of these tests and accompanying chemical analyses may also be the basis for determining specific compounds and compound classes which should be monitored during SRC-II facility operations (studies to be performed in Phase IV). Phase I studies will also provide the first data base for assessment.

BIOMEDICAL STUDIES AND CHEMISTRY

Before detailed discussion of biomedical assays and accompanying chemical analyses, we will discuss sample preparation, chemical fractionation and analyses for a given material (Figure 4).

Liquid materials or extracts/solutions prepared from solid materials or aqueous wastes will be analyzed by a battery of in vitro assays with different genetic endpoints (e.g., Ames mutagenesis). Concurrent bioassays will be performed on unfractionated materials and materials fractionated by high-performance liquid chromatography (HPLC). Negative results for unfractionated material and HPLC fractions (normally, six fractions of different polarity will be analyzed) will be considered indicative of no genotoxicity and no further analyses will be performed.

A positive response in unfractionated material or HPLC fractions will be considered evidence for genotoxicity of the material in that assay system.

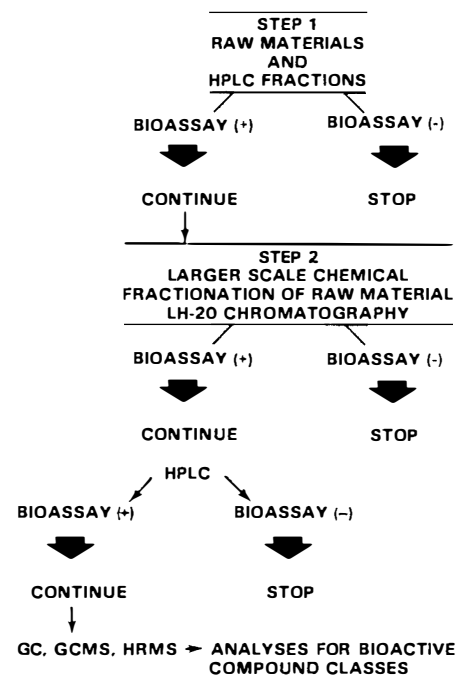


Figure 4. Flow Chart for Phase I In Vitro Assay: Chemical Fractionation and Characterization

The material will then be subjected to LH-20 chromatography to provide sufficient concentrated bioactive material for in vitro assays and chemical analyses. Subfractions from LH-20 chromatography showing genotoxicity will be further fractionated by HPLC. These samples will be analyzed by in vitro assay, and fractions showing mutagenic activity will be subjected to chemical analyses. Gas chromatography (GC) and/or gas chromatography-mass spectrometry (GCMS) will be used to aid identification of specifically genotoxic compounds and compound classes. High-molecular-weight or highly polar subfractions which cannot be assayed by GC will be analyzed by high-resolution mass spectrometry (HRMS), or by HPLC, to determine compounds potentially responsible for genotoxicity. In some cases, contingent on experimental difficulties and conditions, alternative fractionation methods and chemical analyses will be used.

In Vitro Assay for Liquid Process Streams and Products

Based on present design considerations, the liquid process streams (raw naphtha, middle distillate and heavy distillate, as provided by the Ft. Lewis pilot plant) and derived fractions will be analyzed by in vitro assay and integrated chemistry. Potential SRC-II liquid product mixtures, and hydrodesulfurized naphtha will also be analyzed. Analyses to be performed on these materials and derived fractions are shown in Table 9.

Ames Assay

The Ames microbial assay uses strains of *Salmonella* possessing genetically defined mutations in a gene for biosynthesis of the amino acid, histidine (they require this for growth). Ames strains used include: *Salmonella typhimurium* TA98 and TA1538 (frameshift mutants); TA100 (an R-factor-containing point mutant that responds to both point- and frameshift mutagens); and TA1535 (responds only to point mutagens). Ease of use, speed, low cost, requirement for small amounts of test material, and high correlation (at present, > 0.90) with carcinogenicity in the case of pure compounds make this a desirable and useful test for screening a large number of materials. The assay is performed by mixing test material with the organism in the presence or absence of mammalian liver microsomal (S9) enzymes and determining the number of organisms which revert from dependency on histidine in the medium to nondependency, a mutational event. Assay in the presence of S9 detects mutagens which require metabolic activation. Assay in the absence of S9 detects mutagens which do not require metabolic activation. Ames assays can be performed on raw SRC-II liquids.

Examples of data obtained with a number of crude materials are shown in Table 10. Of the three major materials from the SRC-II process, heavy distillate ([HD] high-boiling-range material) is the most mutagenically active. Light and middle distillates showed no detectable mutagenic activity. The known chemical carcinogen, benzo[a]pyrene (BaP), showed about three times the activity of heavy distillate, while another well-known chemical carcinogen, 2-aminoanthracene (2-AA), was about 100 times as active. Raw shale oil showed some activity, but crude petroleum showed no activity in the Ames system.

TABLE 9. Phase I In Vitro Assays: Liquid Materials

Material to be Analyzed	Ames <i>Salmonella</i> Forward Mutation	Induc- test	<i>S. cerevisiae</i> Recombination	SHE Trans-formation	CHO cell Mutagenesis	CHO-Cell Unscheduled DNA Synthesis	CHO -SCE
Raw Naphtha	A,B	C	A	C	A	C	A
Middle Dis-tillate	A,D,E	C	A	C	A	C	A
Heavy Dis-tillate	A,D,E	A,D,F	A	C,F	A,D	A,D,F	C,F
SRC-II Liquid Products	C,B,G	C,F	C,F	C,F	C,B,F	C,B,F	C,F
Hydrodesul-furized Naphtha	C	C,F	C,F	C,F	C,F	C,F	C,F

A = performed on raw materials
 B = to be performed on at least one set of fractions
 C = to be performed on raw materials
 D = performed on at least one set of fractions
 E = chemical analyses performed
 F = extent of chemical fractionation/analyses to be decided by earlier assay results
 G = integrated chemical analyses to be performed

TABLE 10. Comparison of the Mutagenicity of Solvent Refined Coal Materials, Shale Oils, and Crude Petroleum in Salmonella typhimurium TA98

Materials	Revertants/ μ g of Material
SRC-II	
Heavy distillate	40.0 $\pm$ 23
Middle Distillate	<0.01
Light distillate	<0.01
Shale Oil	
Paraho-16	0.60 $\pm$ 0.19
Paraho-504	0.59 $\pm$ 0.13
Livermore L01	0.65 $\pm$ 0.22
Crude Petroleum	
Prudhoe Bay	<0.01
Wilmington	<0.01
Pure Carcinogens	
Benzo[a]pyrene	114 $\pm$ 5
2-Aminoanthracene	5430 $\pm$ 394

Salmonella Forward Mutation

Forward mutation to 8-azaguanine (8-Ag) resistance in Salmonella is, in some cases, more sensitive to weak mutagens (e.g., procarbazine, mitomycin c, perylene) than the Ames test. Histidine revertants derived from Ames (histidine-requiring) strains will be used to compare forward mutation (8-Ag test) with reverse mutation (Ames test).

The 8-Ag test is performed in much the same way as the Ames assay. Agents to be tested are assayed in the presence and absence of S9 enzymes; aliquots of exposed culture are plated on media containing 8-Ag. Colony formation in the presence of 8-Ag is the endpoint of the test. The assay is presently being used with certain SRC-II liquid materials.

Other Microbial Assays

Although the Ames/Salmonella assay detects most types of mutagens/carcinogens, it does not detect all of them (e.g., compounds that act by cross-linking DNA). To overcome this problem, several assay systems have been developed that detect mutagens not detectable in the Ames system. Generally, these assays are based on primary chemical damage to DNA, rather than mutation. In these assays, large segments of the chromosome, including the entire chromosome, are the genetic target. In theory, all types of damage should be

detectable because the increased target size offers essentially all combinations of DNA bases.

Prophage (λ) Induction (inductest). Prophage induction is particularly sensitive for measuring primary DNA damage. The inductest, because of the biological amplifications afforded, measures both direct and indirect-acting mutagens, including frameshift and point mutagens, and mutagens that act by DNA cross-linking. The inductest will be applied to SRC-II liquid materials.

The test is performed with Escherichia coli, K₁₂, strain 6340, which carries a lysogenic derivative of λ phage. The organism is exposed to test material in the presence or absence of S9 enzymes. DNA damage results in phage induction. Induced phage are detected by plating them on a lawn of indicator strain E. coli, K₁₂, strain 8177, an organism which lyses in the presence of λ phage. The assay is quantitated by counting plaques (zones of clearing caused by cell lysis) on the plate. Preliminary results with SRC-II liquids suggest that positive response in this assay may correlate with positive response in the Ames assay.

Saccharomyces cerevisiae. In addition to mutation and primary DNA damage, recombination induced by exposure to SRC-II materials will be determined. Both reciprocal mitotic recombination and nonreciprocal recombination (gene conversion) will be measured using S. cerevisiae, strains D-3 and D-4. Cells will be exposed to test materials in the presence or absence of S9 enzymes. Mitotic recombination will be detected by colony color change resulting from homozygosity at certain mutant adenine genes in strain D-3. Gene conversion will be detected with strain D-4 by change from tryptophan auxotrophy (cells require tryptophan in culture medium for growth) to tryptophan sufficiency (cells no longer require added tryptophan for growth). Formation of colored colonies, due to changes in the genotype at various adenine loci, will also indicate gene conversion.

Bacillus subtilis (Kada) Bioassay System. B. subtilis (Kada) strains will be used selectively to screen for genotoxic agents that may not be detectable, or that are poorly detected in other in vitro assays. The assay employs DNA recombination-deficient (REC-) strains that are highly sensitive to chemicals that damage DNA. The assay is capable of detecting genetically active metals whose effects are poorly resolved by other submammalian assay systems. The Kada test detects differential killing of the REC- B. subtilis strain compared to its recombination-sufficient (REC+) counterpart (i.e., the parent organism from which it was derived).

Mammalian Cell Transformation

Cell culture methods are being used to evaluate the ability of test materials to transform mammalian cells into a neoplastic state. Second-passage mammalian cell cultures (Syrian hamster embryo [SHE] cells) are exposed to test materials in the presence and absence of S9 enzymes. Cultures are monitored to determine cell transformation (i.e., morphological and biochemical changes that result in unrestricted growth in vitro). Representative colonies of transformed cells are inoculated into nude mice to evaluate their tumorigenic ability in vivo. Tumor development in nude mice inoculated with transformed cells provides evidence that test materials are potential carcinogens.

Results to date (Table 11) suggest that SRC-II HD is capable of transforming SHE cells. Dose-effect relationships, expressed as specific activity measurement (number of transformants/ μ g test material) for HD, are similar to those observed for a shale oil and benzo(a)pyrene, but are of greater magnitude than those observed for crude petroleum.

TABLE 11. Comparative Transformation Properties in Syrian Hamster Embryo Cells of Complex Organic Mixtures

Material	Number of Transformants per μ g of Test Material ^(a)	Range of Linear Portion of Concentration Response Curve ^(b)
DMSO Control (0.1%)	0	---
Prudhoe Bay Crude	~0.002	100-200
Wilmington Crude	~0.002	75-150
SRC-II Heavy Distillate	0.7	5-20
Shale Oil (LERC)	0.3	1-10
Benzo[a]pyrene	0.76	1-20

(a) Extrapolated from linear region of the concentration response curve

(b) μ g/ml

Mammalian Cell Culture Mutagenicity

Chinese Hamster Ovary (CHO) Cell Mutation. Mutation assays with CHO cells use the purine analog, 6-thioguanine (TG), to quantitate induction of forward mutation at the gene coding for the enzyme, hypoxanthine guanine phosphoribosyl transferase (HGPRT). In the system, TG is converted to a nucleotide by HGPRT of normal wild-type cells. The resulting nucleotide (or its metabolites) is (are) lethal to the cell. However, mutants lacking HGPRT are able to survive and grow in the presence of TG. Mutants are scored by counting the number of colonies. Mutagenicity with pure compounds (about 150 compounds have been tested to date) follows linear dosimetry. To properly interpret mutation frequency, cellular cloning efficiencies must also be determined to provide a measure of toxicity. Materials are characterized as direct (requiring no metabolic activation by microsomal enzymes) or indirect (requiring metabolic activation) mutagens. Several SRC-II liquid materials are presently being assayed in the system.

Unscheduled DNA Synthesis. CHO cells can also be used to determine whether test materials cause lesions in DNA involving unscheduled DNA synthesis. This is measured by determining the level of tritiated thymidine incorporated into the damaged DNA molecule under conditions in which de novo cellular DNA synthesis does not occur. To prevent de novo DNA synthesis, cells are incubated in arginine-deficient medium for 2 or 3 days before exposure to test material and tritiated thymidine. Arginine deprivation blocks the G1 to S phase conversion without affecting the cell's ability to initiate repair. Cells are then exposed to SRC-II materials which may interact and damage nuclear DNA. Autoradiography is used to evaluate incorporation of tritiated thymidine into the DNA of individual cells. Use of this assay will be contingent on results obtained from microbial analyses and CHO cell mutagenesis.

Sister Chromatid Exchange (SCE). SCE, observed by differential staining of DNA, is a measure of chemically or physically induced DNA damage in mammalian cells. In this assay, high correlation exists between concentrations of known mutagens/carcinogens and numbers of exchanges between sister chromatids. SCE can be applied to established cell lines or cells exposed in vivo.

We will determine SCE and forward mutation in CHO cells exposed to SRC-II materials. This will allow a comparison of primary DNA damage and forward mutation under similar assay conditions. The SCE will be quantitated by differential staining of chromatids with Hoechst 33258 fluorochrome and Giemsa stain after one or two cell divisions in a medium containing SRC-II materials and 5-bromodeoxyuridine. The SCE assay may also be used with cells derived from animals exposed, either acutely or chronically, to SRC-II materials.

Chemical Analyses for Liquid Streams and Products

Fractionation

All liquid product and process stream materials will be subjected to chemical fractionation. Fractionation is essential for removing substances which may interfere in bioanalyses and for concentrating mutagenic/carcinogenic materials. Fractionation also provides a qualitative measure for determining chemical classes causing biological effect. Stoichiometry for fractions versus intact material provides information on potential biological synergisms/antagonisms in intact material.

Three main considerations have guided us in selecting fractionation methods:

- 1) Procedures must produce useful samples for chemical analyses.
- 2) Procedures must yield suitable samples for bioassay.
- 3) Procedures should be rapid, and applicable to large numbers of SRC-II materials.

The following fractionation procedures are equally compatible for chemical and biological assay. However, they differ in rapidity, amounts of fractionated material that can be generated, and degree of chemical definition.

The particular fractionation method selected is a function of biological test purposes. For example, the large quantities of material required for animal testing (see subsequent section) necessitates use of solvent fractionation or, with considerable effort, preparative-scale HPLC. Most methods provide quantities of materials suitable for in vitro analyses. Partition chromatography and HPLC are the most appropriate fractionation methods for our purposes, based on: 1) recovery of mutagenic activity present in unfractionated samples, 2) elimination or reduction of inhibitory or antagonistic effects, and 3) suitability of fractions for subsequent chemical analysis.

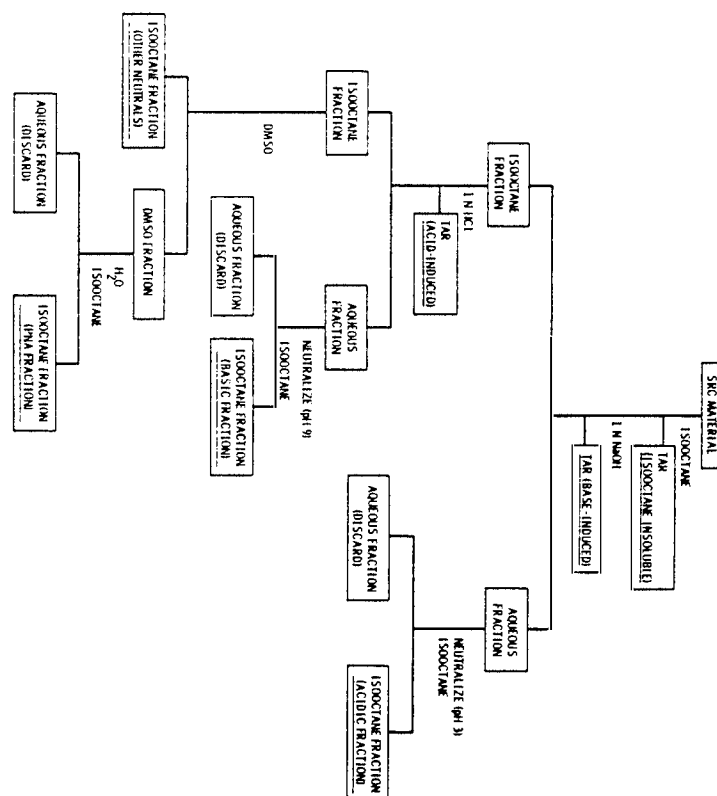
Acid-Base-Neutral Solvent Extraction. The solvent fractionation scheme is a modification of the method of Swain et al. for chemical class fractionation of cigarette-smoke condensates. The procedure involves sequential extraction (see Figure 5) of the sample in iso-octane with 1N HCl, 1N NaOH, and dimethylsulfoxide (DMSO). Fractions produced include polynuclear aromatic hydrocarbon (PAH), neutral, iso-octane insoluble tar, basic, acid-induced tar, acidic, and base-induced tar. Use of iso-octane in place of ether as the primary solvent yields more-quantitative recovery of low-boiling neutral compounds and also provides more-quantitative separation of the PAH fraction.

This solvent fractionation procedure provides the large quantities of sample materials needed for in vivo animal testing, and will eventually allow correlation between in vitro and in vivo analyses. However, when applied to coal distillates, all solvent extraction procedures result in large quantities of insoluble tars. Also, the procedure is laborious and time-consuming, and results are difficult to replicate. Recoveries of biological activity are variable, and may range from 60-100%.

High-Performance Liquid Chromatography (HPLC). HPLC is performed on a normal-phase NH_2 column. The undiluted sample, or a sample diluted in solvent (e.g., hexane or hexane:methylene chloride), is applied to the column and eluted by a continuous ternary gradient. The eluting solvent is changed from the initial 100% hexane to 100% methylene chloride, and subsequently to 100% isopropanol. This elution sequence separates sample constituents into three principal fractions. The first fraction contains neutral hydrocarbon and aromatic constituents. The second fraction consists of more-polar components, including nitrogenous bases and amines. The third fraction contains the most-polar (acidic and phenolic) constituents.

This fractionation method is rapid and highly reproducible, and has greater mixture-component resolving power than other methods described here. Because of the method's speed and reproducibility, composite fraction samples can be generated from a number of runs. The composite samples provide sufficient material for all planned in vitro assays. The method routinely provides quantitative recovery of both biological activity and mass for a given synfuel material. Although present equipment does not allow preparation of fractionated samples in sufficient quantities for animal bioassay, preparative-scale HPLC could do so, with considerable effort.

Partition Chromatography. Partition chromatographic separation involves Sephadex LH-20, and is a modification of the technique (Figure 6) of Klimisch and Stadler, which was further developed by Jones et al. The Sephadex LH-20 is first swelled in methanol:water (85:15). The sample is then applied



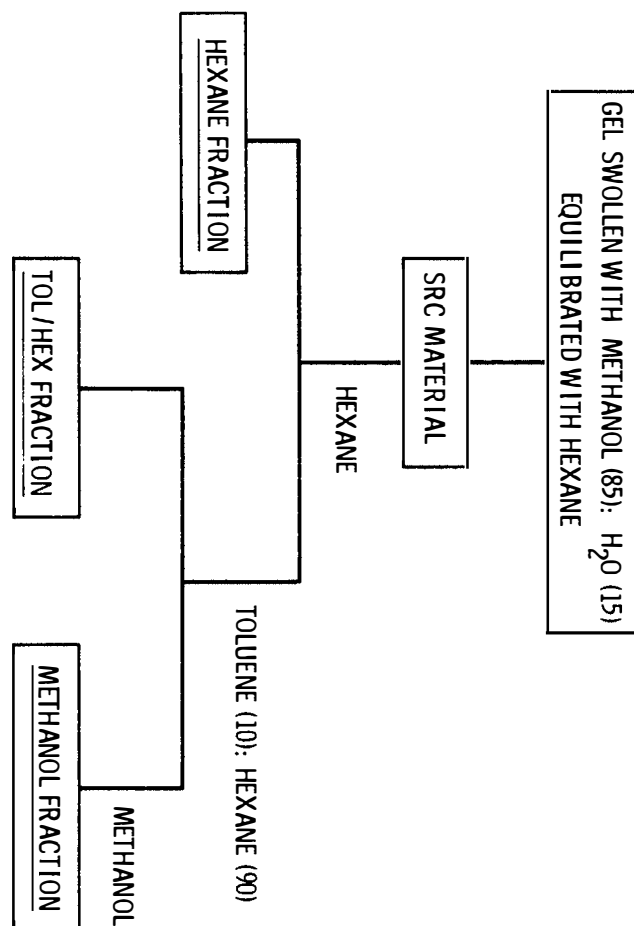


Figure 6. Sephadex LH-20 Fractionation

and sequentially eluted with 100% hexane, toluene:hexane (10:90), and 100% methanol. This elution sequence separates constituents, based on polarity. The hexane fraction contains aliphatic and aromatic hydrocarbons, other neutrals, and 5- and 0- containing heterocycles. The toluene/hexane fraction contains, for the most part, moderately polar constituents, including some azaheterocycles. The methanol fraction contains the most-polar constituents, including most primary amines and phenolic components.

A combination of Sephadex LH-20 partition chromatography and HPLC has been applied to some SRC-II materials. The three major fractions from Sephadex chromatography were re-separated by ternary gradient HPLC, which resulted in large increases in specific biological activity.

Partition chromatography allows fractionation of comparatively large amounts of materials (i.e., 100 times more than HPLC but 20 times less than solvent fractionation). The method also concentrates biological activity by factors of 10 or greater (e.g., increases specific mutagenic activity 10-fold relative to unfractionated material) with high yield of total biological activity.

Thin-Layer Chromatography (TLC). TLC separations of SRC-II materials are performed on silica gel plates, using a solvent system of acetone:hexane:methanol (1:9:0.25). The method has mainly been applied to fractions derived by solvent extraction to aid in chemical identification of biologically active components in SRC-II liquids (see below). Although the method must be considered primarily an analytical tool, it can be applied to fairly large amounts (1-2 grams) of SRC materials or fractions, when necessary. The technique is rapid and reproducible, but recoveries of biological activity tend to be less than 100%.

Data on Fractionated Materials. Fractions obtained from procedures described above have been subjected to Ames assay. Solvent extraction fractions have also been subjected to the inductest and Salmonella 8-Ag resistance tests. Results from Ames assay of solvent extracted fractions are shown in Table 12. The basic fraction derived from SRC-II HD had the highest specific activity (revertants/ μ g) in all assays. However, tar fractions derived from solvent fractionation were also active and, although of lower specific mutagenic activity, contributed the bulk of total activity associated with the crude, unfractionated material.

Mammalian cell transformation results tend to substantiate results of microbial assays. However, unlike microbial assays, the mammalian cell transformation assay shows biological response to the PNA fraction of SRC-II HD.

Organic Chemical Analyses

SRC-II materials and fractions showing biological activity in in vitro assays are chemically analyzed to determine compounds and compound classes capable of causing biological effects. To date, analyses have involved gas chromatography/low-resolution mass spectrometry. A battery of chemical techniques will be used in the future, the form of which will depend on chemical and physical properties of the sample and results of bioassay. Thus far, analytical emphasis has been placed on PAHs, N- heterocycles, and primary aromatic amines (PAAs).

TABLE 12. Recovery of Ames Assay Mutagenic Activity in Fractions Derived by Acid-Base-Neutral Solvent Extraction of SRC-II Heavy Distillate

	Relative Weight (% of Total)	Revertants/ μ g/ 10^6 Cells ^(a)	Weighted Activity ^(b)	Sum & Recovery
SRC-II Basic	1	400	4	
SRC-II Heavy Distillate Basic Tar	24	66	16	S = 48
SRC-II Heavy Distillate Neutral Tar	26	109	28	
SRC-II Heavy Distillate	100	40	40	$\frac{48}{40} \times 100 = 120\%$

(a) Data for *S. typhimurium* TA98, from Tables 1 and 3

(b) $\frac{\text{Relative Weight}}{100} \times \text{revertants}/\mu\text{g}/10^6 \text{ cells}$

Gas Chromatography (GC). High-resolution capillary column gas chromatographic analysis will be performed on standard commercial instruments using either a 60 m x 0.25 mm ID WCOT coated with SP-2250 liquid phase or a specially prepared 25 m x 0.25 mm ID WCOT glass column coated with SE-52 or SE-54 phase. The column effluent is split, and both FID and either N- or S-specific detectors are employed for simultaneous peak detection. The FID trace is automatically integrated for peak quantitation.

The method yields exceptionally high resolution of compounds in complex mixtures, and will be used primarily to analyze biologically active fractions from various SRC-II distillates. Resolution of single compounds in complex mixtures is not uncommon by this means and, based on retention time, it should be possible to obtain confirmatory qualitative and quantitative evidence for compounds of biological interest in SRC-II liquids.

Nitrogen-containing compounds (e.g., aromatic amines, N-heterocycles) will be analyzed in fractions/subfractions by simultaneous use of the N-detector and FID. To determine standards for GC, materials will first be qualitatively analyzed for organic compound composition by GCMS low-resolution methods described below. Tentative compound identification, based on GCMS results, will be used to select appropriate standards.

S-containing compounds (e.g., S-heterocycles) will be analyzed by simultaneous use of an S-detector and FID. S-containing compounds of potential biological interest, and required as standards in GC and other analyses, will be synthesized as needed.

Phenols obtained by caustic extraction of SRC-II materials can be readily isolated by addition of acetic anhydride to a subsample, and extracting the acetylated phenols into hexane. Although catechols and other polyfunctional phenols are not completely analyzed by this procedure, its simplicity outweighs the disadvantage of some loss in analytical detail. Alternatively, phenols in organic solvents will be derivatized using pyridine/acetic anhydride or trifluoroacetic anhydride. These derivatives produce characteristic fragments in the mass spectrometer and are easily identified in complex mixtures. Underivatized phenols can be separated on some of the newer fused-quartz capillary columns, and can be detected using mass spectrometry. The latter technique will be used to analyze nonacidic fractions for the presence of phenolic contaminants. Various mono- and dicyclic phenols are readily available as quantitative standards.

Use to date suggests that SE-52 liquid phase will allow separation of all compound classes discussed above. Other columns, phases, and conditions may be necessary, depending on the material being analyzed. Not all analyses will be performed on all derived fractions. Biological results and the nature of major chemical constituents known or suspected to be present in fractions will be prime factors in determining type and need for analyses.

High-Performance Liquid Chromatography (HPLC). Separation of constituents is performed with a Spectro-Physics 8000 chromatograph or comparable instrument. Columns include normal-phase NH_2 columns, silica gel columns, and reverse-phase C-18 columns. Sample components are eluted from the normal-phase column with a ternary solvent system (i.e., hexane, methylene chloride, and isopropanol). Fractions from the NH_2 column are rechromatographed with an acetonitrile/water solvent mixture on the C-18 column to provide additional resolution of sample constituents. Alternatively, samples may be run directly on silica gel columns. Samples analyzed by HPLC include both crude materials and fractions obtained from one of the separation methods discussed above and will include principally those that are biologically active. Fluorescence, UV absorbance, and electrochemical detectors may be employed, depending on specific compound types of interest. Component identification is achieved both through retention-time comparisons with standards and GCMS analysis of HPLC fractions. HPLC analyses are suitable for nearly all sample types, and are particularly well suited for high-molecular-weight constituents that are difficult to analyze by gas chromatography, highly polar materials, and temperature-sensitive materials.

Gas Chromatography - Low Resolution Mass Spectrometry (GCMS). Electron impact (EI) and chemical ionization (CI) mode GCMS analyses are performed on either a Hewlett Packard 5985 A or 5980 A GCMS system, using either a 60 m x 0.25 mm ID WCOT glass column coated with SP-2250 liquid phase, or a specially prepared 25 m x 0.25 mm ID WCOT glass column with SE-52 or SE-54 phase. Splitless mode injection is used with these capillary columns. The eluate stream may be split to allow simultaneous FID and mass spectrometric detection. The FID trace is automatically integrated for GC peak quantitation and the MS data are used for peak identification. The PAH concentrations are determined both directly and in the PAH fractions. The PAA and N-heterocycle concentrations are estimated from the basic and tar fractions on both the SP-2250 and SE-52 columns. Concentrations of phenol, aromatic and hydroaromatic compounds are determined in intact materials, using the SE-52 column.

High-Resolution Mass Spectrometry (HRMS). HRMS analysis provides accurate molecular weights for constituents in complex mixtures, thus allowing assignment of elemental composition. Ionization modes available on the VG Micromass ZAB IF include EI, CI, field ionization (FI), and field desorption (FD). The latter, with the extended mass range, allows analysis of non-gas-chromatographable components with molecular weights up to 3000 atomic mass units (amu). Negative and metastable ion analysis may also be used when necessary. The latter are two of several recently developed techniques, including FD and high resolution multiple detection, which may be used for analysis of ultra, trace, or refractory compounds.

Initially, samples analyzed by these methods will be fractions comprised of higher-molecular-weight materials and especially those containing N, S, and O functional groups. Generally, we will first obtain elemental composition by high resolution. Structural features may then be studied, using metastable analysis and derivatization, as well as comparison to standards, when such standards exist.

Summary of Results. TLC was used to separate mutagenically active components of the basic, basic tar, and neutral tar fractions of SRC-II HD from other components in this complex material. For the three fractions tested, mutagenic activity was localized in about the same TLC regions. The GCMS analysis of the eluates from TLC regions exhibiting enhanced mutagenic activity showed that the relative concentrations of PAAs (obtained by measuring peak areas for the $[M + 1]$ ion in the CI mode) followed a distribution similar to that of mutagenic activity. The PAAs in the active regions included aminonaphthalenes, aminobiphenyls, aminoanthracenes, aminophenanthrenes, aminopyrenes, aminochrysenes, and their alkyl homologues. Except for small amounts of aminonaphthalene, PAAs were not found in TLC regions that lacked mutagenic activity.

Concentrations of PAA with two to four fused rings increased and decreased commensurate with mutagenic activity in TLC eluates of the basic fraction. Mutagenically active TLC eluates from the basic and neutral tar fractions contained smaller concentrations of two-ring PAAs, while having relatively higher amounts of three- and four-ring compounds such as aminophenanthrenes and aminopyrenes. Concentrations of PAA again correlated with mutagenic activity.

Solid Process Streams and Wastes

Several solid materials (raw sulfur, vacuum bottoms, stripper tower bottoms, coal slurry, gasifier slag, wastewater solids) will be subjected to in vitro bioassay and chemistry. Methods of extracting these materials, the bioassays to be employed and the chemical analyses to be performed are described below. Assays to be performed on these materials are shown in Table 13.

Sample Extraction

Organic-Rich Materials. SRC-II vacuum bottoms, stripper tower bottoms, and coal slurry are rich in organic compounds. These materials must be extracted or dissolved prior to analyses in in vitro bioassays. Boundary conditions for solution/extraction are as follows:

TABLE 13. Phase I - In Vitro Assays: Solid Materials

Material to be Analyzed	Ames <u>Salmonella</u>	<u>Bacillus Subtilis</u> KADA Strain	Mammalian Cell Transfor- mation	Other
Vacuum Bottoms	A,B	A,B	A,B	C
Stripper Tower Bottoms	A,B	A,B	A,B	C
Coal Slurry	A,B	A,B	A,B	C
Raw Sulfur	C,D	C,D	C,D	C
Gasifier Slag: Coarse	C,D,E	C,D,E	C,D,E	C
Gasifier Slag: Fine	0	D	0	C
Waste Water Incinerator Solids	C,D,E	C,D,E	C,D,E	C

A = to be performed on all organic extracts and serum, HCl, and simulated lung fluid extracts.

B = organic fractionation and analyses to be performed on extracts containing biological activity.

C = extent of chemical fractionation/analyses to be decided by earlier assay results. Other bioassays (Table 8) may be used depending upon results of this assay slate.

D = to be performed on all organic extracts and all aqueous leaching solutions in Table 14.

E = metals analyses to be performed if results suggest metals effect.

- 1) Organic solvents of varying polarity (hexane, toluene, methanol, acetone and methylene chloride) will be used to effect maximum dissolution/extraction. Bioassay results with the extracts represent worst-case estimates since it is doubtful that animals exposed to organic-rich materials via inhalation or dermal contact would be capable of totally dissolving or extracting all organic compounds in these solids.
- 2) Solvents representing simulated or actual body fluids will also be used (Table 14). Extracts from these materials may represent potential physiological dissolution.

TABLE 14. Aqueous Leaching Solutions

Solution pH Values:	1, 5, 9, 11
Solution Salt Concentrations:	0.005 M and 0.5 M
Salts:	NH ₄ NO ₃ (plus or minus 0.002 M EDTA)
	HCl for pH range 5-9
Additional Solutions:	Serum
	Simulated Lung Fluid

Stripper tower bottoms and coal slurry cannot be easily ground to give powders suitable for dissolution. These materials will be brought to liquid nitrogen temperatures, shattered, and sieved to particles in the 200- to 400-mesh range. Vacuum bottoms will be ground and sieved; resulting powders will be extracted in each of the organic solvents. Solution-to-solid ratios and mixing conditions will be adjusted to effect maximum dissolution in a given solvent. Concentrations will be expressed as percent of solid dissolved.

Actual or simulated body fluids will include serum, 0.1N HCl, and simulated lung fluids (Table 14), as described by Moss. Serum has been used to extract combustion particulates from operations of diesel- and coal-fired facilities for in vitro assays. Hydrochloric acid solution represents a solvent with pH of gastric fluid. Simulated lung fluids have been used to estimate physiological dissolution for various potentially respirable particulates. Extraction conditions are as described above.

Mineral-Rich Solids. Coarse and fine gasifier slag, wastewater incinerator solids, and raw sulfur will be extracted in each of the organic solvents listed above. This represents worst-case conditions for trace-organic material dissolution from mineral-rich solids.

These materials will also be extracted in aqueous solutions (Table 13) containing from 0.005 M to 0.5 M salt and varying in pH from 1 to 11. Extractions at pH 5 and 9, minus or plus 0.002M EDTA, will allow maximal metal removal. These solutions represent worst-case conditions for analyses of biological effects of metals in solids. Again, serum and simulated lung fluid will be used to represent physiological extraction.

In Vitro Tests and Chemistry

Organic-Rich Materials. Chemical fractionation and analytical methods and in vitro bioassays will be performed as described for liquid products and process streams (pp. 39-51). Routine in vitro bioassays will be performed using the Ames system and mammalian cell transformation. We anticipate that organic chemical entities of concern in these materials may be similar to those found in liquid products and process streams. If this is not the case, further analyses may be indicated.

Mineral-Rich Solids. Bioassays of organic extracts and aqueous leachates from mineral-rich solids will be performed as described previously. One additional bacterial bioassay system useful for detecting metal-induced DNA damage will also be used since extracts and/or leachates from mineral-rich solids may contain high concentrations of metals relative to coal liquids or organic-rich solids. As discussed on p. 42, this assay is based on the sensitivity of recombination-deficient (REC-) strains of *B. subtilis* to DNA damage induced by organics or metal compounds.

Organic materials from mineral-rich solids will be fractionated as previously described. If results from the *B. subtilis* assay suggest the presence of direct-acting mutagens and Ames results do not, the possibility of metal or metal-containing genotoxins must be examined. Appropriate analytical methods for metals of greatest potential biological concern are listed in Table 15.

Process Waters and Treated Process Waters

SRC-II process waters may be the most difficult of the materials to obtain in representative form. Therefore, biomedical studies on process water will be limited to screening assays until waters more representative of potential demonstration or commercial operations are available.

Depending on content of organic and inorganic materials, process waters and treated process waters may require extraction and/or concentration before in vitro assay. Three techniques will initially be used to provide suitable samples. Results from bioassays will aid in determining the most suitable method. Assays to be used are shown in Table 16.

Sample Extraction

Evaporative Condensation. Process water and treated process water will be evaporated in a rotoevaporator or a Kdurna Danish evaporator. Total organic carbon (TOC) content in the condensate will be determined. These samples may represent total carbon load (except for volatile constituents) in a volume usable for in vitro bioassays.

TABLE 16. Phase I In Vitro Assays: Waters

Material to be Analyzed	Ames Salmonella	Salmonella Forward Mutation	Induc- test	S. cerevisiae Recombination	B. subtilis KADA	SHE Transfor- mation	CHO Muta- genicity	CHO Un- scheduled DNA Synthesis	CHO -SCE	95
Process Feed Water	A	A	A	A	A	A	A	A	A	
Process Water	B	C	C	C	C	C	C	C	C	
Treated Process Water ^D	B	C	C	C	B	B	C	C	C	

A = Analyses on raw material and limited number extracts; extent of chemical extraction/analyses expected to be minimal.

B = Analyses on all extracts and raw material; extent of chemical fractionation and analyses dependent upon results.

C = Analyses on extracts and raw materials contingent upon earlier assay results.

D = Number of samples is undetermined; dependent on water treatment options employed.

TABLE 15. Analytical Methods for Determining Biologically Active Metals

Element Determined	Analytical Method
As	Electrochemical techniques, dc-coupled plasma emission, neutron activation, atomic absorption
B	Plasma emission spectroscopy
Cr	Neutron activation, electrochemical techniques
Cd	Electrochemical techniques, atomic absorption, plasma emission
Co	Atomic absorption, neutron activation
Cu	Electrochemical techniques, atomic absorption, plasma emission
Hg	Flameless atomic absorption, plasma emission
Ni	Electrochemical techniques, atomic absorption, plasma emission
Pb	Electrochemical techniques, atomic absorption, plasma emission
Sb	Electrochemical techniques, neutron activation
Se	Electrochemical techniques, neutron activation, atomic absorption
Sn	Atomic absorption, plasma emission
Tl	Neutron activation, electrochemical techniques
V	Electrochemical techniques, neutron activation, Plasma emission
Zn	Electrochemical techniques, neutron activation, atomic absorption, plasma emission

TABLE 17. Phase I In Vivo Assays

Material to be Analyzed	Acute Oral Toxicity (rats & mice)		Acute Dermal Toxicity (Mice)		Eye Irritation	Guinea Pig Skin Sensitization		Aspiration Hazard	Teratogenicity
	A	B	A	B	B	B	B	B	A
Raw Naphtha	A		A			B		B	A
Middle Distillate	A		B		B	B		B	A
Heavy Distillate	A		A		B	B		B	C
Vacuum Bottoms	D		D		D	D		D	D
Stripper Tower Bottoms	D		D		D	D		D	D
Coal Slurry	D		D		D	D		D	D
Raw Sulfur	E		E		D	D		D	E
SRC-II Liquid Product	D		D		D	D		D	D
Hydrosulfurized Naphtha	E		E		B	B		B	E
Gasifier Slag	E		E		E	B		B	E
Process Water	E		E		E	B		B	E
Waste Water	E		E		E	B		B	E
Incinerator Solids									

A = performed and data available

B = will not be analyzed with this assay

C = to be performed on fractions

D = to be performed by P&M

E = to be performed by PNL

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Solvent Extraction. Two organic solvents (hexane and methylene chloride) having differing polarity will be used to extract nonpolar and polar organic compounds from process water and treated process water. Weight of material extracted will be determined by evaporation to constant weight.

Preconcentration onto Adsorption Resins. Process water and treated process water will be passed through small beds of either XAD-2 (polystyrene divinylbenzene resin) or XE-347 (carbonaceous resin). Adsorption on XAD-2 resin is a standard method of preconcentration for trace organic materials in natural waters. Recent evidence indicates that XE-347 is more effective for removing trace concentrations of polar organic compounds from water than is XAD-2.

After adsorption, the resin will be Soxhlet-extracted with hexane, followed by methylene chloride extraction. Weight of material extracted will be determined by evaporation to dryness, and corrected for resin degradation.

In Vitro Assays and Chemistry

In vitro assays to be employed are described on pp. 39-44. Chemical fractionation methods and organic analyses coupled to bioassay needs are described on pp. 44-51.

Short-Term In Vivo Bioassay

Short-term in vivo assays are, in many cases, essential to develop conditions for use in the longer-term, more-definitive, whole-animal studies to be performed in Phase II. Additionally, these assays provide data on potential biological effects which may result from single-incident, high-dose exposures to SRC-II materials which may be encountered in the workplace or environment. Measures of teratogenicity, described below, provide initial data on determining whether fetal tissue may be subjected to unique risk after maternal exposure to SRC-II materials. Assays to be performed are shown in Table 17.

Acute Oral Toxicity

Acute oral studies usually involve single exposures of animals to test material, followed by observations of death, weight change, clinical symptoms and, in some cases, hematologic changes. Short-term, repeated-dose (subchronic) studies involve exposures to test materials for up to 3 weeks. Results of acute and subchronic toxicity studies are generally used to establish doses for chronic studies (i.e., dominant lethality, transplacental carcinogenicity, etc.). Mice and rats are usual test organisms.

Wistar rats and DBA mice will be given varying doses of the liquid, either diluted in corn oil or undiluted, by gavage. Solid materials (gasifier slag, vacuum bottoms, stripper tower bottoms) will be suspended in carboxymethyl cellulose and administered by gavage. Five to 15 animals of each sex will be exposed per dose in two to four replicates. Animals will be fasted overnight prior to exposure.

For acute studies, dose administration will be one-time-only, and animals will be observed during the next 3 days for mortalities and other changes, including weight loss, appearance of neurological changes, etc. Mortalities will be recorded during the first 3 days postadministration. However, surviving animals will be observed for an additional week to determine if recovery from acute symptoms occurs. If latent mortality occurs in initial studies, the observation period will be extended.

Short-term, repeated-dose studies will follow the same procedure, except that animals will be administered test material once per day for 5 consecutive days. Again, mortality, weight changes, neurological symptoms, and other clinical signs will be observed during the first week following the last exposure. This type of exposure will sometimes be performed in conjunction with studies on effects of materials on prenatal development.

Acute Dermal Toxicity

Liquid materials will be administered either undiluted, or diluted in an appropriate solvent (acetone, methanol, etc.). Solid materials will be suspended in an appropriate organic or aqueous solvent as determined by analyses described on pp. 51-54. Dose for mineral-rich solids may be determined from the maximal concentrations that can be dissolved or suspended in the solvent. Five to 15 C3Hf/HeBd mice of both sexes will be used for each dose group. Materials will be applied to the shaved dorsal skin once per day for 10 consecutive days. Animals will be observed for 14 days after exposure for mortality, weight loss, neurological changes and overt symptoms of skin irritation.

Eye Irritation

Liquid materials will be administered undiluted. Solid materials will be administered as finely ground powders. New Zealand White rabbits will be used. Materials will be applied and animals observed according to the Proposed Health Effects Test Standards for Toxic Substances Control Act Test Rules (FR 44 44054). Grading and scoring of irritation will be performed in accordance with the method of Draize et al.

Dermal Sensitization

Liquid materials will be administered undiluted, or diluted with physiological saline. Solid materials will be suspended in a minimal amount of physiological saline. Albino guinea pigs will be used. Materials will be applied according to the method of Landsteiner and Jacobs or, if intradermal injection is impractical, by the method of Buehler. Grading and scoring of reactions will be performed according to the method of Draize et al.

Aspiration Hazard

Materials will be administered undiluted. Young, Fischer 344 rats will be used. Materials will be administered according to the method of Gerarde.

Teratogenicity

Developmental toxicity studies with mice and rats will be performed to determine if embryolethality, early embryonic changes, or malformations are

produced after administration of SRC-II materials to the pregnant female. Test materials will be administered orally, even though other routes of entry (dermal and inhalation) may be more likely in the workplace or general environment. Oral administration is used because: 1) it permits better control of dose, 2) much of the dose after inhalation exposure goes to the gastrointestinal tract, and 3) data for other routes of entry can be related to oral administration through pharmacokinetic data.

Typically, test material will be administered to pregnant rats from 7-11 and 12-16 days gestation (dg), and to mice from 6-10 and 11-15 dg. About 15-20 pregnant animals will be used for each dose, in 2-4 replicates. Pregnant females will be killed at 20 dg (rat) or 19 dg (mouse). The uterus will be removed, and fetuses will be examined for gross malformations, and subjected to microdissection for determination of internal malformations. Soft tissue will then be digested away from the skeleton using potassium hydroxide, and the skeleton, stained with alizarin red, will be examined for malformations.

Results to Date

In studies already conducted, the acute toxicities of SRC-II RN, MD, and HD have been compared to those for shale oil, petroleum crudes, and diesel oil after oral administration. Relative toxicities, expressed as the dose (g/kg body weight) required to kill 50% of the test animals in 3 days, are shown in Table 18. The SRC-II materials would be considered moderately toxic by industrial hygiene standards (Clinical Toxicology of Commercial Products, M76) with a range of LD₅₀ values from 2.3 to 3.8 g/kg.

Repeated-dose toxicity was determined for RN, MD, and HD. Repeated-dose toxicity values for SRC-II materials were substantially lower than the acute values. These data indicate that either the material or the effects of RN, MD, and HD are cumulative.

Administration of RN, MD or HD at 7-11 dg did not significantly increase the incidence of fetal malformations over that in controls. Fetal weight was affected only at doses producing symptoms of maternal toxicity (inhibition of weight gain or death of some females). Prenatal mortalities were increased by all three materials, again at doses producing some maternal toxicity.

These SRC-II materials produced more-severe fetal effects when administered at 12-16 dg than when given at 7-11 dg. Prenatal mortalities were increased by all three materials, and incidence of malformations was increased by HD (Table 19). Although increased prenatal mortalities occurred in the absence of signs of maternal toxicity, increases in incidence of malformations produced by HD were accompanied by inhibited maternal weight gains during pregnancy. Principal malformations observed were cleft palate, immature lung and herniated diaphragms.

INDUSTRIAL HYGIENE - PHASE I

Previous epidemiologic and laboratory data suggest that coal liquids may pose carcinogenic risk. Therefore, a comprehensive industrial hygiene program was initiated at the Ft. Lewis SRC pilot plant. A brief description of the program follows.

TABLE 19. Maternal and Fetal Toxicity in Rats Following Dosing with SRC-II Materials from 12-16 Days Gestation.

Agent	Dose (a) (g/kg/day)	Number Dosed (b)	% Dead (c)	Number Pregnant at 21 dg	Weight Gain (d) to 21 dg	% Implants (e)	Litters with Resorption (f)	% Malformations (g)	Litters with Malformations (h)	Fetal Weight (i) at 19 dg
Corn Oil	--	14	0	12	148 ± 31	1 (h)	1	0	0	5.4 / 0.5
Aroclor (b)	0.11	13	0	10	104 ± 24	7	5	0	0	4.3 / 0.6
Raw Naphtha	0.28	11	9	8	116 ± 3.6	4 (i)	4	2	1	5.5 / 0.6
	0.56	12	8	9	101 ± 3.7	2 (i)	4	0	0	5.5 / 0.5
	0.84	14	43	7	113 ± 2.7	4 (h)	3	1	1	5.4 / 0.5
	1.12	6	67	1	3.2	0	--	0	0	4.7 / 0.3
	1.41	7	86	1	5.0 ± 0	0	2.0	1	0	5.1 / 0.3
	1.69	5	80	1	11.2 ± 0	0	0	0	0	5.8 / 0.6
Middle Distillate	0.33	9	0	9	127 ± 4.3	5	5	3	1	5.8 / 0.6
	0.65	11	9	7	149 ± 3.2	7 (i)	5	0	0	5.8 / 0.6
	0.90	9	11	8	148 ± 4.0	20	5	0	0	5.1 / 0.4
	1.30	6	33	4	126 ± 1.9	6 (i)	2	0	0	4.5 / 0.4
	1.35	6	50	2	5.0 ± 0.6	0	--	--	--	4.5 / 0.4
	1.96	3	100	0	--	--	--	--	--	--
Heavy Distillate	0.37	15	0	4	129 ± 3.1	9 (i)	7	1	2	5.3 / 0.5
	0.73	13	0	10	85 ± 2.3	66 (i)	9	7.4	5	4.3 / 0.7
	1.10	12	17	9	76 ± 2.1	69	9	6.0	6	4.3 / 0.5

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- (a) Administered by gavage once daily for 5 consecutive days; if undiluted, 0.1-1.2 ml given per 300 g body weight.
- (b) Oil used in corn oil, given at 1 ml per 300 g body weight.
- (c) Includes both pregnant and nonpregnant adult females.
- (d) Body weight gain between 0 and 21 days of gestation (dg); mean ± SD.
- (e) Calculated on a per fetus rather than a per litter basis; includes resorbed and dead implants.
- (f) Combination of soft tissue and skeletal malformations.
- (g) Percentages of each litter.
- (h) One or more fetuses delivered prematurely; implant data incomplete and not included.
- (i) One or more litters with all implants resorbed.

TABLE 18. Comparison of Acute and Repeated Dose Toxicities of SRC Materials in the Female Wistar Rat^(a)

Material	Acute (b) LD ₅₀	Repeated Dose (b) LD ₅₀
Raw naphtha	2.30	0.96
Heavy distillate	2.98	1.19
Middle distillate	3.75	1.48
Shale oil	9.22	----
Diesel oil	11.8	----
Crude petroleum	>12	----

- (a) Materials were administered one-time-only by gavage for acute toxicity studies. For subchronic studies, materials were gavaged once daily for 5 consecutive days.
- (b) LD₅₀ is defined as the dose, in grams of material per kilogram of body weight, required to kill 50% of the animals. For the acute toxicity study, this value represents a single dose; for the subchronic studies, the value represents a daily dose.

Worker Education

Initially, each employee is advised of the potential harmful effects of materials with which he will be working, the precautions necessary, good industrial hygiene practices, etc. Thereafter he is periodically shown training films and slide presentations and is given lectures on suitable topics by qualified physicians. The educational program is a continuing effort to educate the employee concerning the potential hazards involved, measures being taken to protect him, and what he should do to protect himself. Information generated in the various health programs is made available to the employee as it becomes available.

Each employee is furnished a complete change of clothing daily, and shoes as needed. A change house is provided to prevent possible contamination of street clothes. Showers are mandatory after each shift. Lunchroom facilities are also provided to avoid food contamination.

The training program also addresses use of respirators, protective clothing for specific jobs where exposure to potentially hazardous materials might occur, and work procedures in potentially hazardous areas.

Medical Surveillance

The medical surveillance program provides periodic examinations and surveillance in sufficient scope to detect, at an early stage, any changes in physiological functions. Each employee is given a complete medical examination initially, and once per year thereafter. The examination consists of a medical history and an extensive physical examination. A complete blood work-up is performed, consisting of a white blood cell count, hemoglobin, hematocrit, mean corpuscular hemoglobin concentration, and differential white cell count. Analysis of blood and urine, including a microscopic examination, is also performed.

The skin is examined carefully for evidence of lesions, and employees are asked to report any unusual skin conditions. The annual skin examination is supplemented by a quarterly skin examination by the Plant Nurse. Any dermatologic problems requiring a physician's care are referred to a Board-certified dermatologist.

Posterior-anterior and lateral chest X-rays are taken and interpreted by a Board-certified radiologist. Pulmonary function tests, consisting of forced vital capacity and forced expiratory volume, are performed by the Plant Nurse. Detailed medical records are maintained on each employee for future epidemiological studies.

To date, there have been five mild transient cases of photodermatitis at the Ft. Lewis pilot plant resulting from exposure to coal liquefaction materials. No other identifiable cases of occupational disease have occurred. Continued follow-up will determine if effects occur after long incubation periods among SRC pilot plant employees.

Industrial Hygiene Monitoring

Site- and personnel-monitoring are ongoing at the Ft. Lewis SRC pilot plant. Methods used and results to date are discussed on p.105.

Toxicological Determinations

Toxicological measures to be performed, and those performed to date, are described in Phases I and II, Biomedical Program (pp. 37-60 and 76-82). Summaries of available information are also provided. Data from animal studies suggest that heavy coal liquids from the SRC-II process may cause dermal carcinogenesis. Results from Phase I and II studies may define specific compounds and compound classes of concern, and allow development of appropriate control, work-practice procedures, and specific monitoring methods.

ECOLOGICAL STUDIES AND CHEMISTRY

SRC-II materials may enter the environment by several routes, including: 1) accidental releases of liquid products during handling, storage, and transportation; 2) aqueous leachates from solid waste disposal; 3) unplanned releases of treated and untreated liquid effluents; and 4) fugitive atmospheric

emissions. Severity and duration of environmental effects will depend on the quantities and rates of releases, and the persistence, behavior, and chemical form(s) of materials released in the environment.

To evaluate the potential fate and effects of SRC-II materials in the environment, research will focus on source materials from pilot plants and will include studies relevant and applicable to demonstration facility site operations. Environmental studies will be phased in the same manner as are biomedical studies. The following section describes studies to be performed in Phase I, utilizing a battery of ecological screening assays. Acute^(a) and chronic screening assays will provide data on potential toxicity of SRC-II materials (liquid and solid) released to the environment. Organisms representing various aquatic and terrestrial trophic levels will be tested. Tests described below consider regulatory agency concerns and the needs of process developers.

Liquids

SRC-II product fuel oil and hydrodesulfurized naphtha may be primary products of SRC-II technology. Because they may be discharged to waters and/or soils as a consequence of shipment or storage, these products will be examined in Phase I screening systems for potential ecological effects, as will both treated and untreated process waters (Table 20). Although the possibility that untreated process water will enter the environment is small, it is essential to establish what effects might occur from an unplanned discharge. Further, these data will aid in establishing the effectiveness of water-treatment systems relative to ecological effect.

Aquatic Screening

Studies described below will assay complex SRC-II liquids, selected chemical fractions, and/or specific compounds and reference commercial oils. Test organisms include: the freshwater green algae, *Selenastrum capricornutum*; the zooplankton, *Daphnia magna*; two sediment-dwelling detritivores, *Chironomus tentans* and *Tanytarsus dissimilis*; the fathead minnow, *Pimephales promelas*; and rainbow trout, *Salmo gairdneri*. These species are accepted reference test organisms and most have considerable experimental history. The two benthic detritivores were selected as species representative of the water/sediment interface, where coal liquids released to the environment are expected to accumulate. The two fish represent eastern and western species.

Acute toxicity tests serve to: 1) provide a means of screening SRC-II raw liquids and chemical fractions, 2) provide a reference data base likely to be required for the generic environmental impact statement and various federal and state permits, and 3) establish appropriate concentrations for longer-term (e.g., chronic) studies. Chemistry will be integrated with toxicity tests because partitioning of SRC-II liquids into water and sediment in test systems varies with time and compound type. Animals exposed chronically (e.g., 30 days) may be exposed to different toxic compounds from those exposed acutely (e.g., 48 to 96 hours). Toxicity results can be drastically changed through

^(a)Acute toxicity studies are funded by the U.S. Environmental Protection Agency.

partitioning effects, depending on the kinetic energy of mixing devices used to introduce pollutants to water.

Our mixing system (termed batch, or replacement) provides five sequential extractions of SRC-II oil with dilution water at 2-day intervals. Each aqueous extract is chemically characterized. The first extraction is used as a stock solution for acute toxicity tests. Chronic tests are conducted with both the first and a later extraction to simulate effects of long-term exposures to sublethal concentrations of acute (relative hydrocarbon concentrations after initial contact with water) and chronic (relative hydrocarbon concentrations after prolonged contact with water) mixes. These tests span the range of mixes anticipated for an SRC-II product spill in a river.

Acute toxicity tests will be repeated only as required for comparative purposes (e.g., when other product blends or fractions become available). Chronic toxicity tests will determine long-term survival, growth rate and reproductive potential of organisms exposed to concentrations of test material that are not acutely lethal.

Algal Test System. For some classes of chemicals, primary producers comprise the most sensitive biological community. Accordingly, development of procedures for algal assay and the laboratory use of periphyton communities for toxicity testing is increasing. Algal assays are designed to determine the concentration of test material having no observable toxic effect and are conducted by preparing four replicates of at least five concentrations of test material, and a control. A standard nutrient medium is distributed in replicated flasks with a known number of *S. capricornutum*. Test cultures are incubated under continuous light at 24°C for 5 days. After 5 days exposure, cell counts and chlorophyll a fluorescence are determined. Remaining algal cells are removed by centrifugation and inoculated into flasks containing clean medium and no test material. After a 9-day recovery period, cell counts and chlorophyll a fluorescence are again determined.

Daphnid Test Systems. Acute tests determine the potential effects of test materials over short-term exposures. Dose-response relationships, including the median lethal concentration (LC₅₀) and lowest concentration producing a toxic response are determined. A 48-hour static approach is employed to assay the effects of six test concentrations, plus controls. Six *D. magna* are used per test concentration or control. Tests are conducted under selected conditions of water hardness, temperature, dissolved oxygen (DO) and pH to evaluate the effects of water quality on toxicity. Water (DO, pH, temperature) and chemical variables (total organic carbon, ultraviolet and infrared hydrocarbon measurement) of stock and exposure solutions are monitored during testing to correlate chemistry with effects.

To study long-term effects of concentrations of test material below those that are acutely lethal, a *Daphnia* population unit is observed over its life cycle. The test procedure employs five concentrations of test material, plus controls. Test concentrations bracket 1/10 the acute LC₅₀. Test organisms are exposed in a static system to the same test concentration for up to 28 days. However, the organisms are transferred three times weekly (standard renewal procedure) to fresh test solution. Long-term survival, growth and reproduction (i.e., timing, number of offspring, etc.) are monitored.

TABLE 20. Phase I Ecological Screening Assays: Liquid Materials

Material to be Analyzed	Algal Test	Daphnid Test	Detritivore Test	Fish Test	Plant Growth Test
SRC-II Liquid Product	A,B,C,D	A,B,C,D,E	A,B,C,D	A,B,C,D,E	A,D,E
Hydrode-sulfurized Naphtha	C,D	C,D	C,D	C,D	C,D
Process Water	C,F	C,F	C,F	C,F	C,F
Treated Process Water	C,F	C,F	C,F	C,F	C,F

A - performed on raw materials

B - chemical analyses performed

C - to be performed on raw materials

D - chemical analyses to be performed

E - to be performed on at least one set of fractions

F - extent of chemical fractionation/analyses to be decided by earlier assay results.

Detritivore Test Systems. Acute toxicity tests with midge larvae, *C. tentans*, measure mortality after short-term exposure (48-96 hours) to test materials under selected water-quality conditions as described for *D. magna*. Each test chamber contains paper substrate to reduce cannibalism.

Chronic toxicity tests with midge larvae evaluate potential effects of materials on organisms found in sediment and living largely on detritus. The procedure is similar to that described for *D. magna* and employs five concentrations of test material, plus controls. Test concentrations bracket 1/10 the LC₅₀. Test organisms are transferred three times weekly to fresh test solution and are exposed for up to 21 days. Life-cycle analyses include monitoring survival, reproduction, emergence timing and growth. Because of differences in larval size and timing of various life-cycle events, *C. tentans* is used to study growth; and *I. dissimilis* is used to study reproduction and emergence timing.

Fish Test Systems. Acute toxicity tests with fathead minnows, *P. promelas*, and rainbow trout, *S. gairdneri*, are designed to measure mortality (LC₅₀) after short-term exposure to test materials under selected water-quality conditions, as described for *D. magna* and *C. tentans*. The exposure period is 96 hours, and tests employ flow-through systems to avoid low DO levels resulting from fish metabolism, bacterial oxygen demand, and waste breakdown. To provide data on sublethal effects, observations are also made on swimming behavior, loss of reflex, discoloration, and mucus production.

Chronic toxicity tests with fathead minnows are conducted under flow-through conditions at five test concentrations which bracket 1/10 the acute LC₅₀. Eggs or larvae are exposed for up to 30 days, and long-term survival and growth are monitored. Test duration can be extended to include spawning of mature individuals. After spawning, 50 embryos are randomly selected for incubation to determine viability, hatchability, and reproductive success.

For western fish species, tests will be conducted in which the fertile embryos of rainbow trout are exposed for 28 to 60 days. Embryo survival and survival and growth of hatched fish will be determined. Tests will be conducted under flow-through conditions and are designed to determine which toxicant concentrations adversely affect early life stages of fish. The procedure employs five concentrations of test material, plus controls. Test concentrations bracket 1/10 the LC₅₀. A dilution factor of not less than 0.5 will be used between treatments.

Behavioral Studies. Organisms in their natural environment may avoid, may be unaware of, or may be attracted to noxious chemicals. Therefore, behavioral studies will be conducted with fathead minnows and, possibly, midge larvae to aid interpretation of acute and chronic toxicity test results. Pollutant concentrations causing death, retarding growth, or limiting reproduction in the laboratory are only important in nature if they are below the avoidance threshold. Avoidance studies with fish will be conducted in circular flow-through systems employing nine chambers surrounding a center drain. The system is designed to allow test organisms to enter or exit ambient water or water contaminated with test material. Delivery systems are designed to allow desired physicochemical partitioning of test material among oil, sediment, and water phases. Visual observations and video recording techniques will document behavior.

Forty-five fish are placed in the system to start a test. After a 24-hour acclimation period, toxicant is introduced to some (randomized) chambers. Observations on fish response (e.g., avoidance/attraction) to SRC-II materials, are made at half-hour intervals for 2-4 days. The effect of other ecological variables (shelter, food, temperature, etc.) on response to SRC-II materials will also be evaluated.

Organic Analytical Chemistry for Aquatic Screening Studies. Chemical analyses associated with aquatic screening studies consist of monitoring concentrations of SRC-II materials as toxicity experiments are conducted, as well as more detailed procedures for determining exposure concentrations of various SRC-II chemical components.

Applicability of individual tests will depend on SRC-II concentrations employed during ecological testing and the quantity of material available for analysis. The following methods and/or analyses will be employed:

- 1) Dohrman or Beckmann carbon analyses - direct injection of aqueous sample; measures total organic carbon (TOC).
- 2) IR analysis - extraction of water with carbon tetrachloride followed by determination of the absorbance at 2927 cm⁻¹; estimates hydrocarbon and phenol concentrations.
- 3) Photometric phenol assay - use of aminoantipyrine to form a colored complex; allows rapid estimation of phenols in aqueous media.
- 4) XAD-2/IR analysis - organic material from solubilized or suspended SRC-II in water can be sampled by pumping large quantities of water over XAD-2 resins and extracting the resin with carbon tetrachloride. The quantity of material trapped on the column is estimated using infrared absorption at 2927 cm⁻¹.

During testing, exposure concentrations of various SRC-II components will be determined as follows:

- 1) Hydrocarbons - aromatic and saturate hydrocarbons are extracted from the test water using hexane. The hexane extract is concentrated, and the aromatic hydrocarbons separated from saturates using silica gel chromatography. Hydrocarbons are then quantitated using capillary gas chromatography and GCMS techniques discussed on pp. 48-51.
- 2) Phenols - the water sample is adjusted to pH 12+ with NaOH to form the sodium phenates, and extracted with hexane to remove impurities. Acetic anhydride is then added to form phenol acetate derivatives, which readily extract into hexane. The hexane extract is concentrated and the phenols quantitated with FID capillary gas chromatography using an internal standard calibrated against a variety of methylated phenols and indanols.
- 3) Pyridines and Anilines - anilines and other basic nitrogen compounds, along with neutral species, are extracted from an

aqueous solution at pH 11-12 with CH_2Cl_2 . Extraction of the CH_2Cl_2 with 1M HCl yields a fraction enriched in basic nitrogen compounds. Anilines in this fraction can be separated from N-heterocycles and quantitated by GC after acetylation with acetic anhydride. Extraction of the derivatized CH_2Cl_2 solution with 1M HCl will remove basic heterocycles and yield a CH_2Cl_2 solution containing neutral acetylated amines, which are then quantitated by GC. The procedure distinguishes between the presence of alkyl pyridines or alkyl anilines in an aqueous sample. Alkyl anilines and pyridines have similar GC and mass spectral characteristics; identification of these compound classes is difficult without prior derivatization.

- 4) Other compounds - it is anticipated that for most SRC-II materials, the analyses described above will account for most organic components extracted into water, unless there is substantial suspended insoluble organic material present. In that case, analytical problems are similar to those discussed on pp. 48-51, and a similar analytical strategy will be employed.

Preliminary Results. Results of acute tests with a potential SRC-II liquid product (a blend composed of 2.9 parts MD to 1 part HD) indicated median lethal concentrations (LC_{50}), determined by probit analysis at the 95% fiducial level, were 2.0 (1.8 to 2.3) ppm TOC for *D. magna*, 8.3 (7.9 to 8.7) ppm TOC for fathead minnows, and 10.0 (4.8 to 20.5) ppm TOC for midge larvae.

An acute test was also conducted with Prudhoe Bay crude oil as a reference toxicant. The stock solution, prepared in the standard manner, as for the SRC-II blend, produced a water-soluble fraction with 19 ppm TOC (compared to the 900 to 1100 ppm TOC produced by the SRC-II blend). The reference oil produced no mortalities in fathead minnows, daphnids or midge larvae at TOC levels producing 100% mortality with the 2.9:1 blend. Therefore, based on TOC, the SRC-II blend appears to be more toxic than Prudhoe Bay crude. The difference in toxicity probably reflects higher concentrations of water-soluble phenolics in SRC-II preparations.

Preliminary chronic studies showed that the first extract of 2.9:1 SRC-II blend inhibited algal growth during exposure to TOC concentrations as low as 6.4 ppm, but did not inhibit algal recovery until TOC concentrations exceeded 57 ppm. *Daphnia* growth was inhibited at TOC concentrations as low as 0.6 ppm, about 25-33% of the acute LC_{50} . Survival and reproductive success of *Daphnia* were reduced at about 1 ppm TOC. Additionally, emergence of midges was delayed at these low concentrations.

Chemical analysis showed that SRC-II aqueous extracts contained a complex mixture of phenols and aromatic and saturated hydrocarbons. Concentrations of total organic carbon, phenols and hydrocarbons decreased with each extraction. Changes in relative concentrations of various compound classes of phenols also occurred with each replacement. These changes in phenols were attributed to differences in the oil-water distribution coefficients as the weights of phenolic molecules increased.

Logarithmic depuration occurred for TOC, total phenols, and phenols of lower molecular weight. Approximately linear depuration was evident for aromatic hydrocarbon classes and phenols of higher molecular weight. Phenolic compounds comprised high percentages of the TOC load of all extractions.

Terrestrial Screening

Plant Growth and Rooting. Small weighing-leaching lysimeters will be used to determine if SRC-II liquids and mineral residues (solid wastes) are deleterious to plant growth when introduced to soil in various amounts. This information is needed for soil decontamination procedures and cleanup following accidental spills in field situations.

The lysimeters are constructed of plastic irrigation pipe, nominally 1 meter long. Lysimeters are placed outdoors so that ambient effects of climate and soil conditions are presented to the growing plants. Water use by growing plants is determined by weighing. Leachates for in vitro biomedical analyses or aquatic screening assays can be obtained through a porous ceramic cup on the bottom of each lysimeter. Plants are grown from seed germination through seedling and vegetative growth, flowering, and seed-ripening stages of development. Experimental materials added to lysimeters are retrievable. Lysimeters can be opened to observe and measure root growth, as well as for customary above-ground observations and quantitative measurements.

Small lysimeters have many of the desirable experimental design features of greenhouse and growth-chamber experiments. Advantages include: 1) minimal quantitative requirements for SRC-II materials; 2) facile recovery of most test material, which allows assay of materials considered to be of high relative toxicity; 3) controls and treatments can be statistically replicated; 4) various concentrations of test materials can be used over a broad range of backgrounds in amounts anticipated from spills; 5) the same experimental soil (or different soils) can be used and replicated; 6) water content of soil can be carefully monitored so plants are never deficient or over-supplied with water; 7) weeds can be controlled; 8) plant harvests can be made and tissues archived or chemically analyzed; 9) seeds can be saved for further tests; and 10) observations for symptoms of chemical toxicity can be made on shoots and roots.

Barley, *Hordeum vulgare*, will be the experimental taxon. Observations and measurements will include: 1) evaluation of standard botanical characteristics: lesions, chlorosis, necrosis, number of flowering culms, length of seed heads, total shoot biomass, etc.; 2) performing standard chemical analyses (protein content of grain, mineral content of shoot tissue); and 3) evaluating biological toxicity (seed germination and in vitro bioassay).

Solids

All waste materials from SRC-II facilities are expected to be in solid or semisolid form and disposed in landfills. Solids of concern include SRC-II gasifier ash, consisting of the gasified residue from vacuum bottoms, and process water incinerator ash. Ecological screening assays for solids are shown in Table 21.

Aquatic Screening

Leachates of solid wastes will be prepared using lysimeters (p. 70) or as described on p. 89, and assayed in the aquatic screening systems described on pp. 64-67. These assays are similar in design and purpose to analyses suggested by RCRA.

Terrestrial Screening

Small weighing-leaching lysimeters, described on p. 70, will be used to screen for potential effects of solid wastes on plant growth and productivity.

ENVIRONMENTAL ASSESSMENT/RISK ANALYSES - PHASE I

Toward the end of Phase I research, it will be possible to define general properties of major products, process streams, and effluents anticipated from the SRC-II demonstration facility. Phase I studies will provide data from short-term screening assays on potential biomedical and ecological effects for a range of test materials within demonstration facility design specifications. Effects data on other materials presently in commerce will also be available for comparative purposes. Phase I studies will identify compounds and compound classes causing biomedical effects in simple systems. Chemistry and environmental fate studies (Phase II) will provide qualitative estimates of chemical entities of potential concern. Little or no information will be available on atmospheric emissions, either in the workplace or the environment around the facility, nor will substantial laboratory or field data on food-chain or hydrological transport of SRC-II materials be available.

Environmental assessment/risk analyses at this stage will therefore be qualitative, and will identify areas where information is needed to lower degree of uncertainty, and allow quantitative analyses of environmental risk. Data needed for environmental assessment/risk analyses of materials specific to the SRC-II process are described below, using several examples. Since analyses for certain criteria pollutants such as SO_x , H_2S , and NO_x are ongoing, specific assessments for effects of these materials will not be performed. However, we will use, relative to these materials, available biological and engineering information in assessment of the SRC-II process.

Phase I analyses consist of short-term screening assays to measure toxicity of major process streams, products, and solid and liquid effluents. Additionally, some chemical analyses on compounds and compound classes of potential biomedical and ecological concern may be available. The following assessment activities will be performed with this information: 1) engineering analyses of potential release situations relevant to occupational and environmental effects of major SRC-II process streams, products, and liquid and solid wastes; and 2) qualitative analyses of biomedical and ecological risk.

The nature of biomedical and ecological assessment can best be illustrated by specific hypothetical examples:

EXAMPLE 1: About percent of the female work force will be exposed to process stream X during facility maintenance operations. Process stream X is teratogenic in rats only at levels approaching those for acute

Table 21. Phase I Ecological Screening Assays: Solid Materials

Material to be Analyzed	Algal Test	Daphnid Test	Detritivore Test	Fish Test	Plant Growth Test
Vacuum Bottoms	A,B	A,B,C	A,B	A,B,C	A,B,C
Ash and Slag					
Waste Water Incinerator Solids	A,B	A,B,C	A,B	A,B,C	A,B,C

A - to be performed on raw materials

B - chemical analyses to be performed

C - to be performed on at least one set of fractions

maternal toxicity. Therefore, existing data suggest minimal hazard to the conceptus of female workers exposed to low doses of stream X. However, to confirm and quantitate this prediction, the following information will be needed:

a) Data on Teratogenic Effects of Process Stream X in Another Species

Teratogenicity of several compounds appears to vary with species. Therefore, acute teratogenicity studies with rabbits exposed to process stream X are planned in FY ____.

b) Data on Developmental Effects of Process Stream X

Presently, there are no data on potential developmental effects occurring as a consequence of in utero exposure. Therefore, possible effects of process stream X on anatomical, physiological, and behavioral maturation of offspring cannot be ruled out. Studies to address this question are scheduled for FY ____.

c) Data on Inhalation Exposure Effects of Process Stream X

Present work on teratogenicity considers only the ingestion route of exposure. We do not anticipate that inhalation exposure would alter rat teratogenicity. For example, we would expect that the relationship between maternal toxicity and fetal effect would be similar for the inhalation route of exposure as compared with ingestion. However, differential absorption of process stream compounds from lung may result in a different teratogenic potential. Thus, work on inhalation teratogenicity of process stream X is planned in FY ____.

EXAMPLE 2: Process stream Y is produced in small quantities in a vessel from which there is little chance of fugitive emission. Process stream Y can easily be cleaned from the vessel and safely disposed of before maintenance. Although the material has been shown to produce significant genotoxicity in submammalian and mammalian cell assays, it does not appear to be of occupational or environmental health concern (based on existing process information). To confirm this assessment, the following information is needed:

a) Final Design Criteria for Composition and Use of Process Stream Y

Our assessment at this stage must be based on process conditions and vessel construction described in Base 0 demonstration facility design. If design considerations result in changes in exposure scenarios, risk may be altered. Phase I demonstration design analyses will be available in FY ____.

b) Information on Inhalation and Dermal Carcinogenicity of Process Stream Y

Carcinogenic potential in animal systems may differ from that derived from the in vitro systems used to date. Data on carcinogenic potential as a function of exposure route will be available in FY ____.

EXAMPLE 3: Relative to crude petroleum, product blend Y shows significant acute toxicity to freshwater biota. Phenolic compounds appear to be primarily responsible. Based on available data, a spill of SRC-II product blend Y may cause severe short-term damage in aquatic habitats, depending on the amount and conditions of the spill. The following information is needed to further quantitate and confirm this prediction:

a) Engineering Estimates of Product Composition for the Demonstration Facility

Analyses of specific phenol types and concentrations are required for the four SRC-II blend options currently being considered. Other options may differ markedly in toxicity to aquatic organisms, due to phenolic composition or physical partitioning characteristics. Decisions on the final product blend are anticipated in FY ____.

b) Information on Biodegradation Rates of Phenols in Water and Sediments

Based on available data, degree of acute risk will be a function of persistence of phenolic residues in aquatic systems. Data on fate of phenolic residues in aquatic systems is anticipated in FY ____.

c) Analyses of Long-Term Fate and Effects of Product Blend Y

Severity or persistence of long-term chronic effects of product blend Y in the environment may not reflect acute toxicity data for single species. Thus, multispecies testing in model ecosystems is planned in FY ____.

EXAMPLE 4: Leachates prepared from gasifier slag X show no genotoxicity in in vitro assays; contain few, if any, toxic trace metals; and have little effect on terrestrial plants and other biota in laboratory studies. Based on available data, disposal of gasifier slag poses no greater risk than disposal of fly ash from coal-fired power plants. The following analyses are needed to confirm and quantitate this prediction:

a) Field Lysimeter Analyses of Gasifier Slag X

Laboratory studies do not usually consider field environmental factors (e.g., climatic processes, soil microbial activity, physical/chemical interactions, heating and cooling cycles, and long-term geochemistry) that may alter biological availability of toxic metals and organics. Studies to address this are planned for FY ____.

b) Confirmation that Gasifier Slag X will be the Primary Solid Waste Generated by the SRC-II Demonstration Facility

Present Base-0 design for gasification of vacuum bottoms requires an F gasifier. However, if a G gasifier (requiring higher heats of gasification over shorter reaction times) is used, the environmental fate and effects of slag might be different. A decision on gasifier type is expected in FY ____.

PHASE II

Phase II biomedical and ecological studies consist of long-term, extensive analyses of effects in animal and ecological systems. These studies are labor-intensive, expensive, time-consuming, and involve long-term utilization of specialized facilities. Therefore, not all materials can be subjected to Phase II analyses, and the following criteria for selecting materials were developed:

- Data base from the Phase I bioassays and chemical analyses suggests potential effect.
- Material is produced in significant quantity.
- Material has potential for occupational/environmental exposure.
- Material can be obtained in form considered representative of demonstration/commercial facility practice.

No one of the above criteria can be considered predominant in selection of materials for Phase II analyses. For example, in certain cases, Phase II analyses may overlap Phase I analyses in time of performance because the material in question has high potential for occupational or environmental exposure. Additionally, since some Phase II studies require methods development, initial Phase II work may employ Phase I materials. In other cases, a material that shows negative results in Phase I assay systems may be produced in large quantities, thus posing significant potential for occupational and environmental exposure. In still other cases, a material produced in limited quantity may demonstrate high biological or ecological activity in Phase I assays and be of concern because limited occupational or environmental exposure may result in significant biological effect.

Phase II assays are considered by the scientific community to be the most indicative of potential biological effect to human populations and the environment. They measure the pathological end-points in animal and ecological systems that are of ultimate concern to human populations (e.g., cancer, neurotoxicity, developmental toxicity, bioconcentration, bioaccumulation, biomagnification, etc.). As such, the data from Phase II assays will be used for a number of essential purposes:

- As a basis for determining dose-effect relationships in assessing biomedical and environmental risk.
- As a basis in determining sources of SRC-II materials needing potential control, regulation or other ameliorative actions.
- In a scientific sense, as a basis for determining the appropriateness of Phase I short-term assays for screening of chemical compounds and compound classes of concern. This is an essential step if results from short-term assays are to be used in analyses of effects of process modification/control technology and definition of specific environmental-monitoring needs.

BIOMEDICAL STUDIES

The present slate of materials and Phase II biomedical assays are shown in Table 22. Test conditions will be similar for those assays (i.e., dermal carcinogenicity, inhalation toxicity, and transplacental carcinogenicity) to be performed by both PNL and P&M. Phase II biomedical assays are discussed below.

Dermal Carcinogenicity

Liquid Process Streams and Products

Studies on liquids consist of applying three dose levels of each material to the shaved dorsal skin of C3Hf/HeBd mice (25 males and 25 females) three times a week for up to 2 years. The highest dose of test material to be used is based on: 1) the maximum concentration of test material in acetone which can be accurately and uniformly applied to the skin, and 2) lack of acute toxicity when the test material is applied at this concentration. Lower doses are 1:10 and 1:100 dilutions of the highest concentration, respectively, in acetone. Positive controls (e.g., benzo[a]pyrene and 2-aminoanthracene) are included. Exposure concentrations for positive controls are based on acute toxicity and carcinogenicity as described in the literature and/or determined in our laboratory.

Animals are observed for appearance of skin alterations such as irritation, papillomas, and tumors. Moribund animals are necropsied and gross pathology determined. Samples of tumors and other tissues, including lung, liver, kidney, spleen, and heart, are taken for histological and pathological examination.

Chemical fractions, derived by solvent extraction (p. 45), are being tested for dermal carcinogenicity by this method. These analyses are essential to correlate Phase I assay results with accepted pathological endpoints. Extent of correlation will determine if Phase I assay data can be used as predictors of specific chemical compounds and compound classes of concern.

Results to date suggest that SRC-II high-boiling-point material (HD) is carcinogenic for mouse skin, whereas low-boiling material (RN) demonstrates little carcinogenicity. A crude petroleum was also found to be carcinogenic for mouse skin, but was less potent than HD.

Solid Process Streams and Wastes

A procedure similar to that followed for liquid samples will be used with solid materials. However, solid materials will be suspended in an appropriate organic or aqueous solvent as determined by analyses described on pp. 51-54.

Inhalation Toxicology

Liquid Process Streams and Products

Inhalation toxicological studies usually include 3-week, 13-week, and life-time exposure periods. Rats and mice will be exposed (whole-body) in PNL chambers. Liquid aerosols will be generated using a Retec nebulizer. Measurements in the chamber will include airflow, aerosol concentration, temperature and humidity, oxygen concentration, and particle size. Several methods may be used to monitor chamber concentration, including nonspecific spectrophotometric methods, total hydrocarbon analyses and GC analyses for compounds of specific concern as determined in Phase I analyses.

Test animals will be young adult Fischer 344 rats and C3H mice. For 3-week studies, animals will be exposed in groups (10 males and 10 females) to one of three concentrations of test material. The exposure regime is 6 hours/day, 5 days/week for the 3 weeks. Animals are weighed prior to, and weekly during exposure, and until 4 weeks after exposure. Animals are observed for mortality, clinical signs of distress and behavioral changes.

Thirteen-week studies will be performed essentially according to Good Laboratory Practices as suggested by the U. S. Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA). Exposure regime is the same as described for the 3-week exposure (i.e., 6 hours/day, 5 days/week). However, sample sizes will be increased to 35 animals/sex/dose. Exposure dose will be selected on the basis of data obtained in 3-week studies. Highest dose will be that which causes no mortality and no more than 10% weight loss in the 3-week study. Lower doses will be 4:1 and 16:1 dilutions of the highest dose.

Animals will be observed as described for the 3-week exposure. Additionally, hematological and blood chemistry measures will be performed at 0, 45, and 90 days exposure. Some animals will be sacrificed at termination of exposure; others will be maintained for 2 months postexposure. At sacrifice, animals will be observed for gross pathological changes, and selected tissues will be saved for histopathological analyses.

Life-time exposures will closely follow the protocol for 13-week exposures; however, sample sizes will be increased to permit appropriate statistical evaluation.

Efforts to date have developed methods for generating aerosols of heavy coal liquids and for whole-body exposure of animals to these liquids. Factors such as aerosol particle size, concentration, and fractionation of chemical constituents as a function of particle size have been measured.

Solid Process Streams and Wastes

Analyses will be performed as described above. However, aerosols will be generated using either a Trost feed-Wright dust mill or a new brush-feed generation system recently developed at PNL.

TABLE 22. Phase II In Vivo Assays

Material to be Analyzed	Dermal Carcinogenicity	Inhalation Toxicity	Dominant Lethality	Developmental Toxicity	Transplacental Carcinogenicity	Neurobehavioral Toxicity
Raw Naphtha	A	B	B	A	B	C,D
Middle Distillate	B	B	B	A	B	C,D
Heavy Distillate	A,D	C	A,D	A,D	C	C
Liquid Products	E	E	C,D	C,D	E	C
Coal Slurry	E	C	C	C	E	C
Vacuum Bottoms	E	B	C	C	B	B
Stripper Tower Bottoms	B	B	D	B	B	B
Gasifier Slag	D	C	C,D	C,D	B	C

A = performed and data available

B = not to be determined

C = to be performed, PNL

D = fractions or extracts to be assayed, PNL

E = to be performed, P&M

Dominant Lethality

The dominant lethal test, using Swiss-Webster mice, permits estimates of the incidence of a specific mutation type (namely, lethality) in a mammalian species. Male animals are administered solid or liquid test materials, either orally or by inhalation (methods described on pp. 57-59 and 78), then bred to unexposed females. Lethal mutations are expressed as death of the embryo. The stage of spermatogenesis affected can be determined by the time post-exposure when an increase in embryo lethality is found. That is, effects on mature sperm would be observed 1 to 2 weeks postexposure. Effects on sperm in earlier stages of spermatogenesis would not be observed until 3 to 8 weeks postexposure. Since the dominant lethal test is more time-consuming and expensive than in vitro mutagenesis systems, it will be used only on a limited set of materials. Material selection for dominant lethal testing will depend on data obtained from microbial and mammalian cell culture systems and other previously discussed criteria. Preliminary results from this assay system indicate that SRC-II HD and its basic fraction induce a low level of dominant lethality in mice.

Transplacental Carcinogenesis

Exposure of a pregnant female to a carcinogenic agent can result in increased tumor incidence in offspring during later life. Studies will be performed to evaluate potential transplacental carcinogenicity of SRC-II materials. Materials will be administered to the pregnant female either throughout gestation or at selected sensitive periods of fetal development (as determined by teratogenesis studies pp. 59-60), and the animal allowed to deliver. The dam and her offspring will be maintained for lifetime observation to evaluate tumor development. Materials will be administered to mice, either orally or by inhalation, as described previously. Materials will be selected based on Phase I results and results of dermal carcinogenesis (p. 76) and developmental toxicology studies (p. 79-81).

Developmental Toxicology

Postnatal consequences of prenatal exposure to SRC-II materials will be evaluated from the following: a) postnatal appearance of a standard set of anatomical markers, b) neonatal appearance of neuromuscular and neurobehavioral capabilities and c) analyses of humoral and cellular elements of the immune system.

Materials will be administered to animals by ingestion or inhalation, as described previously. Dose will be selected based on results of repeated-dose and teratogenesis studies (pp. 59-60). Teratogenicity after inhalation exposure will be evaluated as part of this effort, using protocols similar to those described for 3-week inhalation studies (p. 78) and Phase I teratogenicity studies.

Anatomic and functional measures of postnatal maturation will be evaluated (Table 23). At 40 and 60 days of age, immune system measures will be evaluated. These include determination of serum immunoglobulin levels to indicate effects on humoral system response and response to mitogens, a measure of cell-mediated immunity.

TABLE 23. Anatomic and Functional Measures of Postnatal Maturation

Test Measures	Observation Days (Age)				
	1	7	14	21	35
Body Weight	X ^(a)	X	X	X	X
Teeth Erupt		X			
Ear Unfold		X			
Eye Open			X		
Ear Upright			X		
Movement	X	X	X	X	
Headlift	X	X	X	X	
Gait			X	X	
Turnover	X	X			
Grasp	X	X			
Retraction	X	X			
Vibrissal Placing		X	X		
Cliff Avoidance		X	X	X	
Negative Geotropism		X	X	X	
Righting		X	X	X	
Swimming		X	X	X	
Visual Placing			X	X	
Strength				X	
Audiogenic Seizure					X
Organ Weight					X

(a) Indicates time at which test is performed.

Cell-mediated immunity (specifically, cell-mediated cytotoxicity) is generally thought to be mediated by three types of effector cells: a) specifically immune, mature T-cells; b) antibody-dependent, cytotoxic cells; and c) activated macrophages.

Peripheral blood lymphocytes and cells isolated from spleen, mesenteric lymph nodes, and thymus will be used in the mitogen-induced lymphocyte activation assays. Mitogens used in our assays include concanavalin-A (Con-A) and phytohemagglutinin, which stimulate T-cell populations, and pokeweed mitogen, which is primarily specific for B-cells but which also stimulates a small fraction of the T-Cell population. Tubes containing diluted whole blood or tissue lymphocytes, plus the appropriate mitogen, will be incubated for 3 days at 37°C. Cell activation will be measured by assessing incorporation of ¹²⁵I-iododeoxyuridine into newly synthesized DNA during the final 20 hours of the culture period.

Preliminary evidence suggests that rats treated prenatally with HD have deficits in air-righting and swimming capabilities at early postnatal times. Cell-mediated immunity, as measured by Con-A stimulation of peripheral blood lymphocytes was not greatly affected by any of the SRC-II materials tested (RN, MD, and HD). However, animals treated with a polychlorinated biphenyl mixture (Aroclor 1254) showed significant depression in response.

Neurobehavioral Toxicology

Based on criteria discussed previously and results from acute toxicity studies (pp. 57-59), especially clinical signs of neurotoxicity, and developmental toxicology studies, SRC-II materials will be selected for analyses of neurobehavioral toxicity. Since initiation of these assays is dependent on results from acute tests of inhaled and ingested SRC-II materials, we will describe only briefly tests to be used.

Conditioned Taste Aversion

Rats are given test substance in drinking water or food, along with access to saccharin water (usually preferred to ordinary water). The animal is then tested as to preference for saccharin water vs water. Avoidance of saccharin water indicates an association of the saccharin with the test material administered.

Conditioned Avoidance Behavior

Animals are exposed to a test material, then tested for their ability to learn to avoid electric shock in a shuttle box. Loss of this learned ability is then measured as a function of time.

Learning and Memory

Number of trials to consistently run a maze in a fixed time is a function of learning response. Changes in response after the learning experience, a function of memory, will be measured in animals exposed to SRC-II materials, and compared with that in controls.

Open Field Activity

Animals are placed in the center of a gridded box. Number of squares traversed in 1 minute is indicative of the animal's level of exploratory behavior. Exploratory behavior in animals exposed to SRC-II materials will be compared with that in controls.

Physical Endurance

Endurance of animals exposed to SRC-II materials will be evaluated in a standard National Institute of Environmental Health and Safety (NIEHS) swimming test and compared with controls.

Research Needs

We have described, to this point, state-of-the-art analyses which will be performed to determine potential biomedical effects of materials from the SRC-II process. However, several study areas which require intensive research are not incorporated as cost or work elements of the program since they involve development of new methods. To provide a full information base for biomedical assessment and environmental management of the SRC-II process, appropriate efforts in the following areas should be initiated:

Dosimetry

Unlike radionuclides, the biological disposition or dosimetry of organic chemicals is not well known. This is true even for most pure compounds; when complex mixtures are considered, the data base is almost nonexistent. To relate biological effects to causative agents, information is needed on absorption, tissue distribution and excretion of important compounds, particularly PNAs, PAAs and N-heterocycles. Moreover, assessment of potential effects of human exposure to SRC-II materials will necessarily be extrapolated from data on experimental animals. The extrapolation, and comparison of biological effects of SRC-II materials with materials derived from other coal conversion processes, requires extensive knowledge of pharmacokinetics, distribution and metabolism of important SRC constituents.

Factors Affecting Dermal Carcinogenicity

Dermal exposure to SRC-II materials will be a primary route of exposure for occupational populations. We have described laboratory evidence that high-boiling-point SRC-II materials are skin carcinogens in mice. Epidemiological evidence from a number of sources suggests that coal-derived materials may also be skin carcinogens in man. Therefore, it may be necessary to examine several factors that might affect the carcinogenic process. For example:

Dose Fractionation. Current experimental evidence for carcinogenicity is based on continuous HD application to mice for a prolonged period. Since this is not representative of potential human exposure situations, information is required on effects of doses administered singly, staggered over varying time frames, and on doses mixed from various process streams.

Removal of Dose from Skin. A common industrial hygiene practice in coal facilities is to wash off skin contamination with detergent and water. The efficacy of these procedures has not been fully established. Alternate washing/solvent regimes should be analyzed for their effectiveness in ameliorating dermal carcinogenicity.

Ultraviolet Light Exposure. Skin contamination is presently monitored at coal facilities by ultraviolet (UV) light examination. Furthermore, workers at coal conversion facilities will be exposed both to skin contamination and UV light from other sources. Effects of UV monitoring procedures and/or UV light originating from other sources on response of skin to coal-derived materials have not been examined carefully.

Preventative Treatment. Several materials (e.g., retinoids, beta-naphthoflavone) inhibit skin carcinogenicity from pure chemicals. Their effectiveness for inhibiting skin carcinogenicity from coal liquids should be examined.

Cardiovascular Effects

Although a number of test systems are available for measuring carcinogenic/mutagenic potential of chemical and physical agents, few reliable animal models are available for determining exposure effects on the cardiovascular system. Limited epidemiological data suggest that, in humans, organic materials may cause cardiovascular effects. Cardiovascular disease is the primary cause of death in the United States.

Degenerative Diseases

Preliminary evidence suggests that exposure to organic compounds may be associated with arthritic and other degenerative diseases involving changes in connective tissue. Currently, there are no appropriate models to study such changes.

Pulmonary Physiology

Present methods for measuring pulmonary physiological variables in small animals are expensive, insensitive and lack reproducibility. Since a number of pathological conditions in humans involve altered pulmonary function (e.g., emphysema, silicosis, and other fibrotic diseases), and since inhalation is potentially a major pathway for exposure to SRC-II materials, better methods for determining pulmonary function in small-animal systems may be required.

INDUSTRIAL HYGIENE - PHASES II-IV

Phase II biomedical studies, coupled with those in Phase I, will define biomedical risk for SRC-II materials in a demonstration/commercial facility operating under steady-state conditions. Accompanying chemical analyses may permit definition of compounds and compound classes of biomedical concern. Phase III studies that examine effects of altered plant operations on potential biomedical properties of SRC-II materials may aid in defining risk to workers when SRC-II facilities require maintenance or operate in upset or altered conditions. Qualitative and quantitative changes in compounds and

compound classes of biomedical concern may be defined. Phase IV research will seek to develop chemical and medical methods to monitor the site and personnel and to advise and/or lessen exposure risks.

Data and methods developed in biomedical and chemical studies may allow further development of: 1) specific workplace monitoring procedures as a function of work zone within a demonstration/commercial facility operating under defined conditions, 2) definition of interim threshold limit values for compounds of concern and methods for determining workplace exposure to such compounds, and 3) clinical and epidemiological analyses relevant to the work force.

ECOLOGICAL STUDIES

Biological Fate In The Aquatic Environment

The biological fate of SRC-II liquid materials in freshwater systems will depend on a) physical and chemical properties of material entering the environment, b) quantity of material, c) physical and chemical features of the environment, d) food web (predator-type) relationships of organisms present, and e) metabolic pathways of organisms. The relative importance of each factor varies with the environment, the particular SRC-II liquid material, and the organism.

For example, fish may accumulate carbazoles or quinolines directly from the water column. However, if these compounds accumulate in sediments and are transferred to sediment-burrowing organisms that are in turn consumed by fish, food (rather than the water column) may be the more important exposure pathway. This is a distinct possibility for complex organic compounds of SRC-II origin.

Interactions of metals in SRC-II materials with biological systems are dependent on the metal form, concentration and reactive state. For example, only small fractions of most metals in water (those bound to organic ligands) are biologically available. It is not known how variable these fractions may be, or how other factors in the water column may modify bioavailability. However, when one organism eats another, the ligand-bound materials in the prey are usually more readily absorbed than non-ligand-bound materials.

Phase II ecological studies will include analyses of bioconcentration, bioaccumulation, and biomagnification processes. Ultimately, results of such research will be used to rank bioconcentration/bioaccumulation potential of several SRC-II compounds considered or determined to be of ecological or biomedical concern. Uptake and depuration constants may also be used in evaluating environmental fate through use of compartmental models.

Bioconcentration refers to the process by which chemicals enter aquatic organisms, directly from water, through the gills or epithelial tissue. Bioaccumulation includes bioconcentration and uptake of chemical materials from food sources. Biomagnification refers to the process by which tissue concentrations of bioaccumulated materials increase as they pass up food chains through two or more trophic levels. SRC-II materials to be used in studies of biological fate are shown in Table 24.

TABLE 24. Phase II Biological Fate Studies: Liquid and Solid Materials

Material to be Analyzed	Bioconcentration	Bioaccumulation/ Biomagnification
SRC-II Liquid Product	A,B,C	A,B,C
Hydrodesulfurized Naphtha	A,B	A,B
Process Water	A,B,C	A,B,C
Treated Process Water	A,B,C	A,B,C
Vacuum Bottoms Ash and Slag	A,B	A,B
Waste Water Incinerator Solids	A,B	A,B

A - to be performed on raw materials

B - chemical analyses to be performed

C - to be performed on at least one set of fractions

Bioconcentration

Potential bioconcentration of SRC-II liquid materials will be measured in flow-through systems employing test organisms representing several trophic levels. Water and sediments will be treated, in separate experiments, as potential sources of contamination. Exposures with unfractionated or partially fractionated SRC-II products will be performed to validate information on specific compound classes, particularly where they represent dominant components of an SRC-II material or are known (e.g., PNAs) or suspected (e.g., PAAs) carcinogenic agents. Phase I biomedical analyses and those to be performed in Phase II will aid selection of specific chemical entities of concern. Range of test concentrations will be based on chronic toxicity data obtained from studies described on pp. 66-67. Emphasis will be on persistent organic constituents of SRC-II materials (pp. 89-93). Pertinent trace metals will also be examined with respect to speciation, complexation with organic ligands, and relationships to bioconcentration phenomena. Test procedures will be modeled after proposed American Society for Testing and Materials (ASTM) guidelines addressing bioconcentration of "simple" compounds from water. Modifications of these procedures may be necessary, because major source terms (sediment, interstitial water, and water column) will have to be partitioned with respect

to oil, water and solid phases. The octanol:water partition coefficient has been successfully used to predict partitioning among phases of simple compounds. It may be possible to apply these methods to SRC-II materials. Corrections for interstitial water can be made using a suitable measurement for the distribution constant, K_d .

Daphnids, midge larvae, oligochaetes, freshwater clams and fish (fathead minnow, rainbow trout, channel catfish) will be organisms of primary interest. Uptake from constant exposure concentrations, and depuration (washout following removal to clean water or sediments) will be followed for up to 28 days. Rate constants for uptake and depuration for organs and whole body will be measured. Bioconcentration factors will also be calculated. Mechanisms of uptake, i.e., surface adsorption, gut loading, or lipid soluble absorption, will be identified.

Bioaccumulation/Biomagnification

Potential bioaccumulation/biomagnification will be evaluated using a simple aquatic food chain consisting of a food organism (daphnid or midge larvae) and consumer organism (fathead minnow, rainbow trout, or channel catfish). Potential bioaccumulation will be followed for up to 28 days in a flow-through system. Depuration will also be monitored. Distinction will be made between fish receiving SRC loading from the water column, and fish receiving loading from SRC-contaminated food. Particular attention will be focused on the potential for increased residue accumulation in fish (biomagnification) compared to forage species. Rate constants for uptake and depuration for organs and whole body will be measured. Mechanisms of uptake will be identified.

Water. Required chemical information will be similar to that needed for Phase I aquatic screening assays. The main difference will be the much lower concentrations of SRC materials in chronic exposure systems. This will require introduction of new techniques to enhance sensitivity for component types or to concentrate materials from very large water samples. Sample concentration techniques will involve use of XAD resin adsorption, and other solid adsorbents, including ion exchange resins. Techniques used may be based on results of studies described on pp. 37-57. Enhancement of detection sensitivity for certain components, such as phenols and primary amines, can be accomplished using derivatives such as halogenated acetates, which are extremely sensitive to electron capture gas chromatographic detectors. An alternative analysis for trace amines and phenols will be explored. The method involves selective derivatization of these compounds with fluorescent derivatives, and separation and quantitation using high-speed liquid chromatographic separations. Special gas chromatographic detectors for sulfur and nitrogen components (pp. 49-50) will also be used to enhance detection of these compounds in chronic exposure systems.

Sediments. Methods for sediment analysis will involve many of the analytical techniques described on pp. 48-51. However, problems specifically relating to sediment material must be addressed. Solvent extractions of sediments vary, depending on whether the sediment is extracted wet or dry. Although extraction of freeze-dried material is most satisfactory, the drying process can result in significant losses of volatile material. Extraction of

wet sediment can result in losses of material due to incomplete extraction. Use of polar solvents such as methanol can hinder recovery of polar components in an analyzable form.

Analysis of sediments in chronic systems, together with associated water chemistry, will provide information concerning the availability of hydrocarbons, phenols, amines and other important SRC-II components to test organisms. The approach will also provide data on the rate at which component concentrations are altered, by chemical and/or microbial action, or physical processes such as solubilization or adsorption. Investigations of changes in composition will be closely integrated with environmental chemistry studies on sorption, photo-oxidation, solubility, and microbiology of SRC in sediment systems (pp. 89-93).

Tissues. Tissue analyses will initially emphasize phenols, N-heterocycles and aromatic amines. Where possible, radiolabeled compounds will be used as markers for tissue distribution in bioconcentration and bioaccumulation studies. However, availability of potentially useful, labeled compounds is limited and may require custom synthesis. Accordingly, significant analytical development may be required to perform the proposed studies. Because these efforts are generic requirements, they are not a cost element of this plan.

Numerous methods have been developed for analyzing SRC-II components in environmental samples and may be adaptable to tissue analysis. SRC-II phenols in aqueous samples have been analyzed by acetylation followed by GC analysis. Applicability of the method for tissue analysis is being explored. Alternatively, liquid chromatography with electrochemical detection is effective for phenolic compounds in various matrices and will also be attempted for tissue analyses of SRC-II phenols. Liquid chromatography with electrochemical detection may also prove useful for some types of N-containing compounds. A procedure to detect anilines in aqueous samples by GC, following acetylation, is being developed and shows promise for tissue analysis. Similar approaches for other N-containing compounds are being explored.

Biological Fate In The Terrestrial Environment

There are a number of possible routes for SRC-II materials to enter the terrestrial environment. Research appropriate for determining biological fate in cases of terrestrial spills is addressed on pp. 89-93, and 109-117, as is research addressing planned disposal of solid wastes. One of the more important routes of entry for SRC-II materials in the terrestrial food chain may be via atmospheric emissions onto leaf surfaces.

Atmospheric emissions anticipated from the commercial SRC-II process are presently not well-defined and research priorities cannot be established. Major direct particulate emissions are expected only from coal crushing and cooling-tower drift. Indirect particulate emissions would arise primarily from resuspension of cooled vacuum bottoms (stored, perhaps, during upset), gasifier bottoms, and resuspension of solid wastes dispersed to the ground. Potential gaseous releases during routine operations may arise during coal

drying, acid gas removal, liquid product storage, cooling-tower drift, gasification, flaring, or water treatment. Methanation processes or flue gases may also be sources. Fugitive emissions may arise from process stream leaks, high-pressure steam, heating-fluid releases, or failure of the acid gas-removal process. Materials to be analyzed relative to aerosol effects on plants include SRC-II gasifier bottoms, process water, incinerator solids, liquid product, and volatile components sorbed to atmospheric particulate matter.

Uptake of SRC-II materials intercepted by plant canopies will be determined in the laboratory. The Wright dust mill and air sampling devices will be used to generate and quantify size and concentrations of airborne particles. Canopies will be exposed under controlled conditions of temperature and moisture, using aerodynamically designed exposure systems. Test species will be determined from field surveys at the demonstration site.

For SRC-II materials having highly water-soluble components, as determined by studies described on pp. 89-93, transfer of specific inorganic and organic components from foliage to seeds and phenotypic toxicity effects (dry-matter production and seed yield) will be determined. Additionally, based on ecological, biomedical and chemical analyses described on pp. 63-72 and 76-82, specific SRC-II components or fractions may be evaluated in higher plant systems for effects on seed viability and mutagenicity.

Multispecies Testing In Aquatic Systems

A major concern not addressed in Phase I is the potential for ecosystem damage. Results of Phase I studies and extant literature are being used to design a method to measure ecosystem effects. Initially, we will use artificial streams to study the interactions between SRC-II liquid products and water, sediment and organisms. Organisms will include a primary producer, benthic detritivore, and fish. This system will allow evaluation of partitioning and transport of released material into water, sediment and organisms (bioaccumulation) and measurement of effects on long-term survival, growth, feeding and population response under more natural conditions than in the laboratory. Results of these studies will be used to develop an on-site, ecosystems study using representative SRC-II materials.

Laboratory Studies On Revegetation Of Solid Wastes

Background information obtained on physicochemical properties of solid wastes will be used to recommend plants appropriate to the soil (rooting substrates) and climate of the demonstration site. Measurement of plant response to inorganic and organic components in solid wastes will be an integral part of the program. Efforts will involve: a) selecting plant species and determining effects of solid waste leachates on plant growth, water, and ion fluxes; b) determining potential for plant uptake, accumulation and detoxification of organic residuals and trace metals in solid waste leachates; c) identifying native plant and genetically improved species best suited for revegetation of land disposal sites; and d) recommending preferred waste treatment or disposal scenarios for site revegetation.

Preliminary toxicity tests will be conducted in growth chambers. The range of conditions and remedial treatments for plant growth that minimizes pollutant uptake will be studied in the greenhouse. Treatments will include various leachates (rain, surface, ground, and irrigation waters), pH control, fertilization, and soil conditioners (e.g., sludge from biodigesters). Toxic effects on plants and acceptable threshold application rates with time will be evaluated.

Chemical And Microbiological Fate In Sediment And Soil Systems

Nonoccupational health effects associated with SRC-II operation will be determined by environmental factors which govern form, transport, and persistence of SRC-II products and wastes, and which mediate exposure to man. Research will emphasize the fate of spilled SRC-II products and disposed solid wastes and will focus on water-soluble, persistent materials with greatest potential for mobility and incorporation into water and food supplies.

Chemical Characterization of Water-Soluble Species

Initially, aqueous equilibrations of SRC-II liquid product and solid wastes will be subjected to chemical analysis (Table 25) and fractionation (Figure 7). For organic compounds, methods described on pp. 44-51 for separation and analysis will be employed where applicable. However, for trace analysis of some important organic compounds in environmental samples of soils, water, and soil leachates, methods specially adapted to extraction, concentration, and specific detection may be required. Three in vitro sub-mammalian assays will be employed (pp. 39-42) to define effects of trace metals and organic compounds. This information, in conjunction with solubility and knowledge of the biological properties of specific chemical species, will be used to limit and focus subsequent chemical analyses and investigations.

Aqueous equilibrations of SRC-II liquid products will be repeated at different temperatures and with acidic and basic waters of adjusted ionic strength to simulate different surface-water types. Several standardized conditions of temperature, pH, and ionic strength will be selected to evaluate solubility and provide solutions for use in microbiological and sediment interaction experiments.

For solid wastes, initial efforts will include aqueous equilibration of ungasified and gasified mineral residue, fractionation, and in vitro testing. Aqueous equilibrates of residue will be prepared in batch systems under different conditions of temperature and pH. Results from these experiments will be used to design column experiments and to modify analytical protocols, if necessary. Aqueous equilibrates of solid wastes may be significantly lower in organic material than liquid product equilibrates and may require a more refined analytical protocol. Aqueous equilibrates will be employed in microbial and soil/sediment interaction studies.

Soil and Sediment Interaction

Laboratory studies will emphasize the interaction of aqueous equilibrates of SRC-II products and solid wastes with soil materials, isolated suspended

TABLE 25. Analyses of Solid and Liquid Phases

<u>Solid Phase Analysis</u>	<u>Frequency</u>
Mineralogy (crystalline minerals, oxidic Fe, Mg, Al)	A
Particle size distribution	A
Surface area	A
Cation/anion exchange capacity	A
Organic C	A
Total M, S	A
Total major elements (Na, K, Ca, Mg, Si, Ti, Mn, Fe, Al, Cl, S)	A
Total trace elements (Li, Be, Sr, Ba, La, Zr, V, Cr, Mo, W, Co, Ni, Cu, Ag, Zn, Cd, Hg, B, Tl, Sn, Pb, P, As, Sb, Bi, Se, F, Br, I, Nd, Th, U)	A
Total radioactivity (alpha, beta)	M
Organic materials	A
<u>Liquid Phase Analysis</u>	
Total solids	A
Organic C	A
Total C, N, S	A
Conductivity	A
Major cations (Na, K, Ca, Mg)	A
Major anions (SO_4^{2-} , Cl^- , HCO_3^- , CO_3^{2-})	A
Minor anions (NO_3^- , NO_2^- , reduced S species, Br^- , F^- , PO_4^{3-})	M
Total minor elements (Ti, Mn, Fe, Al, Li, Be, Sr, Ba, La, Zr, V, Cr, Mo, W, Co, Ni, Cu, Ag, Zn, Cd, Hg, B, Tl, Sn, Pb, P, As, Sb, Bi, Se, I, Nd, Th, U)	M
Trace metal speciation: organometal complexes	M
Organic fractions	M
Organic compounds (organic acids and phenols, basic N compounds and aromatic hydrocarbons)	M
Total Radioactivity (alpha, beta)	M

A = planned for each SRC-II material under study

M = as preliminary studies warrant

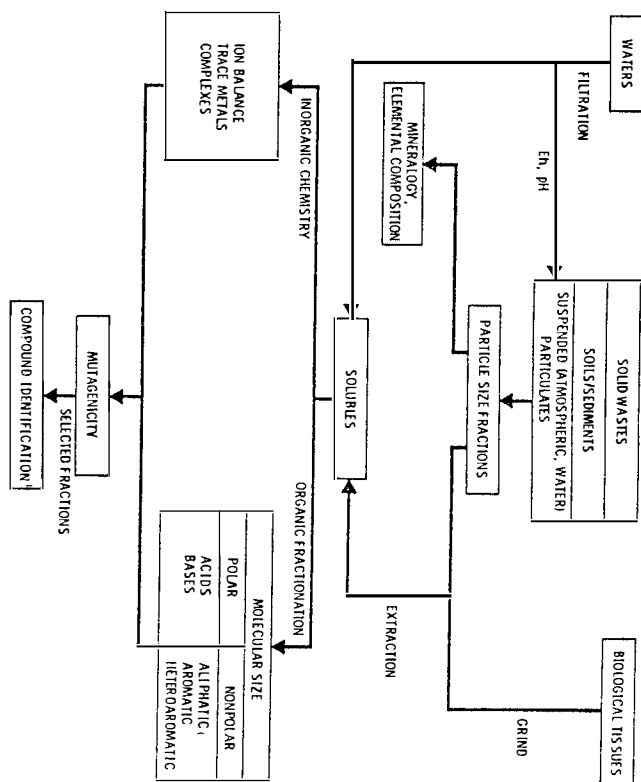


Figure 7. General physicochemical fractionation scheme for waters, solids, and biological tissues from environmental and laboratory studies. The application of common fractionation and analytical methods with emphasis on solubles allows identification of mobile, biologically available compounds, intercomparability of diverse environments, and integration of research.

sediments and bottom sediments. These studies will identify effects of specific sorption reactions, ion or induced ion exchange reactions, solid induced fractionation reactions and microbial degradation on mobility, persistence, and toxicity of water-soluble, biologically active materials from liquid product and solid wastes. Results of these experiments will have applicability to the environmental fate and effects of biologically active compounds released under different scenarios from product spills and solid waste disposal.

Experiments will be designed to differentiate physicochemical from microbiological processes. Interaction studies will be performed in parallel under sterile and nonsterile conditions using batch (suspended matter, sediments and soils) and column (soils) systems. The organic fractionation scheme will then be applied to all solutions generated to insure an integrated analytical approach. An inorganic analytical protocol will also be applied to determine pH, Eh, major and trace elements, and anion/cation balance of solutions, and to ascertain prominent mineralogical controls on solution composition. This information is needed to accurately evaluate the chemical and microbiological mechanisms affecting sorption and persistence of the dissolved organic fraction. Use of parallel experiments should enable definition of key physicochemical and microbiological factors governing fate and persistence of specific organic compound classes or fractions identified during chemical characterization.

Soils and sediments will be selected to insure broad applicability to different geographic regions. Selection requires an understanding of prominent physicochemical mechanisms affecting sorption and retention of trace metals and organic compounds by soils and sediments. These mechanisms include cation exchange, electrostatic retention of polar compounds, lipophilic interactions with soil organic material, specific adsorption and, to a lesser extent, anion exchange. The soil and sediment characteristics most influential in regulating these mechanisms include: a) pH-Eh, b) oxide-hydroxide content, c) clay mineral composition and content, d) bulk parent material mineralogy, e) soil texture, f) composition and quantity of organic materials, and g) basic translocational or soil genetic processes. Several individual soils and sediments exhibiting some of the prominent chemical characteristics listed above will be chosen for use from the PNL inventory of national soils.

Three sets of soil materials (calcareous, acidic, and oxidic), and river sediments which range in pH and exhibit differing prominent physicochemical characteristics, will be subjected to detailed physical and chemical analysis. Aqueous extracts of sterile and nonsterile soils and sediments will undergo organic and inorganic analyses to define background concentrations of specific organic compounds considered biologically active and to identify the appropriate organic chemical regime for compounds of concern.

Soil studies will be conducted with batch and column systems. Batch studies will initially be performed at ambient temperature with aqueous SRC-II product extracts, or solid waste leachates, and one level of organic carbon. Aliquots will be removed, with time, for analysis. Additional extractions will be performed, if necessary, using multiple levels of organic carbon to determine adsorption isotherms, and varying temperatures to identify kinetic restraints on biological growth and adsorption. Column studies will employ a soil perfusion system where soil moisture and aeration can be controlled. Columns will be perfused with SRC aqueous extracts containing various levels

of organic carbon. Perfusates from this system and aliquots from batch systems will be examined for Eh, pH, major and trace elements, and dissolved organic carbon, and subjected to in vitro assays, followed by organic fractionation and additional in vitro assays.

Sediment studies will be conducted in batch systems which will be continuously monitored for Eh, pH, and evolved CO₂. A constant solid-to-liquid ratio (1:10) will be used. Sterile and nonsterile batch systems will contain aqueous extracts of SRC-II liquid products at various organic carbon-loading rates. Samples will be removed, with time, and characterized using the standard organic and inorganic protocol (pp. 48-51).

Specific adsorption isotherms will be calculated when necessary and sorption reactions will be tentatively identified. Additionally, effects of microbial activity on chemistry and biological activity of specific compound classes showing effects in in vitro tests will be determined.

Microbial Processes

Microbial activity is an important factor affecting persistence of organic components in the environment. The effect of microbial communities on environmental fate of water-soluble organic materials from SRC-II liquid products and solid wastes will be examined. Laboratory studies will include the batch and column systems previously described, and will be followed by field lysimeter and other field verification studies (pp. 112-117). Microbial studies will be closely integrated with chemical and soil-sediment experiments and will emphasize compounds showing biomedical or ecological effects.

Studies will include: a) measurement of microbial communities, over time, in systems containing solid waste, solid waste and soil, or SRC-II liquid products with soil or sediments; b) determination of the effects of various growth factors (nutrients, pH, Eh, and temperature) on type and duration of microbial activity; c) measurement of the rate and extent of microbial decomposition of total residual and water-soluble organic carbon as a function of growth at different organic carbon-loading rates; d) elucidation of pertinent segments of microbial degradative pathways for individual compounds showing biological activity; and e) determination of the relationship between microbial degradation of organic materials and trace metal complexation/mobility.

Column and batch equilibrium studies, using systems developed at PNL, will differentiate among major physicochemical factors influencing rate and course of microbial metabolism. The protocol also allows for determination of changes in metabolic pathways due to microbial succession and accumulation or removal of metabolites. Degradation of organics will be measured by monitoring total CO₂ and ¹⁴CO₂ evolution in model compound studies. Analytical methods used for chemical characterization in companion studies will examine degradation and accumulation of specific organic compounds showing biological activity. Rate and extent of degradation will be examined in conjunction with soil and sediment studies to provide input to chemical and transport models.

ENVIRONMENTAL ASSESSMENT/RISK ANALYSES - PHASE II

During Phase II research, design of the demonstration facility should be finalized and construction initiated. All process and product streams, planned liquid and solid emissions, and treatment and disposal methods should be defined. Design analyses relevant to major sources of atmospheric emissions should also be available.

Toward the end of Phase II, biomedical data should provide information on chronic effects of SRC-II materials administered to animals via inhalation and dermal exposure routes. Information may be available on the molecular form of potential releases and/or transformation products that approximate chemical entities of biomedical concern.

Some degree of quantitative environmental assessment/risk analyses will be possible for occupationally and environmentally exposed human populations. However, uncertainties may be great, and will be difficult to define due to the nature of source-term data, the difficulty of extrapolating effects on animals to man without information on comparative pathological mechanisms and dose effects, and uncertainties concerning the shape of dose-effect curves (e.g., threshold vs no threshold).

Ecological data will include information on chronic effects of SRC-II materials on selected aquatic and terrestrial biota, tested singly and in more-complex model ecosystems. Data on fate of solid-waste residues in field lysimeters, information on chemical entities of concern in an aquatic spill situation and data from ecological and chemical monitoring studies at the SRC-II demonstration facility should also be available. These data will span the preconstruction and construction phases of facility development.

Although ability to predict ecological effects and potential problems involving fate of SRC-II materials in the environment will improve in Phase II assessment, meaningful quantitation may still be lacking. Methods for measuring specific chemical materials of known biomedical and ecological effects will still be developmental. Therefore, it is doubtful that many materials of concern will have been measured. Although assessment of biomedical and ecological effects resulting from exposure to SRC-II materials through food chains will attempt to establish magnitude, results of the process will remain highly uncertain.

Environmental Pathways Modeling

The complexity of dose assessment modeling is illustrated in Figure 8. Three major submodels are shown, each requiring development and adaptation to SRC-II compounds of interest. Phase I assessment will review and advise on the design of needed ecological, biomedical, and chemical research to ensure mutual data compatibility with modeling parameters. Boxes in Figure 8 represent environmental components and arrows represent processes affecting components. We will estimate, under defined circumstances, how selected materials are released and partitioned in the environment.

Atmospheric Modeling

Available models for predicting dispersal and deposition of airborne pollutants will be analyzed. We will review available site-specific data required to calibrate air quality models (AQM) applicable to the SRC-II process. The need for further model development and data collection will be determined. The most appropriate AQMs and data bases will be used to estimate atmospheric transport and assess health impacts from airborne emissions of the Ft. Martin, West Virginia SRC-II facility. These models will consider as variables: source term emissions; atmospheric transport via winds; diffusion through thermal and mechanical forces; transformation via photochemistry and reaction with atmospheric gases; and removal processes.

Meteorological data for AQMs can be obtained relatively easily. Given the wide range of organic and inorganic materials which may be released into the atmosphere by a large SRC-II facility, modeling efforts will concentrate on compound types that are: 1) identified through biomedical and/or ecological studies, or 2) presently mandated through existing legislation as being of potential concern. It is noteworthy that the area near the Ft. Martin demonstration facility has long been a site of mining activity and coal-fired electric power generation. Therefore, high backgrounds of coal-based pollutants may already exist, and it is important to develop a data base to define this background.

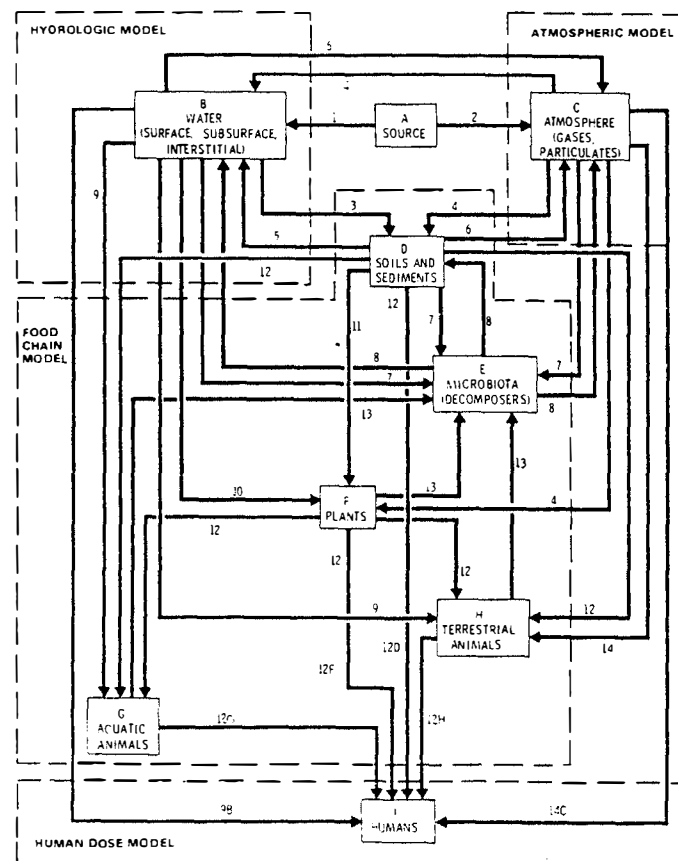
Depending on the timing of assessment and the availability of required information, estimates of atmospheric deposition may have many uncertainties. A firm definition of models to be employed is required, and the nature of input required for assessment needs further study.

Chemical Fate Modeling

Models will be developed to calculate the distribution and activities of chemical species (ions, neutrals, ion pairs, and complexes) in leachate and water samples. Calculations, which assume equilibrium in the aqueous phase, will partition concentrations of each chemical species among its monomeric forms and various soluble complexes with other ions in solution. Speciation will form the basis for evaluating availability of free and unreactive ions in solution, and for additional calculations involving mineral equilibria and the influence of mineral solubility reactions (dissolution and precipitation) on solution composition. The resultant models will be used to: a) estimate mineralogical controls on surface water, ground water, and leachate chemical speciation, b) predict later changes in solution or leachate composition, and c) interface with hydrologic models of the demonstration site to predict the environmental fate of chemical materials discharged or found in ground and surface waters.

Hydrological Modeling

Hydrological assessment will initially review available models for predicting the fate of source terms discharged or found in ground and surface waters. Pertinent archived data will be reviewed and evaluated to identify data needs for hydrological assessment. The most appropriate models and data sets will be used to estimate environmental concentrations of contaminants resulting from water transport.



Key for Food Transport Pathways and Processes Shown in Figure 8:

- 1 Aquatic discharge
- 2 Atmospheric discharges
- 3 Irrigation, water/sediment interphase exchanges
- 4 Surface deposition
- 5 Leaching, erosion, mineralization, water sediment interphase exchange
- 6 Resuspension/evaporation
- 7 Microbial incorporation
- 8 Microbial releases, decomposition
- 9 Water consumption, skin absorption
- 10 Irrigation plant surface exchange
- 11 Root uptake
- 12 Ingestion
- 13 Mortality
- 14 Inhalation

Three basic categories of hydrologic models to be used are:

- overland runoff models that simulate precipitation run off from watershed areas;
- groundwater models that consider waters that are not transported overland or lost by evapotranspiration; and
- surface-water models that use inflows determined by overland runoff models and groundwater models, and couple this information with data on the instream base flow to the outlet of the river system modeled.

As is the case when estimating atmospheric transport, hydrological modeling will only consider compound classes of known biomedical or ecological concern. Background information is needed on the contribution of mining and electric-power generation effluents in the Ft. Martin area relevant to hydrological concerns. Studies relevant to the above are described in Phase IV.

Since hydrological modeling of complex organic materials is currently developmental, no decision concerning modeling approach, data required, or final form of output relevant to assessment can be made. Phase II research will provide only a qualitative assessment of SRC-II contaminant transport through surface and ground waters. However, Phase II will also define needed models and data for more complete and quantitative assessment of potential dose through surface and ground waters.

Food-Chain Modeling

General models exist for estimating food-chain transfer of radionuclides through the environment. These models will be reviewed for their applicability and, where possible, modified to consider metal and organic carcinogen food-chain transfers based on steady-state conditions. Available literature on pathways modeling and food-chain transfer data will be used with data developed in Phase I biomedical and ecological studies to evaluate and select the most appropriate food chain models. If experimental data exist on SRC-II organic materials of concern, they are certainly not as comprehensive as data on nuclear materials. Accordingly, Phase II will involve an initial qualitative (or quantitative) assessment of food-chain transport that will be highly uncertain. Definition of applicable models and data requirements cannot be made at this time. Data for food-chain transport modeling will be developed principally in Phase II and Phase IV ecological studies. As data become available, portions of the conceptual model may be quantified, and coupled to atmospheric and hydrological models to predict transfer of deleterious materials to man.

Available information will be used to describe environmental routes of potential human exposure (Figure 8). Additional data needs will be identified through initial modeling efforts.

Pathway models will consider site-specific factors near Ft. Martin, West Virginia. For example, models developed for sediment chemical processes and physiological data on materials uptake from sediments by fish and detritivores will be used to define transfer of aromatic hydrocarbons from sediments to

organisms in the Monongahela River. Data are needed on transfer functions of materials from sediments to interstitial water to detritivores to fish.

The extent and complexity of interactions among facility effluents, ecological systems, and changing environments dictate the need to simplify approaches wherever possible. For example, because it is not feasible to obtain complete data sets on every compound, we will study selected compound classes which have been identified from studies of environmental transport and fate. Experience in radionuclide and metal pathway modeling efforts indicate that specific compounds can sometimes be grouped according to physicochemical and/or biochemical properties.

Biomedical Assessment

Assessment of human health hazards from exposure to SRC-II products and pollutants involves:

- identification of materials to which human populations are subjected, and estimation of the exposure levels to various subpopulations;
- identification of possible health hazards and estimation of the potencies of these materials; and
- coupling of exposure and potency information.

Coupling must account for such factors as route and temporal pattern of exposures and important characteristics of the exposed populations (e.g., size and age distribution), to arrive at projected measures of morbidity and mortality. The goal of the biomedical assessment will be to derive estimates of potencies of various SRC-II materials, and to relate these to exposure estimates provided by atmospheric, hydrologic, and food-chain transport studies.

The laboratory data base for biomedical assessment has been described previously. Dose estimates from all defined source terms will be in various stages of quantitation and certainty. Phase II biomedical assessments may be qualitative or quantitative; in any case, more certain than Phase I estimates.

Several dose-effect models may be used to quantitate health effects from the available data base, including probit, multi-stage, gamma, multi-hit, and time-to-tumor formation models. Rigorous analysis of appropriateness of data to model and model to data will be performed. Phase II assessment should aid the experimental program by identifying analyses required to further quantitate potential health effects.

Ecological Assessment

Most data developed for the environmental pathways model will also apply to models designed to assess ecological impacts of accidental or long-term effluent releases. Environmental assessment, unlike food-chain modeling, must consider specific toxic materials (e.g., metals, acid vapors, cresols, phenols) in a given ecological system. Data utilized must primarily define organism sensitivity (i.e., behavior or organism health), rather than just metabolism.

Analytically, ecological assessment requires information on transfer coefficients, similar to that for atmospheric, hydrologic and food-chain transport models, and knowledge of dose-response of organisms to compounds of concern at a given site.

Steady-state modeling recommended for predicting dose to man will not be adequate to model ecosystem effects (i.e., model development, based on non-steady-state [seasonal] assumptions may be needed). Phase II ecological assessment will initially be qualitative. However, available models will be analyzed for applicability for quantitative assessment. We will evaluate expanded model systems as they develop for use in ecological assessment.

Example Of Phase II Environmental Assessment/Risk Analyses

Given the complex scenarios for potential human and ecological exposures to SRC materials, Phase II assessment will be illustrated by the following hypothetical example:

Atmospheric emissions from a wet cooling tower may be contaminated with process materials. Engineering estimates suggest that contamination may result from ___ ppm process solvent at the point of entry to cooling water. Process solvent is mutagenic in in vitro assays; a skin carcinogen of some potency; and a weak pulmonary carcinogen in laboratory animals. Chemical analyses and in vitro biomedical assays suggest that compounds and compound types causing biomedical effects may be aromatic amines and large ($n > 3$) polynuclear aromatics. Based on the engineering estimates, it is anticipated that less than ___% of original leakage will be emitted from the cooling tower.

Dose-effect assessment for inhalation risk is performed using data on emissions of known mutagens and carcinogens as a function of distance from the cooling tower. This information is extrapolated from animal data based on a linear extrapolation, not on threshold dose. This mode of data analysis suggests an X percent increase in rates of pulmonary carcinogenesis, adjusted for population age at time of initial exposure. Percent increase is within the standard deviation anticipated for lung tumor incidence in any group the size of the expected target population.

Process solvent also contains ___ ppm of phenolic compounds, and is acutely toxic to fish. This compound class is highly soluble, and worst-case estimates suggest that ___ ppm of original leakage will be emitted from the cooling tower. Available photodecomposition and atmospheric chemistry data suggest that ___% of the original dose entering the atmosphere will be chemically altered or biologically inactivated per ___ meter of plume travel. Using a multi-hit model, surrounding natural waters would be ___% less toxic to fish per meter of plume travel.

On a qualitative basis, phenols decompose in water and sediments through microbial action. Therefore, effects will be contingent on phenol loads versus rates of decomposition versus periods of plant operation.

The following uncertainties affect this assessment:

- 1) Extent of cooling-tower water contamination by process solvent may vary by _____ fold, depending on maintenance status of heat exchangers and process lines.
- 2) Plume output is a function of overall plant heat load, which varies by _____ orders of magnitude.
- 3) Nothing is known concerning atmospheric and photochemistry of compounds tentatively identified as of biomedical concern. Therefore, whether alteration would increase or decrease effective biological concentration is unknown.
- 4) Low potency of process solvent relative to pulmonary carcinogenicity in mice may or may not reflect pulmonary carcinogenicity in man. For example, although cigarette-smoke condensate is a dermal carcinogen in mice, inhaled cigarette smoke does not appear to be a pulmonary carcinogen in mice. Thus, present data may underestimate risk to human populations from cooling-tower plume drift. Additionally, present animal models for pulmonary carcinogenesis may be poor quantitative predictors for lung tumor incidence in man.
- 5) Deposition of materials on crops meant for human consumption may change bioavailability and, therefore, their potential effects on man. Foliar deposition studies on fuel blend A suggest that heavy coal liquids adhere to plant leaves and are not removed by washing. However, studies on ingestion of leaf tissue by animals are not planned at this time.
- 6) Little or no data exist on decomposition rates of phenolic species in natural waters and sediments. Therefore, no estimates of phenolic persistence and its effect on fish toxicity can be made.
- 7) Little or no data exist on the fate of known mutagenic and carcinogenic substances in soils, waters, and food chains. Therefore no estimate of long-term risk to man during and after plant operations can be made.

The above example is illustrative only of a possible assessment of one environmental scenario. It is noteworthy that no single generic path to overall environmental assessment may be available. Assessment will depend on the nature of exposure scenarios, the extent of the environmental data base, and the availability of appropriate models. Given the lack of standard, accepted assessment methods, assessments of different technologies (or even of the same technology, performed by different assessment groups) may not be quantitatively or (in some cases) qualitatively consistent.

PHASE III

Phase III biomedical, ecological and chemical analyses will evaluate materials which may be produced by demonstration and commercial facilities under different conditions from those established as baseline in Phase II. Additionally, materials processed through various control technology options, or subjected to upgrading prior to end-use processes, will be analyzed. Revised versions of this program plan will deal in greater depth with exact process streams, products and wastes to be analyzed as SRC-II technology plans develop.

Research in Phases I and II will establish process, product, and waste streams of potential biomedical and ecological concern and provide data on specific chemical compounds and compound classes responsible for biological and ecological effects (e.g., mutagenicity, carcinogenicity and acute and chronic toxicity). Phase III biomedical research will primarily use in vitro assays shown to correlate with results from Phase II whole-animal assay systems and of proven utility in determining compounds of concern. Phase III ecological research will primarily use acute and chronic screening assays shown to correlate with longer-term Phase II ecosystems approaches. Since the number of materials which may require testing in Phase III may be large, analyses in animal and ecological systems will be limited to materials most likely to cause biological or ecological effects and/or most likely to be produced by a demonstration or commercial facility. Only a limited number of analyses may currently be described as appropriate to Phase III. Studies similar to those described below for biomedical concerns will also be initiated to address ecological issues.

UPGRADED PRODUCTS

To increase the utility of SRC-II liquids as refinery feed or potential final product, Bartlesville Energy Technology Center will treat SRC-II liquids by catalytic hydrogenation, and hydrosulfurization. One set of materials, derived from a 2.9:1 blend of SRC-II middle to heavy distillate and subjected to two different hydrotreatment regimes, has been provided to PNL by UOP.

The UOP samples were subjected to biological and chemical analyses using methods described on pp. 37-51. Fractions were prepared by solvent extraction and LH-20 chromatography and analyzed by Ames assay. Results suggest that catalytic hydrotreatment lowers mutagenicity of fuels relative to feed-stock by an amount proportional to the loss of chemical compounds and compound types (e.g., aromatic amines) which appear to be responsible for mutagenicity. Hydrotreatment also resulted in major losses of PNAs which were converted to more-saturated ring compounds. This result was anticipated and is of some biological interest, given the established role of PNAs in carcinogenesis.

To establish correlation with these results in whole-animal assay systems, upgraded materials considered most likely to be produced from SRC-II products will be subjected to in vitro assay by methods described on pp. 37-51, and to analyses of dermal carcinogenicity in mice by methods described on p. 76.

BOILING-POINT FRACTIONS

Du Pont Co. has been performing analyses of boiling-point fractions derived from a blend of SRC-II heavy and middle distillate relative to mutagenicity in the Ames assay and carcinogenicity in mouse skin using an initiator-promotor assay system. Results from the Du Pont study should be available in the near future.

PNL will also perform a study of boiling-point fractions using the Ames assay and chemical fractionation and analyses methods described on pp. 37-60. P&M is in the process of preparing 50°C boiling-point cuts, over the range 400-950°C, of a 2.9:1 blend of middle to heavy distillate. Depending on results of analyses on the 50°C cuts, further fractionation involving distillation cuts, at 10°C increments, may be performed.

These analyses may have significance for assessment and process environmental management, since preliminary PNL results on boiling-point fractions suggest that mutagenicity resides primarily in high-molecular-weight materials which are found in high-boiling-point ends.

ENVIRONMENTAL ASSESSMENT/RISK ANALYSES

Models for determining atmospheric, hydrologic, and food-chain dose (Figure 7) will be improved in Phase III assessment. Data from Phase II ecological and biomedical assays will be included in the improved models. In particular, a considerable body of food-chain transfer data will be developed for reference compound types. Analyses suggested from Phase II assessment will be performed and results will be used in appropriate models. Analyses of effects of changing SRC-II plant operating conditions and new control technologies on biological and ecological potency will be performed. Results will be used in Phase II models and newly developed models, for comparative purposes.

PHASE IV

HEALTH EFFECTS MONITORING

Health effects monitoring at the Ft. Lewis, WA SRC pilot plant has consisted of work-area and personnel monitoring for criteria pollutants, noise, and lighting conditions. Standard methods for analyses of site and personnel particulate loads, organic vapors, H₂S, SO₂, and CO have been used by P&M to define areas of risk and potential work-force exposure. These analyses are performed on a routine basis (monthly, quarterly or yearly, depending on area examined and nature of potential hazard), and a large body of data has been collected and reported in Quarterly and Annual Reports available to the public through DOE-Assistant Secretary for Fossil Energy. A summary of available information on SRC pilot monitoring follows.

Surveys of airborne organic vapors have indicated that in-plant concentrations of organic vapors and hydrocarbon gases were generally less than 0.1 ppm. A similar study has indicated occupational exposures to benzene were far below the 1-ppm level specified in the proposed Occupational Safety and Health Administration (OSHA) standard. Suspended particulates measurements have shown some inconsistencies and are under more detailed examination. Welding fumes from cutting or welding contaminated parts can pose an exposure problem. Several potential sources of hydrogen sulfide and sulfur dioxide have been identified in the plant, but the measurements thus far indicate very low concentrations. Phenols, because of their presence in a number of process streams, pose a serious occupational skin contact hazard necessitating preventive measures and good personal hygiene. High concentrations of carbon monoxide, detected in several areas of the plant, were traced to the use of plant inert gas and readily correctable. Settleable particulates in the plant were generally lower than those reported for a nearby urban community. A noise survey detected some excessive noise problems in the plant, primarily in remote areas or in areas requiring only infrequent operator attention. A survey of lighting conditions indicated insufficient lighting in several areas; additional illumination was installed.

During initial operations, the Ft. Martin, West Virginia demonstration facility will use, at a minimum, a monitoring program similar to that employed at the pilot plant. Data confirming or negating potential health hazards for polyaromatic amines and other specific organic constituents of SRC-II materials will be used to define further specific needs for work-site and personnel monitoring at the demonstration facility. A generic program addressing instrumentation that might be used in such monitoring is underway at ORNL. The chemistry program affiliated with biomedical studies described in this document should aid in defining instrumentation and assay needs for this effort.

ECOLOGICAL MONITORING - FIELD STUDIES

Field sampling and related measurements at the Ft. Martin, West Virginia SRC-II demonstration site will allow a realistic evaluation of effects on key organisms and on integrative ecological processes which serve as useful indicators of ecosystem health. To identify any abnormal variations, it is necessary to first establish the normal range of seasonal variations in selected

ecological variables prior to facility construction and operation, then monitor these variables during facility operation. The absence of detectable effect after several years of monitoring may provide persuasive evidence that the facility is environmentally safe, provided that sampling effort was suitably designed.

However, due to the existing pollution burden at the site, and the nature of the SRC-II facility, additive effects of normal SRC-II operations may not be environmentally detectable. Additionally, it is currently not possible to identify precisely which samples must be taken and which measurements need to be made. Therefore, a large number of biotic and abiotic samples will initially be taken and archived. Based on results of Phases I-III of this program, decisions will be made on which chemical analyses to perform on archived samples, and the need for additional field studies.

Sampling design will anticipate distribution of pollutants from facility operations (Figure 9). This will be determined by presently available information on plant design, area hydrology, meteorology, and other non-SRC-II industrial activities in the area. We will concentrate on biotic sampling of representative important species to determine relative abundance and distribution at locations correlated with anticipated hydrological or atmospheric pollution gradients. "Abiotic" sampling refers to selected physical and chemical measurements at or near biotic sampling locations. Abiotic measurements will include factors controlling organic productivity or organism behavior (e.g., in aquatic ecosystems, dissolved oxygen, water-quality measurements, etc.; in terrestrial ecosystems, temperature, precipitation, humidity, etc.). If screening studies (described in Phase I, pp. 64-72) indicate that organisms are unduly sensitive to any reference compound classes (other than phenols, which will be determined), additional chemical measurements will be made.

Further chemical analyses on abiotic samples will also be initiated for compounds and compound types which are shown to have biomedical or ecological effects and are found in SRC-II materials. Laboratory bioconcentration/bioaccumulation/biomagnification studies (Phase II, pp. 84-88) will also be used as a basis for making these measurements.

An important initial phase of this work will be detailed site observation, and evaluation of extant ecological data available in local universities and local resource agencies (Federal and State). This work will be coordinated with on-site monitoring studies currently being conducted by Stearns-Roger, Inc.

Aquatic Monitoring

Aquatic monitoring at the proposed Ft. Martin SRC-II demonstration site will focus on potential direct discharges of SRC-II materials to the Monongahela River, or its tributaries, and include analyses of indirect releases through ground water and leachates from solid-waste disposal. Much of the food base in rivers and streams originates from allochthonous organic material. These materials may be taken directly from the water column by foraging aquatic animals or may accumulate in bottom sediments, where they are utilized by microbes and benthic detritivores. Heavy metals and organic materials which may be released from SRC-II materials also accumulate in sediments. Thus,

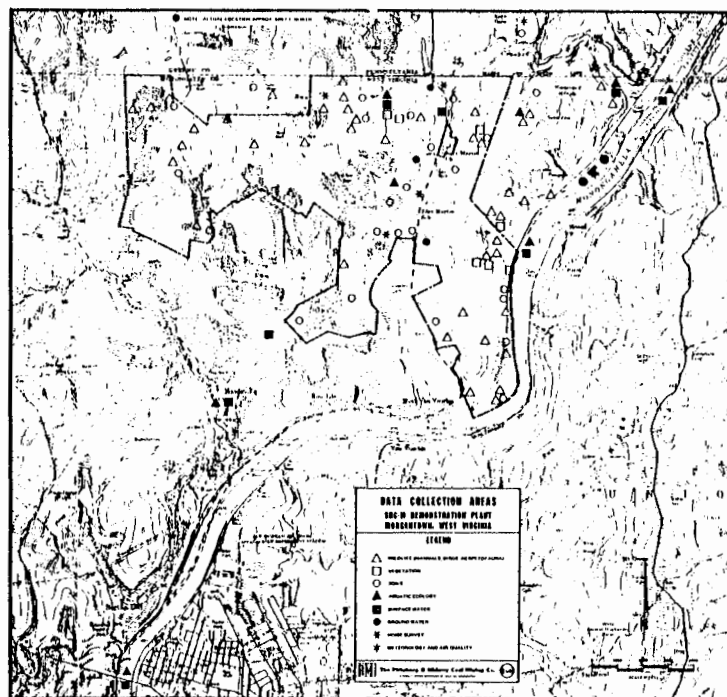


Figure 9. Map of SRC-II Demonstration Site. Monitoring stations used to collect data for Environmental Impact Statements are shown.

sediments serve as a pollutant sink, and animals living in or on sediments serve as potential sources of pollutant uptake and entry to aquatic and terrestrial food chains.

Biological Sampling Criteria

Selection of species to be sampled will be based on:

- Occurrence;
- Known sensitivity;
- Role in ecosystem function;
- Position in food chains leading to man;
- Economic or recreational importance;
- Sampling feasibility (adequate access, adequate numbers, handling ease).

Chemical Measurements on Biological Specimens

Concentrations of several biologically active pollutants will be measured routinely. These include cadmium and mercury, and reference organic compounds for organic acids and phenols, basic nitrogen compounds, and aromatic and heteroaromatic hydrocarbons. Mercury will be measured immediately on all organisms. Specimens to be assayed for other metals may be archived. Specific organic compounds to be measured will be based on results of work described in Phases I and II. Methods for inorganic and organic analyses are described on pp. 48-51 and p. 89. Body burdens of compounds and compound classes of concern will be determined. These data will be established for selected benthic detritivores and fish in the fish-to-man food chain.

Many fish near Ft. Martin, West Virginia belong to the sunfish family (Centrarchidae). Two game species in this group, bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*), will be sampled as representatives of the entire group. Both bluegill and bass are amenable to laboratory and field studies. Body burdens will also be measured in yellow and brown bullhead, and white and channel catfish. Bullheads and catfish feed on the bottom, ingest sediment, and provide another route for pollutant transport to man.

Ducks and geese, which frequent the Monongahela River and its tributaries, feed on submerged aquatic plants and a variety of invertebrates. Because they are hunted and eaten by man, they will also be monitored.

Other Measurements and Samples

The species listed above represent a small portion of the aquatic fauna at Ft. Martin. If effluent or product releases suggest the likelihood of gross ecological damage, as when accident scenarios are considered, it will be important to consider whether or not the damage is acute and whether recolonization of the affected area by unaffected upstream or downstream populations

is possible. If damage is of a chronic nature, biological recolonization may not be possible without cleanup and mitigative action (e.g., introduction of microbes to metabolize persistent organics). Accordingly, the temporal and spatial distribution, abundance and other population characteristics (i.e., growth rates, fecundity, etc.) of selected finfish and shellfish will be determined. When selecting "target" species, such critical life-history requirements as spawning areas, nursery grounds, food habits, feeding areas, wintering areas and migration routes, and their relation to the demonstration facility will be considered. Endangered and/or threatened species and those with specific habitat requirements are of particular concern in this regard.

Terrestrial Monitoring

Terrestrial monitoring will provide the basis for differentiating between ecological changes resulting from SRC-II operations and changes due to natural variations or unrelated pollution stresses extant in the area. Field sampling can also define a zone of effects and provide plant and animal tissues for chemical analyses required in the development and validation of pathway models.

Primary effects on terrestrial communities are expected to result from: 1) episodic deposition of airborne emissions from demonstration-facility operations, codistillation from holding ponds, and resuspension from solid waste and coal piles, and 2) surface run-off and groundwater transport of pollutants resulting from leaching of waste and bulk storage areas, overflow of holding ponds, and accidental spills. Studies described below reflect primary exposure routes. Sampling design will employ a series of fixed sites at varying distances from the source of possible pollutant emissions, and will include control sites in areas relatively unaffected by plant operations. Collection of several years' data before plant construction will also provide controls in time.

Terrestrial Environment at Ft. Martin

The terrestrial environment at the Ft. Martin demonstration site is characterized by a mosaic of plant communities representative of eastern deciduous forests and small agricultural fields. Some fields have been abandoned and are undergoing the natural process of secondary ecological succession. Other fields are still in crop production. Most forest stands have been selectively logged.

Coal mining has been practiced for years and some mined lands are in various stages of revegetation. Gases, particulates and "acid rain," attributed to coal-burning, steam-electric plants, may have already impacted indigenous biological communities.

Soil and topography are the main factors responsible for the local distribution of plant communities. The stony soils and steep slopes are forested. The better soils have been or are still in crop production. Rainfall is sufficient so that irrigation is not required to raise field crops and garden plants. Rainfall percolates through the soil and contributes to ground water.

Important game species include the white-tailed deer, squirrels and cottontails. Migratory and breeding waterfowl are associated with ponds and streams. Generally, wildlife populations at the site are like those of the surrounding nonmetropolitan areas.

Two general kinds of materials produced in the SRC-II process may be released into the surrounding terrestrial environment. Release may be purposeful, as in the disposal of solid wastes in landfills; or inadvertent, as in gaseous or liquid effluent spills. These materials may be organic rich or mineral rich (pp. 51-54).

Although organics may have the highest carcinogenic potential, little is known concerning their behavior in soils; their uptake by plant roots; whether carcinogens can be passed through food chains; or the biodegradability of organics in soils subjected to aging, wetting, drying, freezing, thawing and microbial decomposition. Additionally, little is known concerning potential incorporation of organics during flower production and seed set, and its effect on seed viability and germination, and seedling survival. In contrast, extensive information exists on the behavior and fate of mineral elements in the terrestrial environment, derived from years of agricultural and forestry experience.

Field Experiments

Small weighing-leaching lysimeters (p. 70) will be used outdoors at the demonstration site in support of greenhouse or growth-chamber experiments to provide information on uptake and toxicity of organic-rich and mineral-rich SRC-II materials by plants. Lysimeters use site soil, site climate and site-adapted plants; are large and deep enough to allow reasonable root penetration; and provide a characteristic root-zone temperature profile and normal seasonal patterns of soil wetting, drying, freezing and thawing. Additionally, populations of soil microorganisms at the demonstration site can be maintained by placing the lysimeters in experimental arrays outdoors.

Results of Phase I studies currently underway at PNL will allow us to determine conditions for use of lysimeters at the Ft. Martin site. Phase I studies will establish types of toxic effects and dose to effect for distillation fractions and a 2.9:1 blend of MD to HD.

Field Plots

Field-plot studies differ from field experiments in that plots are not purposefully treated with SRC-II materials. Instead, the plots are strategically located in relation to the demonstration facility at places expected to receive wind-carried materials and at other places more remote and upwind from the facility. Changes in chemical composition of plant tissues and soil will be monitored in plots before and after facility operations. Background chemistry of pollutants contributed by other industrial processes will be determined. Garden vegetables will be grown in small plots, harvested, and their tissues chemically analyzed. Some samples will be archived for future analyses. Field-plot studies may also aid in establishing food-chain pathways to man.

Other Measurements and Samples

Revegetation. SRC-II construction activities and shallow land burial will create disturbances requiring revegetation. Substantial information exists concerning revegetation of surface-mined lands in the coal regions. This information will provide guidance for practical revegetation efforts at the demonstration site.

Forest Monitoring. Forests at the demonstration site provide protection against soil erosion on steep slopes, provide habitat for wildlife, and have esthetic appeal. Additionally, wood is a valuable, renewable resource. In contrast to most crop plants, forest communities are relatively unmanaged and trees are long-lived. Because of large leaf surface areas, trees have high contact potential for airborne gases and particulates. Some gases, such as SO₂ and ozone, are injurious to leaves even at low concentrations. Particles adhere to tree leaves and fall to the forest floor in autumn. Thus, the forest floor acts as a sink for airborne foliar contaminants. Over a long period of years, biologically toxic, nonbiodegradable organics and inorganics may build up in the forest floor. Decomposition of leaves and other plant materials may be slowed to the point where changes in nutrient cycling may reduce wood and leaf production in the forest stand. Without onsite field monitoring, this would not be detected. The following surveillance projects constitute an "early warning" system to detect chemical contamination (SO₂ is one airborne chemical of concern) of forests at the demonstration site:

Photographic Interpretation. False-color infrared aerial photography is a proven tool for detecting patterns of decreased vegetative vigor resulting from air pollution and/or insect pests. Photographs will be taken during the peak growing season. Areas showing unexpected changes will also be inspected on the ground to evaluate specific damage.

Visible Injury. On the ground, we will identify patterns of visible leaf injury, including chlorosis and necrosis characteristic of specific pollutants. In the absence of visible injury, alternative explanations for reduced vigor (i.e., parasite or insect infestations) will be sought. Pre-operational monitoring is required to separate demonstration-facility effects from those of other pollutants originating off site.

Indicator Species. Species sensitive to SO₂, such as white pine (*Pinus strobus*) and tulip tree (*Liriodendron tulipifera*), will be planted to span the potential pollutant gradient at the demonstration site. Survival, growth, and visible injury will be compared among study areas.

Litterfall. Systematic collection of litterfall will provide information on vegetative growth and reproductive success. Spring collections contain flower parts, because most trees at the demonstration site flower before leafing out. Fall collections will identify potential growth (leaf mass) and reproductive impairment (nuts and fruits). Collected materials will be archived for possible chemical analyses. Amount of litterfall can be estimated by placing collectors on the forest floor in statistically designed arrays and periodically gathering the contents.

Leaf Decomposition. Leaves are eaten and fragmented by small invertebrates and further decomposed by microorganisms. Eventually, mineral elements bound in leaf tissues are incorporated into the soil and are available for uptake by plant roots. To determine if leaf decomposition is affected by demonstration facility operations, newly fallen leaves will be placed in nylon mesh bags and periodically weighed to determine rate and amount of breakdown in various forest stands in varying proximities to the facility.

Wildlife Monitoring. Wild mammals and birds may be affected by SRC-II construction activities. Although some wildlife habitat will be destroyed, some land will later be revegetated with plant species that provide food and/or cover for deer, squirrels and cottontails. However, demonstration facility operations may still have subtle effects on animal populations. One way to detect impacts on reproductive success of birds is to record number of eggs laid per female, number of eggs hatched and number of young fledged. Unhatched eggs can also be chemically analyzed.

A wildlife monitoring program in support of the Environmental Impact Statement is currently underway at the demonstration site. Data from this effort will be used to select species to be analyzed and analyses to be performed.

Chemical Transport and Fate

Phase II laboratory studies will investigate physical, chemical, and microbiological processes governing transport, persistence, and fate of trace metals and biologically active organic compounds (PNAs and PAAs) released from SRC-II liquid products and solid wastes. This will establish key controlling variables and estimate mobility and fate over a range of potential geographic, seasonal, and climatic conditions. Phase IV field studies will be designed to validate laboratory results and investigate processes under the specific confines of the local climatic, geologic, hydrologic, and biological regimes.

Investigations will be conducted at two field sites to define possible effects of product spills and disposal of gasified solid wastes on local soils, surface and ground waters. Field sites may include Ft. Lewis, Washington and Ft. Martin, West Virginia.

Field-study objectives are to identify: 1) composition, quantity, and mobility of water-soluble components of SRC-II product oils and solid waste leachates in soils, subsoils, and ground waters; and 2) presence of deleterious materials in local soils and subsurface waters relative to other sources of natural or industrial origin.

A stepwise approach is proposed to fulfill these objectives. Preliminary tasks are designed to evaluate available chemical and hydrological data on local surface and subsurface waters and to initiate limited field work to define the magnitude of potential effects on waters. Initial tasks will form the basis for deciding if a comprehensive field program is necessary.

Field studies will utilize Phase II laboratory information (pp. 89-93) and include organic and inorganic analyses to: 1) compare composition of unaffected waters with contaminated or potentially contaminated waters, and 2) define migration potential of water-soluble material from product spills or

solid wastes through soil, subsoil, and groundwater systems. Analytical studies will identify soils and waters containing SRC-II residuals. Identification criteria may be based on the presence of trace metals or organic compounds unique to SRC-II or the presence of characteristic isomer distributions of organic compound types. The complex organic chemistry of SRC-II solid wastes and liquids suggests that multiple criteria may be necessary to evaluate potential SRC-II contamination. Field investigations entail four principal tasks. Magnitude of subsequent tasks depends on results of previous tasks.

Task I - Preliminary Evaluation of Existing Water Quality and Hydrological Data

Existing water quality data (particularly for trace metals, organic carbon, and organic compound classes identified in Phase II laboratory studies) will be reviewed and the following information evaluated:

- a) well sampling procedures,
- b) sample preservation techniques,
- c) analytical procedures and concentrations measured,
- d) usefulness of analyses performed to identify 1) present state of surface and groundwater contamination, and 2) distribution of solutes with time.

Placement and construction of surface-water monitoring sites and wells will be evaluated to identify those that are unsuitable for further use and to recommend new locations. The following questions need to be considered:

1. Were cores of subsoil lithology logged during well placement?
2. Were wells constructed to prevent interaction between surface and ground waters?
3. How were well screens constructed? Can samples be realistically obtained from discrete depths in the aquifer?
4. What type of hydrologic data were collected (i.e., transmissibility, well draw-downs)?

Task II - Limited Onsite Field Program

Limited onsite field studies, if warranted from evaluations in Task I, may be initiated to define magnitude of potential movement of solutes. Soil and groundwater samples will be collected and initially subjected to trace metal (Table 25) and organic analyses as described in Phase II (pp. 89-93). We will emphasize analyses of biologically active anionic trace metals, organic bases (anilines and pyridines), and organic acids (principally phenols) present in SRC-II products which may move through soils. Trace metals and organic compounds solubilized in significant quantities from gasified solid wastes will be included, as warranted. Detailed studies of organic compounds

will be conducted using derivatization techniques and specific gas chromatographic detectors, mass spectrometry, and isomer distribution patterns, using capillary gas chromatography to elucidate compositional patterns characteristic of solubles from SRC-II liquid products and, perhaps, solid wastes. Additional soil or water samples may be analyzed for hydrocarbons and less water-soluble, polar, organic materials to assess the potential of direct contamination by contact with SRC-II product (as opposed to contamination by migration). However, compound types most likely mobilized in soil or, ultimately, through chemical/microbial processes with time (as indicated from laboratory studies) will be emphasized.

Product Spills - Ft. Lewis

Soil and Subsoil Analyses. Initially, the extent of product and sour water spillage will be evaluated by shallow surface coring with a hand auger. Core samples (continuous or incremental) will then be obtained, from the soil surface to depths below the water table, in a grid over any possible spill areas as follows:

1. Cores should be obtained at the site of any product spill and the point of sour water discharge (if point sources exist).
2. Core segments will be logged, photographed, and subjected to organic and inorganic analyses.
3. Performing inorganic and organic analyses will depend on results of laboratory studies. At this site, compounds and compound classes of concern (e.g., PNAs and PAAs) will be emphasized; inorganic analysis will be of second priority. Methods will include aqueous batch equilibrations and subsequent analyses for pH, electrical conductivity (EC), dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), major cations, anions, and trace elements as identified in Table 25.

Well-Water Analyses. The existing array of groundwater wells will be sampled in the following manner to define water quality and chemical composition of ground waters both down- and up-gradient from spill and disposal sites:

1. Suitable and unsuitable wells identified in Task I will be sampled.
2. The sampling procedure includes removal of stagnant water by pumping, followed by sampling, with time, to identify compositional changes with inflow.
3. Hydrologic variables such as permeability and transmissibility would be obtained, if possible, to evaluate the wells. Standard hydrologic pumping tests will be used.
4. Water quality will be measured as described above. Inorganic analysis may emphasize identification of additional basic characteristics which may affect mobility and form of inorganic or organic constituents, or reflect additional chemical perturbations to the aquifer.

5. Effort will be made to identify background chemical and hydrological characteristics of the prominent groundwater unit by well sampling up-gradient from the Ft. Lewis site; a subsurface access well on the Du Pont tract is one possible location.

Extractions on corings and chemical analyses on surface- and well-water samples in conjunction with laboratory studies should enable identification of existing pollution burdens. If additional studies appear warranted, information from Tasks I and II will be utilized to: 1) design a sampling program for those wells deemed useful, 2) propose additional sites for installation of groundwater access wells, and 3) obtain additional cores on both a temporal and spatial basis to evaluate migration rates of SRC-II solubles from product spills in soil and groundwater systems.

Solid Waste Disposal - Ft. Martin. Our approach to solid-waste studies will be similar to that described for the spill situation in Task II. Preliminary reconnaissance studies have already been initiated at the Fort Martin site, with emphasis on surface-water hydrology/chemistry.

The site is not pristine, and is affected by previous surface and sub-surface coal-mining activities. The site is drained by three runs which flow into the Monongahela River: two, Robinson Run and Crafts Run, are typical acid mine drainages; the third, Crooked Run, exhibits better water quality. Solid wastes from the demonstration plant may be discharged to the region above the headwaters of Crooked Run.

Sampling locations on the three runs and the Monongahela River were chosen, and a range of water and sediment types were collected and chemically analyzed. Additionally, hydrological reconnaissance of the site was undertaken and the need for additional characterization delineated.

This information, in conjunction with laboratory studies of SRC-II gasified and nongasified mineral residues, will allow evaluation of research needs and development of proper pre- and postoperational monitoring to aid prediction of mobility of important residuals from solid wastes to waters.

Task III - Comprehensive Field Program

Based on Task II, a comprehensive field program may be undertaken to identify: (1) extent, geographic distribution, and flow rates of surface waters and groundwater plumes; and (2) movement and behavior of possible contaminants in surface waters, ground waters, and soil systems with time. Inorganic and organic chemical analyses will be similar to those outlined above. The study would include:

- A. Delineation of surface waters at the Fort Martin site as to source, flow rates, and water balance.
- B. Delineation of contaminated or principal groundwater plumes at selected sites through:
 1. Analyses of hydrologic data to accurately assess groundwater flow patterns; i.e., a contoured flow net;

2. Possible placement of additional wells to bracket contaminant flow;
 - a. Possible use of multidepth piezometers;
 - b. Sampling along surface-water margins to identify contaminated inflow.

- C. Assessment of the mobility of solubles in surface water, soils, subsoils, and groundwaters. This will require a continuation of efforts initiated in Task II, as follows:

1. A monitoring program will be initiated to identify the flux of soluble trace metals and organic compounds observed, over time, in groundwater wells.
 - a. Samples will be collected monthly.
 - b. Organic analyses performed on a routine basis will emphasize select organic components identified in the previous task and will be indicative of SRC-II product oils (e.g., phenols and key nitrogen species).
 - c. Inorganic analyses, primarily in the case of solid wastes, will include pH, EC, DOC, DIC, and major and minor cations and anions.
 - d. Routine organic and inorganic protocols will be organized to minimize analytical efforts and take advantage of indicator chemical species.
2. Additional chemical analysis of core samples may be performed to furnish information on migration rates of soluble components and absorptive characteristics of local soil and subsoils.

Task IV - Modeling

If significant contamination of soils, surface and ground waters is observed, we will evaluate the feasibility of applying chemical transport modeling to enable prediction of the rate of movement and distribution of related organic compounds in local soils and ground waters.

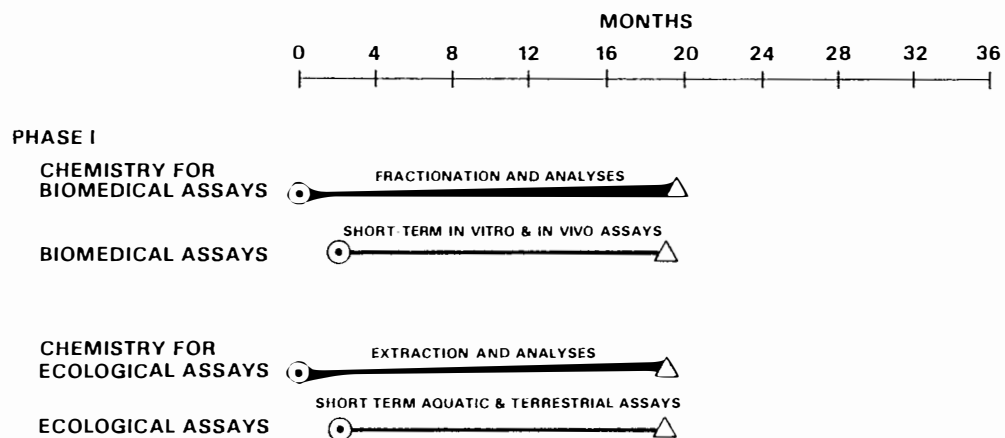
Large leaching lysimeters will be established as sufficient gasified solid waste becomes available to: 1) demonstrate disposal feasibility, 2) validate laboratory studies of solid-waste weathering and leachate composition, and 3) refine the predictive model developed from laboratory studies. Field studies will be desirable to quantitate effects on leachate composition of several variables defined in laboratory studies. These include chemical/microbial weathering, water volume, in situ heat production, water application rate and promising remedial measures; e.g., sludge disposal or soil overburden. Lysimeters will be constructed and instrumented to measure profile moisture distribution, microbial activity, temperature, and salinity. This will allow determination of the influence of measurable variables on leachability of

organic carbon, specific organic compounds, salts, trace metals, and trace metal complexes. Measurements of incoming moisture, evapotranspiration and percolation, and knowledge of leachate composition will allow us to develop material balances on soluble residuals and make proper comparisons with laboratory studies and onsite measurements during Tasks I-III.

Although the efforts described above are comprehensive, the proposed stepwise approach will enable successive reevaluation of the need for further research after completion of each task. Chemical transport and fate studies should provide information to: 1) define immediate operational impact at specific sites, 2) estimate long-term transport and fate, 3) recommend modifications to existing surface and groundwater monitoring systems to establish comprehensive chemical and hydrologic networks and measure long-term effects, and 4) recommend technological changes for waste-management practices which will minimize environmental and human health effects, and permit ecological restoration as necessary.

ENVIRONMENTAL ASSESSMENT/RISK ANALYSES

Field data on SRC-II facility emissions may be available. These data, based on operating experience from a facility of near-commercial size, will aid in determining validity of previous assessments and in providing assessment of environmental effects of the commercial SRC-II process. Pathways models (Figure 8) used for dose assessment will be improved so that error limits for calculated exposures can be estimated.



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FIGURE 10. Estimated Time to Complete Phase I Biomedical and Ecological Studies, Assuming Receipt of Material At time Zero.

TIMELINES

Estimated timelines for various segments of Phases I and II are shown in Figures 10-12. Timelines assume receipt of test material at time zero. To convert these to real time, see Table 1 for anticipated dates of material receipt. Because of uncertainties associated with the initiation and extent of Phases III and IV efforts, no timelines have been developed.

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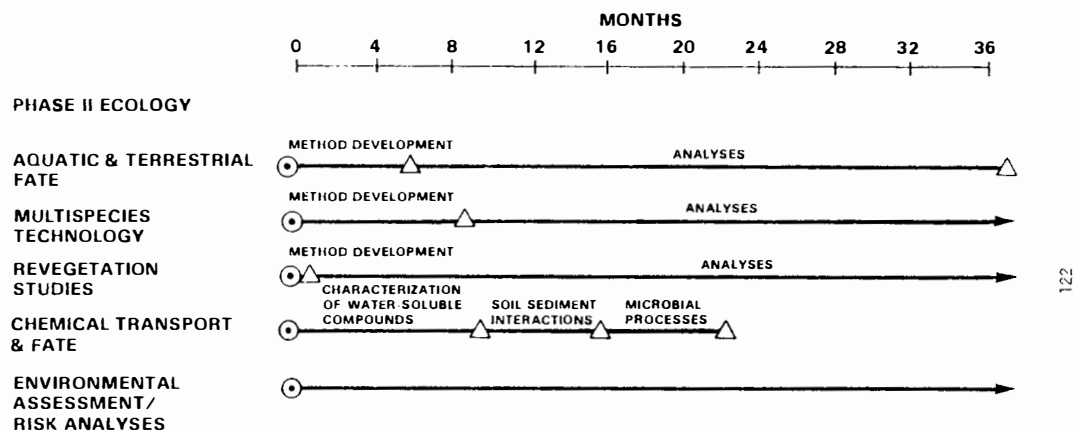


FIGURE 12. Estimated Time to Complete Phase II Ecological Studies, Assuming Receipt of Material at Time Zero.

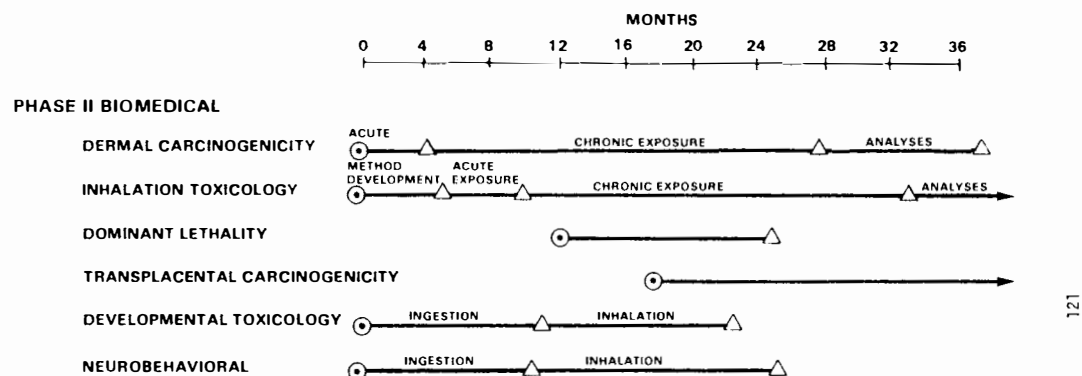


FIGURE 11. Estimated Time to Complete Phase II Biomedical Studies, Assuming Receipt of Material at Time Zero.

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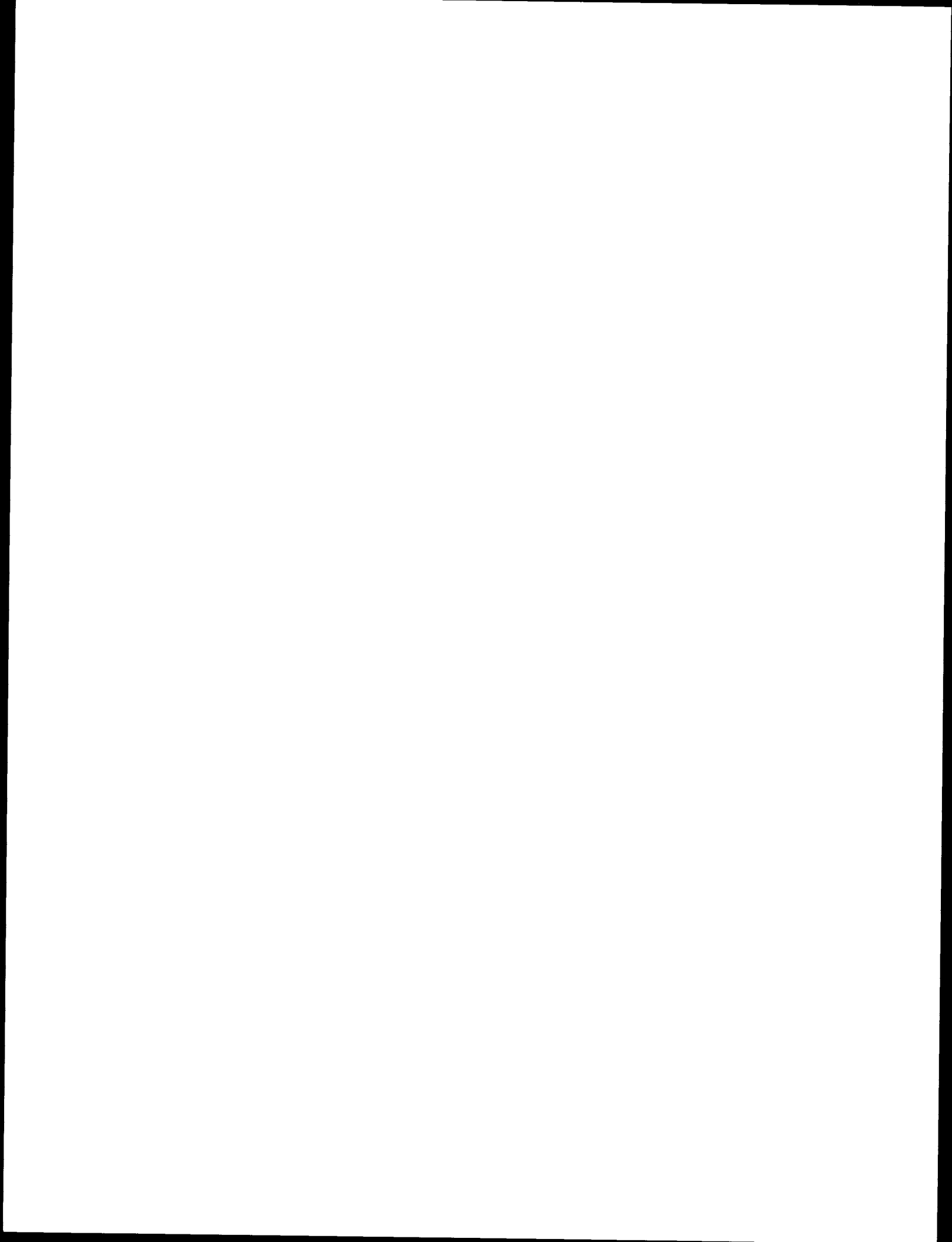
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Appendix Y.2

SUMMARY OF SRC-II-RELATED HEALTH
AND ENVIRONMENTAL CHARACTERIZATION ACTIVITIES



Appendix Y.2

SUMMARY OF SRC-II-RELATED HEALTH AND ENVIRONMENTAL CHARACTERIZATION ACTIVITIES

SRC-II-related health and environmental characterization activities have been under way since the construction of the Fort Lewis pilot plant in 1972. These activities have been significantly intensified since 1977 in response to DOE's decision to extend development studies to demonstration-scale operations.

Y.2.1 MAJOR PARTICIPANTS IN THE CHARACTERIZATION PROGRAM

The Assistant Secretaries for Environment (EV) and Fossil Energy (FE) have assigned specific organizations the responsibility for health and environmental studies and for engineering efforts on SRC-II, respectively. Battelle's Pacific Northwest Laboratory is EV's lead laboratory for the chemical, biological, and ecological characterization and assessment of SRC-II technology. Pittsburg & Midway Coal Mining Company, a wholly owned subsidiary of Gulf Oil, is FE's prime contractor for the process and environmental engineering analysis of SRC-II control technology needs, options, and performance. Additional subcontractors, several of DOE's energy technology centers, and DOE's national laboratories are contributing significantly to the overall characterization program.

Y.2.2 MAJOR CURRENT SRC-II CHARACTERIZATION ACTIVITIES

Consistent with the joint nature of its program, DOE's initial round of characterization activities has focused on a delineation of current regulatory compliance issues and screening for areas of potential health and environmental concern. FE and its contractors have taken the lead in identifying and scoping EPA and OSHA compliance issues necessary to keep the demonstration program on schedule. EV and its contractors have led the effort to scope currently unregulated areas that could pose future health or environmental problems. Because the results of health and environmental screening studies pinpoint areas of further FE control technology evaluation, these tasks are interactive and necessarily iterative.

Principal areas of current FE activity include (1) comprehensive process- and site-specific studies required for compliance with the National Environmental Policy Act and various state and Federal environmental permits; (2) extensive industrial hygiene research, development, and monitoring at the Fort Lewis pilot plant; (3) formulation of a large-scale, multiyear compliance toxicology testing program for the analysis of key SRC-II materials; and (4) analysis of potential environmental incidents and the development and evaluation of remedial action scenarios. Specific projects associated with these activities are summarized by program component (i.e., screening, long-term, parametric, and monitoring) in Tables Y.2.1 through Y.2.4. FE is currently reviewing available project results and will use this information as one basis for the specification of the next round of project studies.

Principal areas of current EV activity include (1) extensive methodology development for sophisticated chemical, biological, and ecological analyses of SRC-II-related materials; (2) screening characterization of the chemical, biological, and ecological properties of a range of generically relevant SRC-II materials; (3) design and initiation of a series of long-term baseline studies of acute and chronic biological and ecological properties of key SRC-II materials; and (4) formulation of a detailed plan for the completion of a comprehensive health and environmental data base adequate for identification and assessment of environmental risks associated with the commercialization of SRC-II technology. Specific projects associated with DOE's program activities are also summarized by program component in Tables Y.2.1 through Y.2.4. As with FE, EV routinely reviews results of current projects as a partial basis for the addition of new projects. This will be particularly true in the area of health and environmental monitoring.

Both OSHA (through the National Institute of Occupational Safety and Health) and EPA (through the Industrial and Environmental Research Library (IERL)) have strong interests in the analyses of DOE environmental program data and in the generation of independent characterization data. DOE is committed to active communication, cooperation, and support of OSHA/EPA and their needs. Tables Y.2.1 through Y.2.4 also list several EPA- and OSHA-sponsored data base projects to which DOE and its contractors are contributing technical and analytical support. As in the past, each new stage of DOE's continuing commitments for SRC-II data base development will receive the full review of both the EPA and OSHA. This policy will ensure the quality and adequacy of the information base for both DOE and EPA/OSHA purposes.

Table Y.2.1

SUMMARY OF CURRENT COMPONENT 1 ACTIVITIES:
SCREENING STUDIES ON SRC-II RELATED MATERIALS

Table Y.2.1. Summary of current Component 1 activities: screening studies on SRC-II related materials

Organization/Program	Material	Source (a)	Summary of Studies			Abiotic Environment	Biotic Environment (d)	Status
			Chemistry (b)	Health & Safety (c)				
<u>STUDIES ON SRC-II PROCESS INTERMEDIATES</u>								
<u>Battelle Northwest Labs</u>								
• Extensive methodology development and generic materials characterization.	Naphtha, middle and heavy distillates.	SRC-II Pilot Plant; 1Q/78	Chemical fractionation and analysis of active compound classes.	Lower-tier biomedical testing; acute, sub-chronic and chronic toxicity testing; rodent skin painting.	--	--	Essentially completed, 1978-1980	
• Effect of boiling point on chemical and biological properties of SRC-II materials.	500F boiling fractions of 400-9750F distillate.	SRC-II PDU; 2Q/80	Chemical fractionation and analysis of active compound classes.	Lower tier biomedical testing.	--	--	To be initiated 3Q/80	
• Methodology development and initial characterization.	Vacuum bottoms, recycle and coal slurries.	SRC-II Pilot Plant; 2Q/80	Chemical fractionation and analysis of active compound classes.	Full range biomedical testing methods development.	--	--	To be initiated 3Q/80	
• Chemical analysis of SRC-II process waters.	Process and makeup water.	SRC-II Pilot Plant; 2Q/80	Chemical fractionation and analysis; trace metals analysis.	--	--	--	To be initiated 3Q/80	
<u>DuPont</u>								
• Biomedical screening of SRC-II, syn crude and petroleum materials.	Naphtha, vacuum bottoms, recycle slurry.	SRC-II Pilot Plant; 4Q/78	--	Ames testing and mouse skin painting.	--	--	Completed, 4Q/78 - 1Q/80	
<u>Pittsburgh Energy Technology Center</u>								
• Effects of temperature, light and gaseous environment on the stability of coal liquids.	Naphtha, middle and heavy distillates.	SRC-II Pilot Plant; 3Q/79, 1Q/80	Physical property measurement (viscosity, density), chemical fractionation and organics analysis.	--	--	--	Ongoing since 1978	
• Structural changes during coal liquefaction.	Coal, naphtha, middle and heavy distillates recycle slurry, process water and wastewater treatment influent.	SRC-II Pilot Plant; 3Q/79, 1Q/80	Chemical fractionation and organics analysis.	--	--	--	Ongoing since 1979	

Table Y.2.1 (continued)

Organization/Program	Material	Source (a)	Summary of Studies				Status
			Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	
• Analytical characterization of coal liquids.	Coal, naphtha, middle and heavy distillates, recycle slurry.	SRC-II Pilot Plant; 3Q/79, 1Q/80	Chemical analysis screening for specific hazardous compounds.	--	--	--	Ongoing since 1979
• RCMA testing of coal conversion solid wastes.	Vacuum bottoms.	SRC-II Pilot Plant; 2Q/80	ASTM and EPA leach testing, organics analysis of leachates.	--	--	--	To be conducted 2-3Q/80
Environmental Research and Technology, Inc.							
• Characterization of SRC-II process waters for organic and inorganic contaminants.	Process waters.	SRC-II Pilot Plant; 2Q/80; SRC-II PDU; 2Q/80	Standard wet chemical analysis for organic and inorganic contaminants.	--	--	--	Ongoing, 2Q/80
Washington State Univ.							
• Characterization of trace elements and their fate in materials from the SRC-II process.	Coal, distillates, coal and recycle slurries, process waters, gaseous streams, Stretford sulfur.	SRC-II Pilot Plant; 1979-1980	Identification and quantification of trace metals, balancing across the SRC-II process.	--	--	--	Ongoing, 1978 thru 1Q/81
Hittman Associates (e)							
• Initial screening characterization of SRC-II process and materials to identify streams of potential environmental concern.	Coal, distillates, recycle and coal slurries, process waters, gaseous streams, Stretford sulfur.	SRC-II Pilot Plant; 1Q/78, 1Q/79	Chemical fractionation and analysis for organics; trace metals analysis; wet chemical analysis of process waters.	Lower-tier biomedical testing.	Soil and plant response to SRC-II materials.	Algae growth and animal toxic response to SRC-II materials.	Completed, 1978-1979
Oak Ridge National Labs							
• Effect of waste treatment on the toxic properties of coal conversion effluent water.	Treated process water.	SRC-II Pilot Plant; data unspecified	--	--	--	Aquatic cellular organisms monitored for population and O ₂ uptake in diluted effluent.	Completed, 1978
STUDIES ON INDUSTRIAL HYGIENE							
Enviro-Control (e)							
• Industrial hygiene compliance survey of Fort Lewis SRC-II pilot plant.	--	SRC-II Pilot Plant; 1Q/79	--	--	Monitoring of pilot plant workplace environment for trace organics, trace metals, particulates and physical agents.	--	Completed, 1979

Table Y.2.1 (continued)

Organization/Program	Material	Source (a)	Summary of Studies				Status
			Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	
<u>Flow Resources Corp.</u>							
• Literature search of coal conversion occupational related issues and review of available data.	--	--	--	--	Evaluation of health-related issues and programs to identify potential hazards in coal conversion processes.	--	Completed, 1977
<u>STUDIES ON ENVIRONMENTAL CONTROL SYSTEMS</u>							
<u>Chem Pro, Inc.</u>							
• Performance evaluation of Chem Pro process for removal of phenols from water.	Process water	SRC-II PDU; 3Q/79	Identification of Total Organic Carbon and phenols in raw and treated process waters.	--	--	--	Continuing, 1980
<u>STUDIES ON SOLID WASTE AND DISPOSAL</u>							
<u>Oak Ridge National Labs</u>							
• RCMA testing of slag from gasification of SRC-II vacuum bottoms.	Gasifier slag	Texaco Pilot Plant Gasifier; 3Q/78	ASTM/EPA leach testing, and trace metal leachate characterization. CH ₂ Cl ₂ slag extraction for organics analysis.	--	Lysimeter testing of slag to determine trace metal mobility and fate.	Algae and animal response to diluted slag leachates.	Essentially completed, 4Q/78-1Q/80
• Field lysimeter testing of a Pittsburgh #8 coal.	Pittsburgh #8 coal.	--	Water leaching to identify leachate characteristics, including trace metals.	--	--	--	Essentially completed, 1978-1980
<u>Gulf Research and Development Co.</u>							
• Identification of residual organics in slag from gasification of SRC-II vacuum bottoms.	Gasifier slag	Texaco pilot plant gasifier, 3Q/78	Benzene extraction of slag to determine benzene solubles and PMA's.	--	--	--	Completed, 1979

Table Y.2.1 (continued)

Organization/Program	Material	Source (a)	Summary of Studies				Status
			Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	
STUDIES ON SRC-II PRODUCT MATERIALS							
DuPont							
• Biomedical screening of SRC-II, syn crude and petroleum materials	Fuel oil blend of 2.9/1 middle to heavy distillate	SRC-II Pilot Plant; 4Q/78	--	Ames testing and mouse skin painting	--	--	Completed, 4Q/78-1Q/80
Martinsville Energy Technology Center							
• Effect of hydro-treatment on the biomedical properties of SRC-II liquids.	Fuel oil blend of 3/1 middle to heavy distillates.	SRC-II Pilot Plant; 4Q/77	--	Ames testing.	--	--	Completed, during 1979
Battelle Northwest Labs							
• Effect of hydrotreatment on the chemical and biomedical properties of SRC-II liquids.	Fuel oil blend of 2.9/1 middle to heavy distillates.	SRC-II Pilot Plant; 1Q/79	Chemical fractionation and analysis of active compound classes. Distillation of blend into 100°C boiling fractions.	Ames testing of whole, fractionated and distilled materials.	--	--	Completed, during 1979
	Hydrotreated fuel oil, two severities.	UOP hydro-treater					
• Ecological screening of the effects of SRC-II products.	Fuel oil blend of 2.9/1 middle to heavy distillates.	SRC-II Pilot Plant; 1979	Chemical and physical characterization.	--	--	Acute and chronic toxicity testing of dissolved organics on aquatic organisms.	Completed, 1979
Oak Ridge National Labs							
• Screening of chemical, biomedical and environmental characteristics of an SRC-II product fuel oil.	SRC-II fuel oil blend, generic.	SRC-II Pilot Plant; data unspecified	Chemical fractionation and analysis, PNA identification.	Lower tier biomedical testing, acute toxicity testing, mouse skin painting studies.	--	Acute toxic characterization in fresh water and marine ecosystems.	Ongoing, 1978-1980
Pittsburgh Energy Technology Center							
• Performance of coal-derived liquids in a 20 HP fired tube boiler.	Middle and heavy distillates; fuel oil blend, 3/1 middle to heavy distillate.	SRC-II Pilot Plant; 3Q/79	Chemical and elemental analysis.	--	Monitoring of boiler emissions for SO ₂ , NO _x , particulates, VOM, CO; gaseous and particulate-borne PNA's.	--	Ongoing, 1980

Table Y.2.1 (continued)

Organization/Program	Material	Source (a)	Summary of Studies				Status
			Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	
• Structural changes during coal liquefaction.	Fuel oil blend, generic.	SRC-II Pilot Plant; 3Q/79	Chemical fractionation and organic analysis.	--	--	--	Ongoing since 1979
• Analytical characterization of coal liquids.	Fuel oil blend, generic.	SRC-II Pilot Plant; 3Q/79	Chemical analysis, screening for specific hazardous compounds.	--	--	--	Ongoing since 1979

Footnotes:**(a) Facilities include:**

- SRC II Pilot Plant - 30 tons per day capacity located at Port Lewis, Washington.
- SRC II PDU - 1 ton per day capacity located at Harnarville, Pennsylvania
- Toxaco Pilot Plant Gasifier - 12 tons per day capacity located at Montebello, California.

(b) Chemical fractionation performed using acid/base/neutral extraction, column partition chromatography, Thin Layer Chromatography or High Performance Liquid Chromatography. Detailed chemical analysis can include High Resolution Mass Spectroscopy, combined Gas Chromatography/Mass Spectroscopy, Nuclear Magnetic Resonance, Ultraviolet or Infra-red Spectroscopy.**(c) Lower-tier tests can include, but are not limited to, Ames Salmonella, mammalian cell mutagenesis and transformation, prophage induction, recombination, acute oral and dermal toxicity and teratogenicity. Long-term tests can include carcinogenicity, inhalation toxicology, developmental toxicity and neuro-behavior.****(d) Aquatic organisms used in tests typically include species representing primary producers (e.g., algae), sediment dwelling organisms (e.g., insect larvae) and fish species.****(e) Interagency programs: Hittman Associates funded through U.S. EPA, Enviro-Control funded through NIOSH.**

Table Y.2.2

SUMMARY OF CURRENT COMPONENT 2 ACTIVITIES
LONG-TERM BASELINE STUDIES ON SRC-II RELATED MATERIALS

Table Y.2.2. Summary of current Component 2 activities: long-term baseline studies on SRC-II-related materials

Organization/Program	Material	Source (a)	Summary of Studies				Status
			Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	
STUDIES ON PROCESS INTERMEDIATES							
Battelle Northwest Labs							
• Baseline chemical, biomedical and environmental characterization of SRC-II materials.	Naphtha, middle and heavy distillate, recycle and coal slurry, vacuum bottoms, process water.	SRC-II Pilot Plant; 2Q/80	Chemical fractionation and active compound class analysis, trace metal and inorganics analysis.	Full range biomedical testing.	Acute and chronic testing with aquatic organisms and terrestrial systems. Determination of environmental fate, transfer, and bioaccumulation.		To begin by 3Q/80
Gulf Mineral Resources Co.							
• Compliance toxicology testing of SRC-II materials.	Recycle and coal slurry, vacuum bottoms.	SRC-II Pilot Plant; 2Q/80	--	Acute, oral and dermal toxicity; inhalation toxicology, animal skin painting, carcinogenesis, DNA repair.	--	--	To begin by 3Q/80
Hydroscience, Inc.							
• Chemical characterization of process waters from Texaco gasification of SRC-II vacuum bottoms.	Process waters: • quench blow-down, • clarifier overflow, • lockhopper overflow, and • scrubber blow-down.	Texaco Pilot Plant; 1Q/80	Characterization of inorganics, trace metals, dissolved gases and priority pollutants.	--	--	--	Ongoing thru 2Q/80
Hittman Associates (e)							
• EPA Level II assessment of the SRC-II process to quantify potential environmental effects.	Coal, naphtha, middle and heavy distillates, coal and recycle slurry, vacuum bottoms, process and treated waters, Stratford sulfur, gas treatment blowdown solutions, wastewater treatment sludges and gas vents.	SRC-II Pilot Plant; 1-2Q/80	Chemical fractionation and analysis for organics, inorganic and trace metals analysis, volatile organic matter analysis.	Ames mutagenesis, mammalian cell testing, acute/chronic toxicity.	Terrestrial soil respiration.	Aquatic acute static bioassay.	Ongoing, 1980

Table Y.2.2 (continued)

Organization/Program	Material	Source ^(a)	Summary of Studies			Status	
			Chemistry ^(b)	Health & Safety ^(c)	Abiotic Environment		Biotic Environment ^(d)
<u>STUDIES ON SOLID WASTE AND DISPOSAL</u>							
<u>Battelle Northwest Labs</u>							
• Baseline environmental testing of slag produced by Texaco gasification of SRC-II vacuum bottoms.	Gasifier slag.	Texaco Pilot Plant; 1Q/80	Chemical analysis for trace metals/contaminant; aqueous and organic leaching.	Oral and dermal toxicity, teratogenicity, inhalation and developmental toxicity, neuro behavior; leachate carcinogenicity and toxicity testing.	Acute and chronic testing with aquatic organisms and terrestrial systems. Determination of environmental fate, transfer and bioaccumulation.	To begin 3-4Q/80	
<u>Oak Ridge National Labs</u>							
• Toxicity testing of slag produced by Texaco gasification of SRC-II vacuum bottoms.	Gasifier slag.	Texaco Pilot Plant; 1Q/80	ASTM/EPA leach testing, chemical analysis of leachates for trace metals, priority pollutants. Organic extraction of slag for trace organic characterization.	--	Lysimeter testing to determine mobility and fate of slag leachates.	Acute toxicological testing of slag leachates on aquatic organisms and terrestrial systems.	To begin 3Q/80
<u>Hydroscience, Inc.</u>							
• Physical, chemical and biological treatment of process waters from Texaco gasification of SRC-II vacuum bottoms.	Quench blow-down and clarifier overflow water.	Texaco Pilot Plant; 1Q/80	Chemical characterization of sludges produced during physical, chemical, biological treatment. Dewatering and incineration drying tests. Toxicity testing of sludges, trace metals.	--	--	Toxicity testing of treated waters and sludge leachates using aquatic organisms.	In progress, 1980
<u>STUDIES ON SRC-II PRODUCTS</u>							
<u>Battelle Northwest Labs</u>							
• Baseline chemical, biomedical and environmental characterization of upgraded naphtha.	Product Naphtha.	SRC-II Pilot Plant; 2Q/80 Hydrotreating pilot units; timing undetermined.	Chemical fractionation and analysis for active compound classes.	Full range biomedical testing.	Acute and chronic testing with aquatic organisms and terrestrial systems. Determination of environmental fate, transfer and bioaccumulation.	To begin by late 1980	
• Baseline chemical, biomedical and environmental characterization of SRC-II fuel oil.	SRC-II fuel oil blend, ratio not determined.	SRC-II Pilot Plant; 2Q/80	Chemical fractionation and analysis for active compound classes.	Full range biomedical testing.	Acute and chronic testing with aquatic organisms and terrestrial systems. Determination of environmental fate, transfer and bioaccumulation.	To begin by 4Q/80	

Table Y.2.2 (continued)

Summary of Studies							
Organization/Program	Material	Source (a)	Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	Status
<u>Gulf Mineral Resources Co.</u>							
• Toxicological testing of SRC-II product fuel oil.	SRC-II light fuel oil (middle distillate),	SRC-II Pilot Plant; 2Q/80	--	Acute, oral, dermal toxicity; inhalation toxicology; animal skin painting, carcinogenesis; mutagenesis, DNA synthesis.	--	--	To begin by 3Q/80

Footnotes:

(a) Facilities include:

- SRC II Pilot Plant - 30 tons per day capacity located at Fort Lewis, Washington.
- SRC II PDU - 1 ton per day capacity located at Harnsville, Pennsylvania
- Texaco Pilot Plant Gasifier - 12 tons per day capacity located at Montebello, California.

(b) Chemical fractionation performed using acid/base/neutral extraction, column partition chromatography, Thin Layer Chromatography or High Performance Liquid Chromatography. Detailed chemical analysis can include High Resolution Mass Spectroscopy, combined Gas Chromatography/Mass Spectroscopy, Nuclear Magnetic Resonance, Ultraviolet or Infra-red Spectroscopy.

(c) Full-range biomedical testing can include both lower tier and long term testing, depending upon the extent of the screening study database. Lower-tier tests can include Ames Salmonella, mammalian cell mutagenesis and transformation, prophage induction, recombination, acute oral and dermal toxicity and teratogenicity. Long-term tests can include carcinogenicity, inhalation toxicology, developmental toxicity and neuro-behavior.

(d) Aquatic organisms used in tests typically include species representing primary producers (e.g., algae), sediment dwelling organisms (e.g., insect larvae) and fish species.

(e) Interagency program; Hittman Associates funded by U.S. EPA.

Table Y.2.3

SUMMARY OF PROPOSED COMPONENT 3 ACTIVITIES:
PARAMETRIC STUDIES ON SRC-II RELATED MATERIALS

Table Y.2.3. Summary of proposed Component 3 activities: parametric studies on SRC-II-related materials

Organization/Program	Material	Source ^(a)	Summary of Studies			Status
			Chemistry ^(b)	Health & Safety ^(c)	Abiotic Environment	
<u>STUDIES ON SRC-II PROCESS INTERMEDIATES</u>						
<u>Battelle Northwest Labs</u>						
• Variation of chemical and biological properties of SRC-II materials with changes in process conditions and configuration, including: coal type, distillate endpoint, reactor configuration, and operating modes and conditions.	Coal, coal and recycle slurries, naphtha, middle and heavy distillates, process water, vacuum bottoms.	SRC-II Pilot Plant, SRC-II PDU; 1981-1984	Chemical fractionation and analysis for active compound classes.	Lower-tier biomedical testing, longer term extensive testing based on comparison with results of baseline studies.	Testing in environmental and ecological systems limited to use of acute and chronic screening assays, based upon results of baseline studies.	To be conducted, 1981-1984
<u>Washington State Univ.</u>						
• Characterization of the fate and form of trace metals released from coal during the SRC-II coal liquefaction process	Coal, coal and recycle slurries, naphtha, middle and heavy distillates, process waters, vacuum bottoms, gas streams, Stretford sulfur.	SRC-II Pilot Plant; 1979-1Q/81	Trace metal analysis.	--	--	Ongoing, thru 1Q/81
<u>STUDIES ON ENVIRONMENTAL CONTROL SYSTEMS</u>						
<u>Battelle Northwest Labs</u>						
• Chemical and biomedical characteristics of treated SRC-II process waters.	Process waters: NH ₃ removal, tar acid removal, and biological treatment.	Byproduct recovery pilot units Bench-scale biotreatment units 1981 and later	Chemical fractionation/ extraction and analysis for active compound classes.	Lower-tier biomedical testing, long term testing based upon results of lower-tier tests and baseline studies.	Environmental and ecological testing limited to use of acute and chronic screening essays, further work based on comparison to baseline results.	To be conducted, 1981 and later
• Chemical and biomedical characteristics of offgases from controlled combustion testing of SRC-II hydrocarbon materials.	Coal and recycle slurries, distillates and vacuum bottoms. Particulates, offgases.	SRC-II Pilot plant; 4Q/80 and later. Combustor PDU's, 4Q/80 and later.	Chemical fractionation/ extraction and analysis of particulate-borne hydrocarbons, gaseous hydrocarbons. Trace metal characterization, conventional pollutant characterization.	Limited lower-tier biomedical testing where quantities available.	--	To be conducted, 1981 and later

Table Y.2.3 (continued)

Summary of Studies							
Organization/Program	Material	Source (a)	Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	Status
<u>Mittman Associates (e)</u>							
• Detailed characterization of SRC-II pilot plant Stratford unit performance.	Acid and offgas streams, absorber solution, vents, product sulfur.	SRC-II Pilot Plant; 1981	Chemical fractionation and analysis: trace metals, trace organics, minor inorganic, and contaminants, and elemental composition.	--	--	--	To be conducted 1981
<u>STUDIES ON SOLID WASTE AND DISPOSAL</u>							
<u>Battelle Northwest Labs</u>							
• Chemical and biomedical characteristics of solid wastes/sludges produced from the SRC-II process.	Treatment system wastes: chemical, biological, and byproduct recovery, Incinerator solids, Combustor solids.	Treatment system testing units; evaporator/incinerator units controlled combustors.	Chemical fractionation and analysis for organics, inorganics, trace metals, leach testing of potential solids for disposal.	Lower-tier biomedical testing, further testing based on comparison to baseline studies.	Environmental and ecological system testing limited to use of acute and chronic screening assays, further work based on comparison to baseline results.		To be performed 1981 and later
<u>STUDIES ON SRC-II BYPRODUCT MATERIALS</u>							
<u>Battelle Northwest Labs</u>							
• Chemical and biomedical characteristics of SRC-II byproducts.	Tar acids	Byproduct recovery pilot units; 1981 and later.	Chemical fractionation and analysis for trace organics and metals.	Lower-tier biomedical testing.	Environmental and ecological system testing limited to use of acute and chronic screening assays.		To be conducted, 1981 and later
<u>STUDIES ON SRC-II PRODUCT MATERIALS</u>							
<u>Battelle Northwest Labs</u>							
• Effects of hydrotreatment on the chemical and biomedical properties of SRC-II product materials.	Raw and hydrotreated distillates: naphtha, middle, heavy, and fuel oil blend.	Hydrotreatment pilot units; 4Q/80 and later	Chemical fractionation and analysis for active compound classes.	Lower-tier biomedical testing.	--	--	To be conducted, 1981 and later
• Effects of refinery upgrading on the chemical and biomedical properties of SRC-II product materials.	Raw and upgraded distillates: naphtha, middle, heavy, and fuel oil blend.	Refinery upgrading pilot units; 1981 and later	Chemical fractionation and analysis for active compound classes.	Lower-tier biomedical testing.	--	--	To be conducted, 1981 and later

Table Y.2.3 (continued)

Organization/Program	Material	Source (a)	Summary of Studies				Status
			Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	
STUDIES ON SRC-II PRODUCT END-USE TESTING							
Battelle Northwest Labs							
e Environmental effects of utilizing SRC-II product fuel oils in end-use testing systems,	Middle and heavy distillates, full boiling range fuel oils.	SRC-II pilot plant; 1981 and later.	Chemical fractionation and analysis for trace organic and metal contaminants, gaseous and particulate-borne hydrocarbons, conventional pollutant characterization.	Lower tier biomedical characterization if ample quantities of particulates generated.	--	--	To be conducted, 1981 and later
	Particulates offgases.	End use testing pilot units: boilers, and turbines.					

Footnotes:**(a) Facilities include:**

- e SRC II Pilot Plant - 30 tons per day capacity located at Fort Lewis, Washington.
- e SRC II PDU - 1 ton per day capacity located at Harmarville, Pennsylvania
- e Texaco Pilot Plant Gasifier - 12 tons per day capacity located at Montebello, California.

(b) Chemical fractionation performed using acid/base/neutral extraction, column partition chromatography, Thin Layer Chromatography or High Performance Liquid Chromatography. Detailed chemical analysis can include High Resolution Mass Spectroscopy, combined Gas Chromatography/Mass Spectroscopy, Nuclear Magnetic Resonance, Ultraviolet or Infra-red Spectroscopy.

- (c) Lower-tier biomedical testing can include Ames Salmonella, mammalian cell mutagenesis and transformation, acute oral and dermal toxicity and teratogenicity.
- (d) Aquatic organisms used in tests typically include species representing primary producers (e.g., algae), sediment dwelling organisms (e.g., insect larvae) and fish species.
- (e) Interagency program: Hittman Associates funded by U.S. EPA.

Table Y.2.4

SUMMARY OF CURRENT COMPONENT 4 ACTIVITIES:
MONITORING STUDIES

Table Y.2.4. Summary of current Component 4 activities: monitoring studies

Organization/Program	Material	Source	Summary of Studies				Status
			Chemistry	Health & Safety	Abiotic Environment	Biotic Environment	
FORT LEWIS PILOT PLANT STUDIES							
Battelle Northwest Labs							
• Industrial hygiene monitoring.	In-plant contaminants.	Fort Lewis	--	Early warning system development.	Levels of contaminants characteristic of plant stream product fugitive emissions.	--	Ongoing
• Ecological assessment.	Plant liquid, solid and emission releases.	SRC-II process	--	Adapt existing models (source-transfer) to the SRC-II process in general.			1980 to 1981
• Terrestrial vegetation contact toxicity.	Product and slag.	Fort Lewis 1979	--	--	--	Determine vegetation response to atmospheric releases of SRC-II product and solid waste.	1979
	Gasifier bottoms, process water, incinerator solids, liquid products.	Fort Lewis 1980	Routine analytical testing of toxic components.	--	Organic and inorganic transfer from foliage to seeds.	Biomass response.	1980 to 1981
Pittsburg & Midway Coal Mining Company							
• Air quality data collection.	Area air quality.	Fort Lewis Site	--	--	15 monitoring stations - air quality characteristics and wind speed/direction.	Vegetation response.	1972 to Ongoing
• Surface water quality.	Area water quality.	Fort Lewis Site	--	--	Surface water quality monitoring at 3 stations - physical, organic and inorganic characteristics.	Bacteria.	1972 to ongoing
• Foliage monitoring.	Vegetation.	Fort Lewis Area	--	--	--	Foliage from 3 leeward and 1 upwind sites.	1976, 1978 to ongoing
Electric Power Research Institute							
• Health, personnel protection and regulatory considerations in the electric utility use of coal-derived fuels	--	--	--	Evaluation and potential use of existing health and environmental regulations - study results to the handling of coal derived fuel oils. Define areas for additional research. Estimate exposure effects. Draft guidelines and procedures.			ongoing

Table Y.2.4 (continued)

Organization/Program	Material	Source ^(a)	Summary of Studies				Status
			Chemistry ^(b)	Health & Safety ^(c)	Abiotic Environment	Biotic Environment ^(d)	
<u>Gulf Mineral Resources Company</u>							
• Workplace personnel monitoring.	Workplace.	Fort Lewis	--	Personnel and area monitoring. Skin contamination.	Particulates, organic compounds, noise, illumination.	--	Ongoing
• SRC-II Industrial hygiene procedures, methods and protective devices.	Workplace.	Fort Lewis	--	Personnel training in the use of protective clothing, first aid, personal hygiene, disciplinary program.	--	--	Ongoing
• SRC-II clinical monitoring.	Personnel.	Fort Lewis	--	Pre-employment physical, annual physical, and periodic pulmonary function and skin tests.	--	--	Ongoing
<u>Oak Ridge National Labs</u>							
• Computerized data management for environmental effects data.	--	SRC-II	--	Computerized data management to catalogue data results. System capabilities to include merging, statistical analyses and graphical-tabular displays.			1979 to ongoing
<u>Kadian Corporation</u>							
• Ground water quality, hydrology and remedial action plan.	Product	Fort Lewis pilot plant	--	Evaluate human health consequences of product spill.	Ground water quality and hydrology characterization. Installation of monitoring system. Development of remedial product spill plan.	Evaluate ecological consequences of product spill.	ongoing 1980
<u>PRE-CONSTRUCTION DEMONSTRATION PLANT STUDIES</u>							
<u>Pittsburg & Midway Coal Mining Company</u>							
<u>CONSAD Research Corp.</u>							
• Socioeconomic baseline investigations.	--	Morgantown site area	--	--	Site accessibility, regional economy, housing, community services and fiscal capabilities.	Demographics, labor availability and anticipated impacts.	1978 to 1979

Table Y.2.4 (continued)

Organization/Program	Material	Source	Summary of Studies				Status
			Chemistry	Health & Safety	Abiotic Environment	Biotic Environment	
<u>Stearns-Roger</u>							
• Surface water investigations,	--	Morgantown site area	--	--	Seasonal monitoring of all surface drainages. Complete range of physical and chemical characteristics.	--	1978 to 1979
• Noise Investigations.	--	Morgantown site area	--	--	Background noise levels. Seasonal, day and night, 24 hour.	--	1979
• Aquatic Ecology.	--	Morgantown site area	--	--	--	Monogahela River, 1978 to 1979 Robinson Run, Crooked Run, Crafts Run. Fish, ichthyoplankton, benthic macroinvertebrates, macrophytes, periphyton phytoplankton and zooplankton.	
• Vegetation investigations	--	Morgantown site area	--	--	--	Mapping and characterization of vegetation communities. Species identification and composition.	1978 to 1979
• Terrestrial animal investigations.	--	Morgantown site area	--	--	--	Mammals, birds, reptiles and amphibians, species composition, habitat, relative abundances, and distribution.	1978 to 1979
• Soils investigation. (West Virginia Univ., CDM Labs, MUS Corp., and Gulf Science and Technology Company)	--	Morgantown site area	--	--	Types - location, Trace elements, hydrocarbons, physical characteristics. Soil salvage-reclamation.	--	1979
• Groundwater investigations. (D'Appolonia Consulting Engineers, Inc.)	--	Morgantown site area	--	--	Occurrence, hydraulic characteristics, and water quality (organic and inorganic - Level I hydrocarbon).	--	1978 to 1979

Table Y.2.4 (continued)

Organization/Program	Material	Source	Summary of Studies				Status
			Chemistry	Health & Safety	Abiotic Environment	Biotic Environment	
• Geology Investigations. (D'Appolonia Consulting Engineers, Inc.)	--	Morgantown site area	--	--	Stratigraphy, lithology, structure, hazards, seismic history, risk, and mineral resources.	--	1979
• Meteorology and air quality investigations. (DeNardo and McFarland Weather Service)	--	Morgantown site area	--	--	Continuous monitoring of wind speed direction, air temperature, humidity, precipitation, potential pollutants.	--	1978 to 1979
• Archeological, historical and paleontological investigations. (West Virginia Geological and Economic Survey)	--	Morgantown site area	--	--	--	Identification of archeological, historical and paleontological characteristics.	1978 to ongoing

PNE-OPERATIONAL DEMONSTRATION PLANT STUDIESPittsburgh & Midway Coal Mining Co.Gulf Mineral Resources Company

• Air monitoring research.	Plant emissions.	--	--	Data to be used for industrial hygiene program.	Develop more sensitive tests for aromatic amines, cyanides, thiocyanates, and heterocyclics.	--	Ongoing
• Hi-Volume PNA silver membrane filter solid sorbent sampling research.	Plant emissions.	--	--	Data to be used for industrial hygiene program.	Develop more sensitive PNA monitoring system.	--	Ongoing
• SRC uniforms and protective clothing.	Plant pollutants.	--	--	Uniform and protective clothing for personnel.	--	--	Ongoing

Stearns-Roger

• Socioeconomics.	--	Morgantown site area	--	--	Economic conditions.	Labor migration and demographics.	Ongoing
• Soils.	--	Morgantown site area	--	--	Agronomic trace element and hydrocarbon analyses at 6 locations. Development of operational monitoring test plots.	Development of vegetation operational monitoring test plots.	Ongoing

Table Y.2.4 (continued)

Organization/Program	Material	Source	Summary of Studies				Status
			Chemistry	Health & Safety	Abiotic Environment	Biotic Environment	
• Terrestrial ecology.	--	Morgantown site area	--	--	--	Establishment of permanent study plots to monitor vegetation and animal populations. Vegetation monitoring 3 times/year, mammals 2 times/year.	Ongoing
• Aquatic ecology.	--	Morgantown site area	--	--	Chlorophyll content of phytoplankton and periphyton.	Sampling 2 times/year for fish, ichthyoplankton, benthic macro-invertebrates, phytoplankton, zooplankton, periphyton and macrophytes. Species composition, abundance and distribution.	Ongoing
• Surface water and sediments.	--	Morgantown site area	--	--	Seasonal water quality analyses for 38 characteristics. Seasonal sediment analyses for 30 characteristics.	--	Ongoing
• Groundwater.	--	Morgantown site area	--	--	Establishment of 4 monitoring wells. Quarterly analyses.	--	Ongoing
• Noise.	--	Morgantown site area	--	--	Baseline and construction noise level measurements.	--	Ongoing
• Meteorology and air quality.	--	Morgantown site area	--	--	Continuous measurement of wind speed-direction, temperature, relative humidity and precipitation. Air quality monitoring in accordance with US EPA.	--	Ongoing
<u>Pittsburgh Energy Technology Center</u>							
• Tenax GC PNA sampling system.	PNA.	--	--	Data to be used for industrial hygiene program.	Development of more sensitive PNA sampling device.	--	Ongoing

Table Y.2.4 (continued)

Organization/Program	Material	Source	Summary of Studies				Status
			Chemistry	Health & Safety	Abiotic Environment	Biotic Environment	
PRESENTLY ANTICIPATED DEMONSTRATION PLANT STUDIES							
Battelle Northwest Labs							
• Biological fate-aquatic system.	Water toxicants.	Morgantown site area	--	--	Physical-chemical characteristics.	Uptake and accumulation of toxicants by aquatic primary producers, benthic macroinvertebrates and fish in a sediment-water-organism test.	1984
• Terrestrial uptake.	Toxicants.	Morgantown plant	--	--	Physical-chemical characteristics. Soil sediment interaction.	Uptake and accumulation of toxicants by garden vegetables. Re-vegetation planning. Decomposition pathways.	1984
• Biological fate-solid waste Revegetation.	Solid wastes.	Morgantown plant	--	--	Chemical characterization of potential toxics.	Toxicity testing, vegetation toxicant uptake, accumulation and detoxification. Identify native and genetically improved species for revegetation.	1984
• Biological fate-terrestrial ecosystem.	Air emissions.	Morgantown plant	--	--	Chemical characterization of potential toxics.	Toxic transfer from vegetation to small mammal and accumulation through food chain.	1984
• Biological fate - aquatic ecosystem.	Solid wastes.	Morgantown plant	--	--	Chemical characterization of leachates and sediments.	Aquatic organism uptake, accumulation and transfer.	1984
• Biological fate - atmospheric emissions.	Air emissions.	Morgantown plant	--	--	Physical and chemical characterization of potential toxicants.	Uptake and accumulation of toxicants.	1984

Table Y.2.4 (continued)

Organization/Program	Material	Source (a)	Summary of Studies				Status
			Chemistry (b)	Health & Safety (c)	Abiotic Environment	Biotic Environment (d)	
• Solid waste disposal.	Solid wastes.	Morgantown plant	Physical and chemical characterization.	--	Physical and chemical characterization of water and sediments in proximity to the disposal site.	--	1984
• Aquatic ecology baseline.	Biologically active pollutants.	Morgantown plant	--	--	Physical and chemical characterization of potential pollutants.	Determination of baseline and any elevated body burdens of pollutants in Monongahela River organisms.	1984
<u>Pittsburgh & Midway Coal Mining Company</u>							
• Industrial hygiene program.	Emissions, solid waste and liquids.	Morgantown plant	--	Complete health-safety training and monitoring program.	Physical and chemical characterization and surveillance of potential pollutants.	--	1984

Appendix Y.3

OVERALL HEALTH AND SAFETY PROGRAM PROPOSED
FOR THE SRC-II DEMONSTRATION PLANT

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Appendix Y.3

OVERALL HEALTH AND SAFETY PROGRAM PROPOSED FOR THE SRC-II DEMONSTRATION PLANT

The health and safety program proposed for the SRC-II demonstration plant will consist of (1) a Health Protection Program aimed at protecting personnel from potential toxicological effects of some coal-derived materials and (2) a General Industrial Health and Safety Program aimed at protecting personnel from conditions and materials common throughout much of the chemical and petroleum processing industries. Both programs are discussed in the following sections.

Y.3.1 HEALTH PROTECTION PROGRAM

A comprehensive health protection program planned for the SRC-II demonstration plant will include the following subprograms:

1. Education,
2. Hygiene,
3. Medical,
4. Monitoring, and
5. Toxicology.

The demonstration plant health program will be patterned after and based on information obtained and developed since 1974 from the health program for the SRC pilot plant at Fort Lewis, Washington.¹

Y.3.1.1 Education

Objectives of the demonstration plant educational program will be to (1) inform the worker of the known and potential hazards in the work environment, particularly those associated with exposure to coal-derived materials, and (2) motivate the worker to use appropriate protective measures.

At the Fort Lewis SRC pilot plant, all new employees receive a health protection indoctrination that begins with an audiovisual slide presentation. This slide presentation shows the employee the potential health hazards present in the plant, the measures taken by the company to protect the employees, and what the employees must do to protect themselves. The presentation begins with a brief explanation of the plant process, then progresses to cover a variety of topics ranging from hazardous compounds, air monitoring, and animal toxicity studies to clothes changing during shift (when clothes get excessively contaminated), ear protection, footwear, gloves, skin barriers and emollients, skin cancer, skin wipe samples, reporting of skin abnormalities and injuries, respirators, and first-aid equipment. The slide presentation concludes by encouraging the employee to ask questions concerning the health protection program. All new employees are issued a health protection manual. Employees are then taken through the locker/changehouse area and shown the location of (1) entrances and exits (for both before and after work); (2) their lockers and stalls; (3) the shower, soap, and towels; and (4) clean and dirty clothing storage areas. During the tour of the locker/changehouse, the employee is encouraged to ask questions. Following the tour, the new employee is taken to the nurse's office for completion of the health protection induction.

Health protection classes on various subjects have been held for SRC employees since the spring of 1974. Generally, the classes are presented by the Supervisor of Health Protection, who is assisted by the SRC industrial hygiene technician. Occasionally, various members of the Corporate Medical Department, such as the Regional Medical Director or the Regional Senior Industrial Hygienist, have given health protection presentations. In addition to the SRC health protection slide presentation, classes in the SRC Health Protection Program cover the following topics: health and hygiene, toxic hazards to the human body, and toxic gases (SO₂, H₂S, and CO).

Y.3.1.2 Hygiene

Workers in the demonstration plant will be provided with protective equipment, clothing, facilities, and techniques to minimize exposure to coal-derived materials.

At the Fort Lewis pilot plant, each process area employee is issued rubber boots, leather high-top safety shoes, a hard hat, work coats, skin emollient, barrier creams, and two weeks' supply of work uniforms, underclothing, and socks. Each employee is assigned a locker in the locker room (clean area) and a stall in the changehouse (dirty area).

To protect the worker and to prevent carrying coal-derived contaminants off the plant site, special procedures have been developed for process area workers.

Upon coming to work, the employees go directly to the locker room and change into a clean uniform, which includes underwear, shirt, pants, and socks. Then, proceeding to the changehouse in shower shoes, the employees don work footwear, headgear, and rain suit, if needed. They then proceed to the work area, and the procedure is reversed at the end of their shift. On the way to the shower, dirty underclothing is left in a mesh bag in the changehouse (dirty area), and the dirty uniform is dropped in a dirty-clothes bin to be laundered. The employees are encouraged to thoroughly wash any coal product from their body. Skin examinations with an ultraviolet light are periodically given by the plant nurse to determine the effectiveness of the employees' showers. Any employee experiencing a spill of coal-solution solvents or chemicals during work is required to shower and change clothes as soon as possible.

Employees entering vessels or undertaking exceptionally dirty jobs are required to wear rain suits or coveralls over their uniforms and appropriate gloves. Impervious gloves providing good grip and wrist protection are favored by the employees. Neoprene appears to be more resistant to the solvent than other materials.

Y.3.1.3 Medical

The demonstration plant medical program will seek to (1) detect any occupationally related changes in worker medical profiles at the very earliest stages; (2) reverse, to the extent possible, any untoward impact; and (3) establish causality and preventive strategies if any occupationally related health problems are detected. The anticipated approach will be an extension of the SRC pilot plant program and will use preemployment and periodic medical examinations together with intensive analysis of such examinations and the occupational and personal histories of the workers.

The medical program for all exposed employees at the SRC pilot plant was started in 1974, before the plant was put into operation. Before an applicant is hired and annually thereafter, a medical examination is performed that consists of a medical history and a complete physical examination.

A complete blood count is performed consisting of a white blood cell count, hemoglobin, hematocrit, mean corpuscular hemoglobin concentration, and a differential count of white cells. Blood chemistries are performed that include total protein, albumen, calcium, inorganic phosphorus, cholesterol, uric acid, creatinine, total bilirubin, alkaline phosphatase, creatinine phosphokinase, lactic dehydrogenase, serum glutamic oxalacetic transaminase, potassium, sodium, blood urea nitrogen, and glucose. A urinalysis, including microscopic examination, is also done.

The skin is examined carefully for evidence of lesions, and the employees are asked to report any unusual skin conditions or lesions. The annual skin examination is supplemented by a quarterly skin examination by the plant nurse. Employees with dermatologic problems requiring a physician's care are referred by the plant nurse to a board-certified dermatologist.

Posterior-anterior and lateral chest x-rays are taken and interpreted by a board-certified radiologist. Pulmonary function tests are performed by the plant nurse.

Evaluation of the findings of the surveillance medical program has indicated no discernible changes in the medical profiles of the exposed employees. The only known occupational health problem encountered at the SRC pilot plant is mild transient dermatitis from skin contact with coal-derived materials.

The most common medical problem has been eye irritation; 50 to 60 cases, approximately 10 of which involved substantial quantities of coal-derived solvents contacting the employees' eyes, have been treated. In all cases, these eye irritations responded satisfactorily to first-aid treatment consisting of eye irrigation with saline solution. Follow-up medical examinations by an ophthalmologist confirmed the absence of any prolonged or permanent eye damage. The strongly irritating characteristic of the lower boiling fractions of SRC liquids is probably due to their phenolic content.

About 25 cases of transient erythema and multiple cases of mild folliculitis (mechanics acne) have been observed. These cases have responded well to temporary suspension of exposure.

Two employees developed squamous cell cancers. One employee had previously worked nine years in a petroleum refinery and was a cigarette smoker. The Washington State Board of Industrial Insurance Appeals determined that the lip cancer was unrelated to his employment in the SRC pilot plant. The other employee had only worked at the pilot plant for one year in a supervisory capacity, and the cancer was diagnosed as the result of exposure to sunlight from his past work history in such areas as Kuwait.

Current experience with the SRC pilot plant employee population has not revealed any of the problems experienced in the Institute plant population where 60 skin lesions were excised from a group of 359 coal hydrogenation workers during a five-year period.² The intensive employee health programs, in place at the SRC pilot plant essentially since start-up, are felt to be the major differences between the plants.

Y.3.1.4 Monitoring

The demonstration plant monitoring program will monitor the workplace for conventional toxic materials and physical agents common to refinery and chemical operations as well as to those exposures unique to coal liquefaction. Development work is currently under way on techniques for monitoring dermal contamination by potentially toxic materials; if successful, these techniques will be implemented in the demonstration facility.

In late 1972, before construction of the SRC pilot plant at Fort Lewis, Washington, an ambient air and water quality study was initiated around the plant site. Designed as a baseline assessment of the air and water quality in the vicinity of the plant, the study would then be used for comparison with a similar study to be accomplished during full plant operation to assess the impact of the plant on the surrounding community. This study subsequently was expanded to include determination of the fate of trace elements in the SRC process.

The baseline study was conducted during the period of December 1972 to December 1973. An air quality network composed of 15 sampling locations was established around the new facility in areas where a receptor would be exposed to a change in air quality. Measurements were made for suspended particulates, carbon monoxide, carbon dioxide, oxides of nitrogen, hydrocarbons, sulfur dioxide, and hydrogen sulfide. Water quality was measured through a series of sampling stations at locations on the adjacent lake, streams, swamps, and drainage ditches that might be influenced by the plant operation. Samples were collected and analyzed during the period December 1972 to August 1973. A biological examination of the lake, springs, creeks, and marshes adjacent to the facility was conducted in June 1973.

Start-up of the pilot plant began in late 1974 with integrated operation of the plant accomplished in February 1975. Environmental sampling and analyses will continue for the duration of the pilot plant operations. Results of the water sampling program for stations surrounding the pilot plant are shown in Table Y.3.1. Hundreds of samples have been obtained and analyzed with these typical results for various materials.

	SRC-I	SRC-II
Airborne organic vapors, ppm	<0.1	<0.1
Benzene vapor, ppm	<<1	<<1
Total suspended particulates, mg/m ³	~0.7	~0.6
Asbestos fibers, fibers/ml	<0.1	^a
Hydrogen sulfide, ppm	Trace	Trace
Sulfur dioxide, ppm	≤0.04	≤0.04
Phenolic vapors, ppm	<0.008	<0.008

^aNo asbestos used in plant during SRC-II operation.

As a result of this program, the following can be concluded:

1. Air quality around the SRC pilot plant is essentially unchanged from those conditions that existed during the baseline study.
2. Overall, little change occurred in the various waters sampled around the SRC pilot plant between the baseline period and the plant operating period.
3. Foliage studies in areas adjacent to the SRC pilot plant that would be probable receptors of airborne pollutants indicate no discernible effect upon the dominant vegetative species.

Table Y.3.1. Surface water quality at the Ft. Lewis SRC plant

	Average values (seven sampling stations)					
	1973 ^a	1976	1977	1978	1979	1980
Dissolved oxygen, mg/liter	8.8	7.6	7.2	6.8	7.0	7.2
Specific conductance, $\mu\text{ohm}/\text{cm}$	103	139	161	138	135	110
pH	6.8	7.1	6.6	6.4	6.8	7.7
Sulfate, mg/liter	10.8	9.9	26	16	17	21
Phenol, $\mu\text{g}/\text{liter}$	<50 ^b	<50 ^b	<5	<5	<5	<5
Chemical oxygen demand, mg/liter	2.7	7.1	11.2	9.1	4.6	11.2
Phosphate, mg/liter	0.05	0.01	0.08	0.08	0.06	0.16
Nitrate, mg/liter	0.26	0.19	0.26	0.19	0.11	Not available

^aBaseline.^bDetectable limit of analytical method then in use.

Y.3.1.5 Toxicology program

In early 1975, a toxicology program on SRC-I materials was initiated. The proposed work included various acute and subacute tests and chronic skin painting studies on laboratory animals. The scope of work was subsequently expanded to include chronic inhalation studies and teratogenic studies. Animal testing at a contract laboratory, Industrial Bio-Test (IBT), began early in 1977 and is summarized in Table Y.3.2. Initially, the program was devoted to SRC-I products and process materials, but it was terminated in June 1978 due to several problems experienced by the contract toxicology laboratory.³ A revised toxicology program that includes studies of SRC-II materials has been proposed to DOE. The SRC-II portion of the proposed program is summarized in Table Y.3.3. A complementary program developed at the Battelle Pacific Northwest Laboratory is described in Table Y.3.4.

The revised and extensive toxicological program has been designed for product and intermediate streams from the SRC-II process to evaluate the acute, inhalation, dermal, reproductive, and mutagenic properties of these materials on various test animals. This is an industrial program designed specifically to provide information on effects that may occur through plant operator exposure to these materials as well as exposure of the general public through commercial transport and product use. The program has been closely integrated with the Battelle program, which is primarily research oriented, to minimize overlap and provide the maximum amount of information.

Approval has been received from DOE to award subcontracts to (1) International Research & Development Corporation, Mattawan, Michigan, to conduct the acute, inhalation, and reproductive studies; and (2) SRI International, Menlo Park, California, to conduct the mutagenicity studies. Approval is expected in the near future for awarding a subcontract to conduct the dermal studies. Initiation of the preliminary studies is anticipated by September 1980. Collected during a special run earlier this year, all materials required for these studies are being stored at the Fort Lewis pilot plant.

Y.3.1.5.1 Results of the original IBT toxicology program

The only studies accomplished by IBT that were judged to be complete and acceptable were a number of acute studies including eye irritation and several pilot studies designed to determine appropriate dose levels for use in the subsequent chronic (two-year) studies. The principal results of these studies were that the light oil and wash solvent produced severe acute eye irritation in rabbits and the wet mineral residue produced extreme acute eye irritation. Pilot teratogenic studies on rabbits indicated that the wet mineral residue and the filter feed, while not giving convincing evidence of teratogenic effects, did show some evidence of fetal toxicity through increase in resorptions, decrease in percent of live young, and slight decreases in pup body weights. This information was reported to the EPA under the requirements of the Toxic Substances Control Act.

Y.3.1.5.2 Results of studies at Battelle Pacific Northwest Laboratories⁴

Microbial mutagenesis. The Ames *Salmonella* mutagenesis assay and modifications were used to study the mutagenic properties of naphtha, middle distillate, and heavy distillate from the SRC-II process as well as several other materials for comparative purposes. Results indicate

Table Y.3.2. SRC process summary of original toxicology program

Test material	Process solvent	Coal slurry	Filter feed	Dry mineral residue	Wet mineral residue	Light oil	Wash solvent	Pulverized SRC	Pulverized coal
Acute oral range finding in rats	X	X	X	C	X	X	X	C	
Acute dermal toxicity in rabbits	X	X	X	C	X	X	X	C	
Guinea pig skin sensitization	X	X	X	X	X	X	X	X	
Eye irritation in rabbits	C	C	C	C	C	C	C	C	
Acute inhalation range findings in rats	C					C	C		
Subacute dermal study in rabbits	X						X	X	
Subacute inhalation toxicity in Swiss mice	C	C	C		C	C	C		
Dermal teratogenicity in rats	X		X		X	X	X	X	
Dermal teratogenicity in rabbits	P		P		P	P	P	P	
Inhalation teratogenicity in rats and rabbits	P		D	P		X	P	P	P
Two-year skin painting in mice	X	X	X		X	X	X	X	
Two-year inhalation carcinogenesis	X			X			X	X	

X = material to be studied

C = study completed

P = pilot study completed

D = study deleted; impractical to aerosolize filter feed

Table Y.3.3. Revised toxicology program proposal for SRC-II

Materials	Task No.													Muta- genicity In vitro
	1					2		3			4			
	Acute studies					Dermal studies		Reproductive toxicology			Inhalation			
	Oral LD50	Dermal LD50	Eye irritation	Guinea pig sensitivity	Aspiration hazard	90-d ^a rabbit	18-month ^a mouse	Teratology		Dermal Mutagenicity rat	Inhalation LC50	90-d ^a rat	2-year rat	
								Dermal ^a rat/rabbit	Inhalation ^a rat/rabbit					
Coal slurry	X ^b	X	X	X		X	X	X		X				X
Stripper tower bottoms	X	X	X	X				X						X
Product fuel oil	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vacuum bottoms	X	X	X	X			X	X						X

^aPilot study necessary.^bMaterial to be studied.

Table Y.3.4. SRC-II studies by Battelle PNL

Assays	SRC-II materials ^a									
	Coal slurry	Naphtha	Middle distillate	Heavy distillate	SRC-II product	Vacuum bottoms	Stripper tower bottoms	Mineral residue	Mineral residue leachates	Fractions from SRC and other reference materials
Cellular studies										
Microbial mutagenesis	P ^a	C ^b	C	C	P	P	P	P	P	IP ^c
Mammalian cell toxicity and transformation		IP	IP	IP	P	P	P	P	P	IP
Chinese hamster ovary cell mutagenesis				P	P	P				P
Oral studies										
Acute toxicity		C	C	C	P	P	P	P	P	P
Subchronic toxicity		C	C	C	P	P	P	P	P	P
Developmental toxicity										
Prenatal effects		IP	IP	IP	P					P
Postnatal effects			IP	IP	P					
Transplacental carcinogenicity				P	P					P
Dominant lethality				P	P					P
Dermal Studies										
LD ₅₀		C	IP	C			P			IP
Carcinogenesis in mouse		IP	P	IP						IP
Inhalation studies										
Teratology								P		
Subchronic toxicity (90-day)								P		
Chronic (carcinogenesis)								P		
Pulmonary function								P		
Other toxicity tests										
Absorption and distribution				P						P
Enzyme induction			P	P	P					P
Metabolism of known carcinogens					P					P

^aP Proposed.

^bC Completed.

^cIP In progress.

that, of the three major process stream materials from the SRC-II process, the heavy distillate is the most active mutagenically. The light and middle distillates showed no mutagenic activity. The known chemical carcinogen, benzo[a]pyrene, shows approximately three times the activity of heavy distillate, while another well-known chemical carcinogen, 2-aminoanthracene, is about 100 times as active. Raw shale oil shows a small degree of activity, and crude petroleum showed no activity in the Ames system. Further separation of the heavy distillate into a number of discrete fractions, Ames assays, and additional identification studies have suggested that much of this activity may be attributed to the aromatic amines present in the material.

The actual comparison of the mutagenicity of SRC materials, shale oils, and crude petroleums in *Salmonella Typhimurium* TA98 gives the following results:

Materials	Number of revertants per μg of material
SRC-II	
Heavy distillate	40.0 $\pm$ 23
Middle distillate	0.01
Light distillate (naphtha)	0.01
SRC-I	
Process solvent	12.3 $\pm$ 1.9
Wash solvent	0.01
Light oil	0.01
Shale oil	
Paraho-16	0.60 $\pm$ 0.19
Paraho-504	0.59 $\pm$ 0.13
Livermore L01	0.65 $\pm$ 0.22
Crude petroleum	
Prudhoe Bay	0.01
Wilmington	0.01
Pure carcinogens	
Benzo[a]pyrene	114 $\pm$ 5
2-Aminoanthracene	5430 $\pm$ 394

Oral toxicity. Acute toxicity studies were done on SRC-II naphtha, middle, and heavy distillates using the female Wistar rats. The LD₅₀ values (dose in g/kg body weight required to kill 50% of the animals in 3 days) of the SRC-II materials were all between 2.3 to 3.8 g/kg as compared with shale oil, diesel oil, and crude petroleum, all of which were in excess of 9.0 g/kg. Subchronic toxicity studies gave substantially lower values than the acute studies. Data also indicate that either the material or the effects are cumulative for all three substances.

Developmental toxicity. Because the prenatal individual is significantly more sensitive to a number of toxic agents than are adults, studies have been performed to determine the effects of SRC-II materials administered during pregnancy in rats. The study materials were administered once daily for five consecutive days at each of two different periods, 7 to 11 and 12 to 16 days of gestation (d.g.). The first represents the early period of organogenesis, when organs are beginning to form, and the second represents late organogenesis, a period of rapid growth and early maturation.

Administration of light, middle, or heavy distillate at 7 to 11 d.g. did not significantly increase the incidence of malformations over that found in the control group. Fetal weight was only affected at doses producing symptoms of maternal toxicity (inhibition of weight gain or death of some dams). The incidence of prenatal mortality was increased by all three materials, but again at doses producing some maternal toxicity.

These materials produced more severe fetal effects when administered at 12 to 16 d.g. than when given from 7 to 11 d.g. The frequency of prenatal mortality was increased by all three materials, and the incidence of malformations was increased by heavy distillate. The increased frequency of prenatal mortality occurred in the absence of signs of maternal toxicity, but increases in incidence of malformations produced by heavy distillate were accompanied by inhibited maternal weight gains during pregnancy. The principal malformations observed were cleft palates, immature lungs, and herniated diaphragms.

Dermal toxicity carcinogenesis. Initially, pilot studies were performed on the SRC-II light distillate (naphtha) and heavy distillate in which mice were exposed to the maximum tolerated

dose as determined by response in terms of inflammation, cellular changes, etc. This was done as a preliminary to the carcinogenesis study to select proper dose levels. Both materials were then subjected to a two-year dermal carcinogenesis study at three dose levels and compared with shale oil, crude oil, and two known chemical carcinogens. At the end of two years, both the heavy and medium dose levels of the heavy distillate showed a 100% tumor response with a minimum latency period of 56 d. The light distillate, however, showed essentially zero tumor response at all dose levels. For comparison, crude petroleum gave a 100% tumor response at the high dose level but a minimum latency of 260 d; shale oil also gave a 100% tumor response at a minimum latency of 95 d.

Y.3.2 GENERAL INDUSTRIAL HEALTH AND SAFETY PROGRAM

In addition to the program specifically aimed at protecting the workers and the surrounding community from the potential toxicological effects of the coal-derived materials, a program will be developed to protect them from the acute and chronic health and safety hazards resulting from exposure to such things as toxic gases, coal dust, noise, combustible and explosive materials, and high pressures. Most of these health and safety hazards will be similar to those encountered in a petroleum refinery, petrochemical plant, or steam power plant. Through application of currently available technologies and industrial practices (including safety hazards analyses), mitigation of the hazards probably can be reduced to equivalent levels of the refinery, petrochemical, and electrical generation industries. Brief discussions of planned actions follow.

Y.3.2.1 Hydrogen sulfide (H₂S) and carbon monoxide (CO)

With regard to these two toxic gases, the SRC-II demonstration plant is quite similar to a petroleum refinery; each handles large quantities of these toxic gases.

The demonstration plant will follow the same procedures as refineries use to protect employees and the surrounding community from these materials, that is, (1) proper design, including construction materials, (2) the ability to rapidly isolate and depressure the affected system, (3) burning of the vented materials to greatly reduce toxicity, (4) a well-designed fire protection system, and (5) trained fire fighting personnel on duty at all times, backed up by local fire departments.

Data collected in the Fort Lewis pilot plant health protection and safety program have shown that normal airborne concentrations are so low that there is no health hazard due to long-term exposure to hydrogen sulfide or carbon monoxide. In isolated cases, however, substantial releases that occurred for short periods of time have created safety hazards. Quantities handled in the demonstration plant will be much greater than those handled in the pilot plant, but, if a large leak occurs, a larger area of high concentration will increase the potential of short-term exposure. However, note that the quantities of hydrogen sulfide and carbon monoxide handled in the SRC-II demonstration plant will be much less than those handled in large petroleum refineries, many of which are located in highly populated areas.

In comparison with the Fort Lewis pilot plant, the demonstration plant will have many more elevated operating areas, some with numerous levels that will make evacuation more difficult. As such, the hazards of these toxic gases will more nearly approximate those of a refinery or some large petrochemical plants.

A more comprehensive program will be required for the demonstration plant than for the pilot plant to protect personnel from these two toxic gases. Such a program may include (1) restriction of the number of persons allowed above ground-level at any one time, (2) requirements that employees have gas masks on their person when in certain areas (especially when above ground level or inside vessels), and (3) instruments that continuously monitor the gas concentrations and sound an alarm above a specified concentration.

As in a refinery, however, the release of large quantities of hydrogen sulfide and carbon monoxide will be prevented or minimized by proper design of the equipment and piping (including materials of construction), by providing emergency release systems to controlled combustors and/or flares, and by training personnel in the accepted operating and maintenance procedures.

Y.3.2.2 Coal dust

High concentrations of coal dust present a safety hazard due to potential explosion and a health hazard due to long-term inhalation. Coal pulverization and handling of the dust will take place in an inert atmosphere. Equipment will be designed to minimize the release of dust to the environment, including dust recovery equipment such as bag filters. Experience gained in the design and operation of coal-fired power plants and pulverized coal gasification plants will be utilized. During some maintenance activities, dust masks or respirators will be required.

Y.3.2.3 Noise

Noise levels throughout the plant will be limited to acceptable limits by proper equipment design, location, and soundproofing to limit workers' exposure to acceptable levels whenever feasible. For some specific short-term activities and during emergency conditions, ear muffs or ear plugs may be required in some areas. The design will be such that the noise level at the plant boundary will meet regulatory standards.

Y.3.2.4 Combustible and explosive materials

The SRC-II demonstration plant, as well as petroleum refineries, handle large quantities of combustible and explosive materials — oils, liquefied gases, methane, and hydrogen. Although the quantities of these materials will be large in the SRC-II demonstration plant, the quantities handled in most modern refineries are far greater. The design, operating, maintenance, and emergency procedures for handling these materials will be patterned after those developed for petroleum refineries.

Y.3.2.5 High-pressure equipment and piping

Again, this type of equipment and piping is not unique to the SRC-II demonstration plant. Materials such as polyethylene, ammonia, and methanol are prevalent in petroleum refineries and petrochemical plants. Similar safety practices will be followed.

Y.3.2.6 Corrosion and/or erosion

For much of the SRC-II demonstration plant, the design, operation, and materials of construction required to prevent serious corrosion and/or erosion can be patterned after experience gained in refineries and petrochemical plants. This experience will be supplemented by the large amount of corrosion and/or erosion data obtained on many different materials of construction at the Fort Lewis and P-99 pilot plants.

Y.3.2.7 Nickel carbonyl

Under certain conditions, highly toxic nickel carbonyl can be formed from nickel catalyst during its cooldown. However, procedures to prevent its formation have been developed and used successfully for many years in refineries and hydrogen production plants. Such procedures will be followed rigorously in the SRC-II demonstration plant with the relatively small amount of nickel catalyst that will be included in the plant.

Y.3.2.8 Safety analyses

Formal safety hazards analyses will be performed during the design of the SRC-II demonstration plant. The direct effects of fires, explosions, and acute exposures to process materials will be evaluated to the extent possible. These analyses will incorporate elements of probabilistic risk assessment, failure modes, effects analysis, or fault-tree analysis, as appropriate. Analyses will be performed by hazards analysis teams composed of individuals who are knowledgeable of the process, equipment, and safety issues associated with the project. A subcontractor experienced in these types of analyses will train the analysis teams in proper procedures and will supervise and audit their work.

Initially, during the process design, the teams will concentrate on reviews of the process flow diagrams with each team responsible for a specific area of the plant. As risks or hazards are identified, the team will evaluate the potential impacts. As detail design progresses, additional analyses will be made. Some preliminary safety analyses work has been performed and is summarized in Tables Y.3.5 and Y.3.6.

These tables identify hazards and protective actions but not the impact of a failure or a possible event. The safety analyses will evaluate the impact of specific events such as a blockage in the piping downstream of the dissolvers, trip-out of the gasifiers, and tube failure in a preheater, and will identify the need for additional methods, measures, design changes, or equipment to mitigate the potential impacts.

The documented findings of the design safety hazards analysis teams will be published in a Safety Analysis Report.

Table Y.3.5. Process safety evaluation: definitions of hazards, risks, and protective actions

Hazard	Risk	Protective actions ^a
<i>b</i>	Burns, leak potential	1, 2, 3
<i>c</i>	High energy release, leak potential	1, 2, 3
<i>d</i>	High energy release, maintenance exposure	1, 2, 3, 4
<i>e</i>	Fire, explosion	1, 2, 3, 4, 5
<i>f</i>	Ignition source	3
<i>g</i>	Poisoning, burns	4, 5
<i>h</i>	Leaks, noise, maintenance exposure	4, 5
<i>i</i>	Equipment damage	2, 4
<i>j</i>	Personnel exposure	1, 2, 3, 4, 5
<i>k</i>	Personnel exposure, exceeding of regulatory limits	1, 2, 3, 4
<i>l</i>	Freezing of process and instrument lines, poor visibility, slipping	3, 4, 5
<i>m</i>	Loss of control, maintenance exposure, pollution potential	4, 5
<i>n</i>	Injury to operating and maintenance personnel	3, 4
<i>o</i>	Catastrophic failure of vessels and/or piping	4
<i>p</i>	Catastrophic failure of vessels and/or piping	4

^aDefinitions of protective actions: (1) extensive use of systems for vapor recovery, enclosed pressure relief, liquid drainage, and waste recovery for normal operating and emergency situations; (2) highly automated equipment with elaborate instrumentation to aid in control of the process and to minimize the number of personnel subject to exposure; (3) carefully planned equipment locations and overall plant layout arrangement; (4) special and specific design, operational and maintenance procedures, practices, and methods; and (5) protective clothing and gear, plus monitoring equipment.

^bHigh temperatures.

^cHigh pressures.

^dLarge reactors.

^eFlammable materials.

^fFired heaters.

^gAcidic liquids, gases, and solids.

^hCompressors, pumps, and valves.

ⁱDynamic fluctuations.

^jToxic gases and chemicals.

^kPollution (air and water).

^lWeather.

^mPlugging and coking.

ⁿMoving equipment (conveyors and elevators).

^oHydrogen embrittlement.

^pStress corrosion cracking.

Table Y.3.6. Process safety evaluation: summary of plant hazards and protective actions

Plant unit and number	Degree of risk	Hazards
Dissolver plant, 11	High	<i>a, b, c, d, e, f, g, h, i, j, k, l, m, n, o</i>
Hydrogen treating and recovery, 12	Medium high	<i>a, b, d, f, g, h, i, j, k, n, o</i>
Syngas production, 21	Medium high	<i>a, b, c, d, e, f, g, h, i, j, k, l, o</i>
Syngas shift conversion, 22	Medium	<i>a, b, c, d, f, g, h, i, j, k, o</i>
Hydrogen purification and compression, 23	Medium	<i>b, d, f, g, h, i, j, k, o</i>
Syngas purification, 24	Medium	<i>b, d, f, g, h, i, j, k, o</i>
Methanation, 25	High	<i>a, b, c, d, g, h, k</i>
Low-pressure gas compression and treating, 31	Medium	<i>d, f, g, h, i, j, k</i>
Product gas plant, 32	Medium	<i>b, d, f, g, h, i, j, k</i>
Sulfur recovery, 33	Medium	<i>a, c, d, e, f, g, h, i, j, k, l</i>
Refining plant, 34	Medium	<i>a, d, e, f, g, h, i, j, k, l, o</i>
Hydrosulfurization unit, 35	Medium	<i>a, b, c, d, e, f, g, h, i, j, k, m</i>
Ammonia recovery, 41	Medium	<i>d, f, g, h, i, j, k</i>
Tar acids recovery, 42	Medium	<i>d, f, g, h, i, j, k</i>
Plant water reclamation, 43	Medium	<i>d, e, f, g, h, i, j, k</i>
Oxygen plant, 44	High	<i>b, d, e, g, h, i, j, k</i>
Steam generation, 51	Medium	<i>a, b, e, g, h, j, k</i>
Raw water system, 52	Low	<i>f, g, i, j, k</i>
Cooling water system, 53	Low	<i>d, f, g, i, j, k</i>
Coal-supply system, 61	High	<i>d, i, j, k, l, m</i>
Coal-crushing system, 62	High	<i>d, e, i, j, l, m</i>
Fine-coal-handling system, 63	Medium	<i>d, g, i, j, l, m</i>
Slag handling system, 64	Medium	<i>f, g, i, j, k, l, m</i>
Slag disposal system, 65	Medium	<i>f, g, i, j, k, l, m</i>

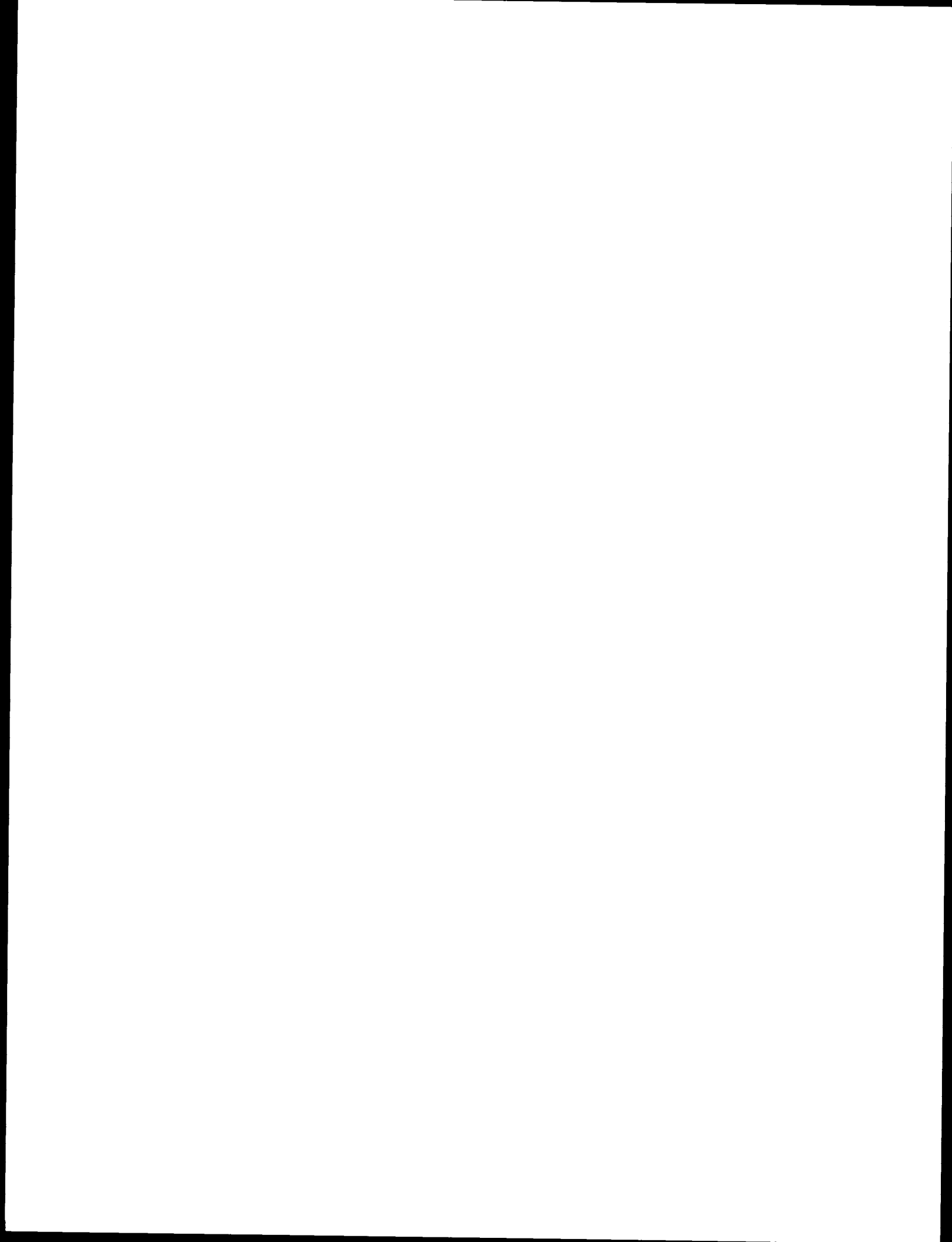
^aHigh temperatures.^bHigh pressures.^cLarge reactors.^dFlammable materials.^eFired heaters.^fAcidic liquids, gases, and solids.^gCompressors, pumps, and valves.^hDynamic fluctuations.ⁱToxic gases and chemicals.^jPollution (air and water).^kWeather.^lPlugging and coking.^mMoving equipment (conveyors and elevators).ⁿHydrogen embrittlement.^oStress corrosion cracking.

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Appendix Y.4

COMPARISON OF HEALTH RISKS IN PETROLEUM REFINERIES AND SRC PROCESSING



Appendix Y.4

COMPARISON OF HEALTH RISKS IN PETROLEUM REFINERIES AND SRC PROCESSING

Probably the two major similarities in SRC processing and oil refining are:

1. Both facilities process hydrocarbon material at high temperatures and pressures. The temperatures and pressures required for coal hydrocracking and hydrogenation reactions taking place in the dissolver vessel are equivalent to the operating conditions of a refinery's hydrocracking unit.
2. Both facilities must handle large quantities of toxic gases such as H₂S. Similar processes can be used to convert it to by-product elemental sulfur.

While such similarities do exist, the main differences between SRC-II and a petroleum refinery, especially in regard to health effects, are a direct result of the difference in feedstock, namely coal vs petroleum crude oil.

Coal unloading, storing, conveying, and crushing can be sources of a fugitive coal dust. Similarly, the major solid waste from the SRC-II plant, slag, can be a source of fugitive emissions. While these types of emissions are not found in petroleum refineries, they are not peculiar to SRC-II and can be controlled by conventional control technology.

Undoubtedly the major difference between SRC and refineries is the relatively higher biological activity of some coal-derived liquids when compared to petroleum distillates. Coal is highly unsaturated, that is, it has a much higher carbon-to-hydrogen ratio than petroleum. Although the SRC-II process results in products with a decrease in this ratio, it still is somewhat higher than petroleum products. The unsaturation in some coal-derived liquids is primarily in the form of condensed aromatic rings often referred to as polynuclear aromatics (PNAs). Some PNAs are known to be carcinogenic. Because of coal's high nitrogen content, coal liquids contain a higher nitrogen content than petroleum products. This is true even though the SRC-II process converts some of the original coal-nitrogen to ammonia that is recovered as a by-product.

Recent investigations at Battelle Northwest Laboratories have indicated that the light (naphtha) and middle distillates have little biological activity but that the heavy distillate has significant activity. Studies attribute a substantial portion of this biological activity to aromatic amines, for example, polynuclear aromatics with nitrogen. Note that heavy distillate will be handled in only a few areas of the plant (coal dissolver, product separation, liquid refining and fractionation, hydrogen recovery, and naphtha hydrogenation) and that its vapor pressure at ambient temperature is quite low. A comparison of the mutagenicity of solvent-refined coal materials, shale oils, and crude petroleum in *Salmonella Typhimurium* TA98 tests follow:

Materials	Number of revertants per microgram of material
SRC-II	
Heavy distillate	40.0 ± 23
Middle distillate	0.01
Light distillate (naphtha)	0.01
SRC-I	
Process solvent	12.3 ± 1.9
Wash solvent	0.01
Light oil	0.01
Shale oil	
Paraho-16	0.60 ± 0.19
Paraho-504	0.59 ± 0.13
Livermore LO1	0.65 ± 0.22
Crude petroleum	
Prudhoe Bay	0.01
Wilmington	0.01
Pure carcinogens	
Benzo(a)pyrene	114 ± 5
2-Aminoanthracene	5430 ± 394

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Appendix Z

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Z.1 INTRODUCTION

Although accidental releases on the plant site are not expected to result in public exposure, it is likely that transportation of the products will result in accidental releases that result in direct and indirect exposure of the public to process materials. Direct exposure may result from contact with the material because of involvement in the accident or response and cleanup operations or because of inhalation of materials aerosolized as a result of fire. Indirect exposure may result from contamination of surface water and groundwater affecting municipal water supplies and aquatic life.

Based on observed rail spill frequencies for similar products, spills of SRC-II liquids to bodies of water can be expected to occur every 30 to 60 months (Sect. Z.4.1). The worst-case spill of SRC-II liquids in transit is considered to be a loss of 75,800 liters (20,000 gal) into the Potomac River at the Harper's Ferry, West Virginia, crossing. Such a spill could cause a minor water supply emergency for Washington, D.C., because the city's water intake is 80 km (50 miles) downstream from the crossing. Such a worst-case spill is considered exceedingly unlikely (Sect. Z.5.2.1).

Of all liquid petroleum products and crude oil shipped on the Chesapeake Bay during 1976-78, about 1.4 bbl were spilled for each 100,000 bbl shipped. This accident rate would result in about 50 bbl of SRC-II liquid being spilled in estuaries and oceans per year. A worst-case spill during marine transport would be the loss of an entire barge, equalling 3,411,000 liters (900,000 gal) of SRC-II liquid.

Potential impacts of spills of by-products such as anhydrous ammonia, sulfur, butane, propane, and tar acid during tank truck transportation are not considered in this spill analysis. The first four of these products are standard items of commerce, and all will be produced in volumes that are insignificant compared with the volume of existing commerce and the volume of SRC-II liquid fuel oils (Table Z.1). The one product that is viewed with some concern from a health standpoint is tar acid, of which only 43 bbl/d will be produced. Therefore, only about six truckloads of tar acid per month will be transported. A spill of tar acid to a stream would have impacts similar to those of SRC-II liquid although the volumes would be smaller (Sect. Z.5.2). Best standard practice safety precautions will be used in the shipment of the tar acid, but if such shipments are determined to involve excessive risk, the tar acid could be blended with the SRC-II liquid fuel product or burned onsite as a plant fuel.

In this appendix, the likelihood of spills in transit is discussed, along with potential impacts of such spills, cleanup and mitigation measures that might be taken, and regulations relating to the transportation of hazardous materials. This analysis assumes full plant production, although the facility will operate at well below 100% capacity for the first 3 to 5 years.

Z.1.1 Health risks and market selection

Three liquid products will be produced by the SRC-II Demonstration Plant: a naphtha component that will be sold to petroleum refiners to make gasoline, a light fuel oil, and a heavy fuel oil. Programs are in place to define any health risks associated with using these products (see Sect. 4.1 and Appendixes T, Y, and AA). It is not yet possible to speak with certainty, but preliminary results suggest that only one of the three has potentially harmful long-range effects. Animal tests at Battelle's Pacific Northwest Laboratory, funded by DOE, indicate that prolonged exposure to heavy fuel oil may have the potential to cause cancer in humans and may be hazardous to the human fetus. Preliminary research suggests that the naphtha or light fuel oil products may not pose similar hazards (see Sect. 4.1 for a more complete discussion of the health risks).

The naphtha product exported from the plant will be fairly similar to gasoline. It will therefore pose the same dangers (fire and explosion hazards, etc.) to product users. The light fuel oil is a skin irritant and can produce skin burns.

Table Z.1. Population of selected towns along the southern alternative SRC rail route from Morgantown, West Virginia, to Baltimore, Maryland

Town	State	Population
Morgantown	West Virginia	30,000
Fairmont	West Virginia	26,300
Grafton	West Virginia	6,433
Rowlesburg	West Virginia	829
Terra Alta	West Virginia	1,474
Oakland	Maryland	1,786
Piedmont	West Virginia	1,763
Keyser	West Virginia	6,586
Cumberland	Maryland	25,700
Hancock	Maryland	1,881
Martinsburg	West Virginia	13,100
Harper's Ferry	West Virginia	423
Brunswick	Maryland	3,566
Mount Airy	Maryland	1,825
Sykesville	Maryland	1,399
Ellicott City	Maryland	2,100
Baltimore	Maryland	786,000

Sources: *Rand McNally Road Atlas*, Rand McNally & Co., Chicago, Ill., 1980; Rand McNally 1979 population estimates for cities over 25,000; 1970 census or latest available estimates for other cities and towns.

Research is beginning to suggest that the potentially hazardous components of heavy fuel oil may be a relatively small fraction of the total product. One control strategy that could develop is to remove such components from the heavy fuel oil product by further processing (discussed in Sect. Z.6). Another approach is for DOE to impose the restriction that the heavy fuel oil product be used only in markets where product handling and use can be carefully controlled.

The commercial plant will be a private venture, and operation of it will be under the control of the industrial participant. The results of ongoing health effects research, as discussed in Sect. 4.1 and Appendix Y, will be used in establishing procedures for safely handling the product in the plant and at the end user. Currently, DOE is studying the applicability of the Toxic Substances Control Act to SRC-II products (see Appendix T).

A marketing strategy has been developed that takes distribution safety into account. Possible markets were evaluated in terms of the ease or difficulty of assuring safe product distribution and use. The home heating market, for example, was quickly ruled out for heavy fuel oil because the fuel distribution system is too complex (hundreds of delivery trucks are required to move fuel through residential areas) and because the delivered fuel must be stored in thousands of home storage tanks and used in many different types of furnaces and boilers. The commercial market (department stores, office buildings, etc.) was excluded for similar reasons.

This type of analysis led to the conclusion that electric utilities offer the most controlled, and therefore the safest, market for SRC-II heavy fuel oil. A single, large boiler in an electric utility would consume a substantial fraction of the total heavy fuel oil product from even a commercial scale SRC-II operation. This fact greatly simplifies the distribution system because very large volumes of fuel will be moved to only one or two locations. This plan will be more amenable to control than sending small shipments to a wide range of customers. In commercial plants of the future, distribution to electric utilities would probably involve dedicated pipelines that would further minimize the risk of problems during product distribution. In addition, electric utilities have relatively small, but skilled, staffs responsible for fuel storage and use. This fact simplifies educating and safeguarding personnel through the establishment and policing of appropriate operating procedures.

Z.1.2 Product transportation

Distribution of products from the demonstration plant is still under study. It is impossible at this time to specify the transportation routes that will be used. The following alternatives are

under study and will be used to evaluate the environmental impacts of transporting SRC-II products, including the fate of SRC-II products should accidents and resultant spills occur.

1. Unit trains would transport fuel oil and gasoline blending stock to a barge terminal along the Atlantic seaboard between Norfolk, Virginia, and Philadelphia, Pennsylvania. Baltimore Harbor was chosen as an example for this analysis. These products would then be transferred to ocean barge for delivery to the ultimate customer. Fuel oil would go to one or more utilities with barge unloading capability. The gasoline product would go to an East Coast refinery for blending.
2. All products would be shipped by unit train to the end user. This alternative is not considered to be very likely since most end users do not have the capability of unloading unit trains.
3. The gasoline blending stock could conceivably be shipped by barge to refineries along the Ohio River.
4. Samples of middle distillate fuel oil could conceivably be shipped in carload quantities to potential industrial end users. Shipments under this alternative would be on an ad hoc basis as potential industrial customers were developed and arrangements were made for them to accept sample shipments.

It should be noted that alternatives 1 and 2 are mutually exclusive. Alternatives 3 and 4 would apply to a small portion of the product output and would be in conjunction with either alternative 1 or alternative 2.

Propane and butane are expected to be shipped by rail and/or truck. Methane, if transported offsite, would be connected into a natural gas pipeline in the vicinity.

The bulk of the products will be going to a very limited number of customers. Therefore, once the distribution network has been established, the transportation and handling of SRC-II products can be tightly controlled.

Z.2 DESCRIPTION OF TRANSPORTATION ROUTE FROM FORT MARTIN, WEST VIRGINIA, TO END USERS

Z.2.1 Description of the railroad route from Fort Martin, West Virginia, to Baltimore, Maryland

For purposes of this analysis it was assumed that the SRC-II distillate product will be transported to Baltimore, Maryland, although alternative ports under consideration range from Norfolk, Virginia, to Philadelphia, Pennsylvania. A number of possible routes exist from the site to Baltimore, and identification of the specific route to be used has not been made. Two rail routes were chosen by computer analysis as representative of typical routes from the proposed Fort Martin site to Baltimore. One route leaves the site to the north through Pennsylvania to Maryland. The other route leaves the site to the south through Morgantown and travels through West Virginia and Maryland to Baltimore. Both routes would use class A and class B mainline track only. The northern route would be 713 km (445.9 miles) in length, with termination in Baltimore on the Conrail system; the southern route would be 485 km (303.0 miles) in length with termination in Baltimore on the Chessie system (see Sect. Z.2.1.5). It is assumed that both routes will be considered in order to assure competitive tariffs, but the southern route is significantly shorter and is thought much more likely to be used. The southern route is discussed below.

Z.2.1.1 Towns along the route

Shipments of SRC-II products from the Fort Martin plant via the Chessie system will originate on the Monongahela Railroad at the railroad spur at plantside. The shipment would be routed south into Fairmont, West Virginia, where it would be transferred to the B&O lines of the Chessie system. The shipment will make its first river crossing over the Monongahela River at Fairmont. The shipment will then proceed along a B&O class B mainline to Grafton, West Virginia, where it will be switched onto the B&O class A mainline.¹

From Grafton the shipment will be routed along the mainline of the Maryland division of the B&O Railroad into Baltimore. The main route for the long-haul segment of the SRC-II shipment is along a high traffic density line that has demonstrated the capability to haul an additional 765,000 tons annually.

The shipment is routed eastward into Cumberland, Maryland, and through numerous towns in the Potomac River valley. The SRC shipment will continue east through Harper's Ferry, West Virginia, into Frederick Junction, Maryland, and finally to Baltimore (Tables Z.1 and Z.2). The B&O mainline generally parallels the Potomac River until Harper's Ferry, crossing the Potomac four times and crossing more than 100 smaller creeks and streams.

Table Z.2. Population of selected counties along the southern alternative SRC route from Morgantown, West Virginia, to Baltimore, Maryland

County	State	Population
Monongalia	West Virginia	67,116
Marion	West Virginia	62,805
Taylor	West Virginia	15,188
Preston	West Virginia	26,844
Garrett	Maryland	23,694
Mineral	West Virginia	24,757
Allegany	Maryland	83,175
Hampshire	West Virginia	12,997
Morgan	West Virginia	8,818
Berkeley	West Virginia	40,288
Jefferson	West Virginia	24,132
Washington	Maryland	108,045
Frederick	Maryland	96,158
Carroll	Maryland	80,607
Howard	Maryland	97,994
Baltimore	Maryland	637,114
Baltimore City	Maryland	851,698

Source: U.S. Department of Commerce, Bureau of the Census, *County and City Data Book 1977—A Statistical Abstract Supplement*, U.S. Government Printing Office, Washington, D.C., 1978.

From Grafton to Frederick Junction the B&O mainline has double, and in some locations triple, tracks. This fact allows for flexibility of scheduling and routing of a large volume of traffic. The final segment of the SRC-II delivery route from Frederick Junction into Baltimore is single track. The traffic on this segment is heavy and congestion is often a problem. A revision and upgrading of the automatic signaling system would improve the traffic flow along this final route segment.

Because the B&O mainline is a main rail artery into Baltimore, it carries a high volume of commodities from Ohio, West Virginia, Pennsylvania, and western Maryland. The major commodities transported along this route are grains, coal, auto parts, and trailers on flat cars. The annual tonnage volumes vary between 10 and 50 million gross tons on the different segments of the B&O mainline route. The line segment between Grafton and Cumberland has a traffic density between 20 and 30 million annual gross tons. East of Cumberland to Frederick Junction and Baltimore, traffic falls to a 10-20 million annual gross ton range.

In addition, the route is used for passenger service; Amtrak has two passenger trains in each direction, using segments of the B&O mainline from its origin in Washington, D.C., to its destination in Cincinnati and other midwestern points.

Z.2.1.2 Water courses along the route

For most of the length of this route, the railroad lines follow streams in order to reduce the difficulty of traversing the rugged terrain that is found in the Allegheny Plateau and ridge and valley physiographic regions. The proximity of the rail lines to these streams poses a threat to the aquatic ecology of the streams and downstream municipal water supply systems in the event of a spill of SRC liquids in transit. Two streams that are followed for significant distances are the Monongahela and Potomac rivers, both of which are important sources of water for multiple municipal systems. The B&O line follows the Youghiogheny River and its tributaries for approximately 15 miles in Garrett County, Maryland. The Youghiogheny is a part of the Maryland State Wild and Scenic Rivers system and is being considered for inclusion in the national Wild and Scenic Rivers system. As such, water quality is of critical concern for the Youghiogheny watershed. Table Z.3 lists the major streams adjacent to the railroad route from Fort Martin to Baltimore.

Table Z.3. Water courses along the railroad route

Stream	Distance followed (miles)
Monongahela River and tributaries	57
Cheat River	4
Saltlick Creek (tributary to Cheat River)	8
Youghiogheny and tributaries	15
Savage River, Westernport Reservoir, and tributaries to Savage River	14
North Branch Potomac River	32
Potomac River	48
Brush Creek (tributary to Monocacy River)	7
Patapsco River	27

Z.2.1.3 Water crossings

On the B&O mainline route from Fairmont to Baltimore, there are 15 major river crossings (Table Z.4). In total, along this route, there are over 100 bridges that cross both major rivers and smaller streams and creeks. As noted previously, the major river along this route is the Potomac, which the B&O mainline crosses four times. The rail bridges along this route are constructed of concrete, wood, and steel and are capable of accommodating 125-ton rail cars.

Table Z.4. Major river crossings of the B&O mainline from Fairmont, West Virginia, to Baltimore, Maryland

State	Town ^a	River
West Virginia	Fairmont	Monongahela River
	Fairmont	Three Forks River
	Grafton	Cheat River
Maryland	Cumberland	Wills Creek
	Cumberland	Potomac River
	Patterson Creek Junction	Patterson Creek
West Virginia	Green Spring	South Branch (Potomac River)
	Paw Paw	Potomac River
	Paw Paw	Potomac River
	Berkley Springs	Cacapon River
	Cherry Run	Sleepy Creek
	Falling Waters	Opequon Creek
	Harper's Ferry	Potomac River
Maryland	Frederick Junction	Monocacy River
	Catonsville	Patapsco River

^a Identifies the nearest town associated with the river crossing.

Source: E. R. Lichty, General Manager of Operations and Planning, B&O Railroad, personal communication, Oct. 3, 1980.

The majority of these streams and rivers that the B&O mainline crosses are part of the Potomac River watershed region. On the originating segment of the SRC shipment, the rivers that the shipment crosses (the Monongahela, Cheat, and Three Forks rivers) flow north into the Ohio River watershed region. Along the destination segment of the route, one river (the Patapsco) flows east into Baltimore Harbor and the Chesapeake Bay. The Potomac River and its tributaries have direct exposure to a rail spill occurring along the majority of the B&O mainline. It is at these crossings that stream systems are most vulnerable to spills of SRC-II liquids, with no opportunity for detention or attenuation of hazardous chemicals. Cleanup procedures for spills to surface water are discussed in Sect. Z.6.

Z.2.1.4 Municipal water intakes along the route and downstream

Spilled SRC-II liquid could contaminate municipal water supplies supplied by surface water and groundwater along the route. Spills on land could contaminate groundwater by infiltrating the soil and percolating to groundwater. However, the soil tends to retard and attenuate many chemical species. The role of the soil in attenuating spilled chemicals is discussed in Sect. Z.5.2.2. There is no such buffer against contamination of surface waters in the event of a spill directly into open water. Listed in Table Z.5 are the municipal users of water along the railroad route from Fort Martin to Baltimore, plus some of the downstream users. The most widely used water body that is subject to being contaminated by SRC liquid spills is the Potomac River.

Table Z.5. Municipal water intakes along the railroad route from Fort Martin, West Virginia, to Baltimore, Maryland, and selected communities downstream

Municipality or community	Source(s) of water	Population served
Morgantown, W.Va.	Wells, Monongahela River, Cobun Creek	58,000
Riversville, W.Va.	Tygart Valley River	5,200
Fairmont, W.Va.	Tygart Valley River	54,000
Monongah, W.Va.	Tygart Valley River	3,500
Grafton, W.Va.	Tygart Valley River	12,000
Tunnelton, W.Va.	Groundwater	700
Rowlesburg, W.Va.	Cheat River, Keyer Run	967
Terra Alta, W.Va.	Groundwater	1,649
Hopemont, W.Va.	Snowy Creek	721
Oakland, Md.	Youghiogheny River	2,200
Westernport, Md.	Savage River	3,900
Piedmont, W.Va.	Savage River	2,300
Keyser, W.Va.	Groundwater, New Creek	8,300
Paw Paw, W.Va.	Groundwater	950
Martinsburg, W.Va.	Springs, wells	23,000
Kearneysville, W.Va.	Groundwater	790
Shenandoah Junction, W.Va.	Groundwater	350
Harper's Ferry, W.Va.	Wells, springs, Potomac River	5,600
Brunswick, Md.	Springs	4,500
Mount Airy, Md.	Groundwater	1,200
Baltimore, Md.	Streams (intakes are not in drainage area of RR route)	1,500,000+
Washington, D.C. (metropolitan area)	Potomac River	1,500,000
Hagerstown, Md.	Potomac River	57,000

Sources: EPA Public Water System Report, computer printout form FRDSO 1, 1979 ed.; J. D. Thomas and S. G. Heidel, *Chemical and Physical Characteristics of Municipal Water Supplies in Maryland*, Maryland Geological Survey Report of Investigations No. 9, Annapolis, Md. 1969.

It is estimated that, including the metropolitan D.C. area, more than 2 million people rely on the Potomac for water (Kevin Flynn, Interstate Commission for Potomac River Basin, personal communication, Oct. 6, 1980). Although the water intakes for the Washington, D.C., area are south of Harper's Ferry, downstream from the point at which the rail route last crosses and diverges from the Potomac, the water supply could be threatened by any spill upstream of the treatment plant.

Z.2.1.5 Alternate rail route

The second routing is primarily over Conrail rail lines in Pennsylvania after the Monongahela Railroad originates the SRC shipment. The route is north from the Fort Martin plant to Pittsburgh on the Monongahela Railroad. The shipment would then interline with Conrail and travel east through Pennsylvania on the Conrail mainline. At Harrisburg, Pennsylvania, the shipment would be routed south to Havre de Grace, Maryland, and south into Baltimore. The alternate route provides a second carrier to compete with Chessie and possibly ensures the shipper a more competitive tariff. Because Conrail also owns one third of the Monongahela Railroad, there should be no impacts or additional costs to Conrail that Chessie would not incur.

The Conrail route through Pennsylvania presents a few impacts worth noting. The route is approximately one third longer than the B&O mainline route and is through another major metropolitan area -- Pittsburgh. The route at Havre de Grace, Maryland, intersects with the northeast corridor (NEC) mainline heading into Baltimore. This segment of the alternate route could have serious impacts upon the passenger service trains operated by Amtrak on the NEC. This section of the NEC has frequent passenger trains, and the shipment of heavier and hazardous commodities may interfere with passenger schedules and/or accelerate deterioration of the track bed. For these reasons, this alternate route is not expected to be used, and its impacts upon population and watershed areas are not analyzed in detail.

Z.2.2 Transfer of SRC-II product from railroad cars to barges and shipments from Baltimore to end users

The exact location of the barge terminal that will transfer the SRC shipment is unknown, but some assumptions and descriptions of the necessary facility can be stated. The rail-to-barge transfer point will most likely require a storage and handling facility with the necessary storage tanks and piping connections. The SRC shipments could probably use the facility of a previous oil tank terminal. There are private oil terminals in the Baltimore Harbor; for the purpose of this analysis it is assumed that there is excess capacity to store the similar SRC product. The end users and their locations are not known at this time. For this analysis, it is assumed that the final destination of the SRC-II liquid will be New York City. The probability and likely volume of spills from barges are discussed in Sect. Z.4.

Assuming that the annual production of SRC at the Fort Martin plant is 765,800 tons, approximately 255 barges will be required to haul the product to market. This will require about two 3000-ton barges every three days for transshipping. Also, depending on the specific customers of SRC and their location, barge equipment designated for ocean transport may be required for shipping. Smaller barges are acceptable for inland water shipments. Additional research is required for the marine segment of SRC shipments. Issues and elements of the water transport mode include the mix of barges and tows, the routing (either ocean or inland waterway), and storage and handling facilities.

There is one privately operated liquid bulk storage terminal in the Baltimore Harbor complex. This facility, Skyline Terminals, Inc., is currently handling and storing vegetable oils and chemical liquids. Skyline terminals have rail connections with the Chessie System; this facility appears to be the possible transshipping and storage terminal.

The Chesapeake Bay is over 200 miles long and has two shipping lanes, one at each end. The southern exit from the bay is into the Atlantic Ocean at the mouth of the bay at Virginia Beach. This route would be used for SRC-II shipments to southeastern utilities along the Atlantic Seaboard. The northern exit from the bay is through the Chesapeake and Delaware Canal into the Delaware Bay. This route would be used for shipments to New Jersey, New York, and New England Utilities. The Chesapeake Bay is the largest body of water that could be affected by a SRC-II transportation-related spill.

Data from the U.S. Coast Guard's Pollution Incidence Reporting System (PIRS) indicates that spills are somewhat more likely to occur at marine shore facilities and/or at modal interfaces (i.e., rail-to-barge transshipment) than they are for tank barges or tank ships (see Table Z.15). However, the average volume of spills for ships in transit is much larger.

Z.3 CHEMICAL ANALYSIS OF SRC-II PRODUCT

Z.3.1 From Radian Corporation report

Samples of SRC-II product fluid, consisting of a 2.9:1 middle distillate to heavy distillate fuel oil blend, were analyzed by the Radian Corporation; a similar SRC-II product fluid was analyzed by the Gulf Science and Technology Center of the Gulf Mineral Resources Company. Although this particular blend is only one of many possible blends, it is assumed for the purpose of this analysis that SRC-II liquids produced at the Fort Martin demonstration plant will be similar in composition. The detailed reports of the two laboratory tests may be found in a report by the Radian Corporation.² Listed below are some of the general results of those tests.

Approximately 60 wt % of the product was identified by chromatography/mass spectrometry (GC/MS). Table Z.6 shows a comparison of GC/MS weight-percent data with the weight-percent data by simple separation.

Among these classes of organic compounds, attention has been focused on the phenol and phenolic compounds, because they are soluble in water and thus mobile in the environment. The phenolic

Table Z.6. Summary of analytical results of SRC-II fluid

Fraction type	Found after extraction (wt %)	Found by GC/MS ^a (wt %)
Aromatic and aliphatic compounds	82	52
Phenolic compounds	11	5.4
Basic compounds	6.9	2.3
Total	99.9	59.7

^aGas chromatography/mass spectrometry.

Source: Radian Corporation, *Remedial Measures Plan for a Spill of SRC Liquid at the SRC Pilot Plant, Ft. Lewis, Washington*, August 1980.

(base-extractable) compounds comprise 11 wt % of the fluid tested. Therefore, in a spill of average volume, approximately 950 gal of phenolic compounds would be spilled (see Sect. Z.4). The basic (acid-extractable) compounds, such as amines, are generally nitrogenous and are slightly soluble in water. These compounds make up approximately 7 wt % of the SRC-II fluid.

The largest portion of the SRC fluid (82 wt %) consists of aromatic and aliphatic hydrocarbons, which are substantially soluble in water. However, these hydrocarbons may slightly dissolve in water and be present at levels of a few parts per billion. In the case of some toxic or otherwise hazardous materials, available water quality criteria are also at levels of parts per billion.²

The inorganic chemical content of the SRC fluid was not determined for the Radian Corporation study. However, data are available describing the metal content of SRC-II process streams.² The breakdowns of priority pollutants from the Gulf Science and Technology Center's chemical analysis are listed in Table Z.7.

Table Z.7. HPLC/TLC^a analysis of polynuclear aromatics priority pollutants in SRC-II liquid, in parts per million

Naphthalene	1780
Acenaphthene	1190
Phenanthrene	498
Anthracene	145
Fluoranthene	130
Fluorene	560
Pyrene	12
Benz[a]anthracene	38
Chrysene	85
Benz[e]pyrene	5
Benzo[b]fluoranthene	17
Benzo[k]fluoranthene	28
Benzo[a]pyrene	15
Dibenz[a,h]anthracene	57
Benzo[g,h,i]perylene	28
Indeno[1,2,3-cd]pyrene	9

^aHigh-pressure liquid chromatography/thin-layer chromatography.

Source: Radian Corporation, *Remedial Measures Plan for a Spill of SRC Liquid at the SRC Pilot Plant, Ft. Lewis, Washington*, August 1980.

Also included in the analysis by the Radian Corporation is a breakdown on aromatic hydrocarbons, aliphatic hydrocarbons, phenolic compounds, and basic compounds.² Listed in Table Z.8 are the analyses performed by the Gulf Science and Technology Center.

Table Z.8. Chemical tests performed on a sample of SRC-II distillate by Gulf Science and Technology Center

Test	Description
1	Analyses of phenolics by liquid chromatography
2	Analysis of nitrogen compounds by mass spectrometry—nitrogen group type 5298
3	Analysis of nitrogen—Test No. 2594
4	FIA separation of neutral oil fraction—Test No. 5100
5	Preparative separation of neutral oil fraction by liquid chromatography—Test No. 5479
6	Analysis of aromatic cut of neutral oil fraction by gas chromatography—polyphenyl ether capillary column
7	Analyses of aromatic cut of neutral oil fraction by mass spectrometry—Test No. 5374
8	Normal paraffin analysis of saturate cut of neutral oil fraction by gas chromatography—Test No. 5299
9	Analysis of saturate cut of neutral oil fraction by mass spectrometry—Test No. 5380
10	Analysis of saturate cut of neutral oil fraction by mass spectrometry (high boiling range)—Test No. 5378
11	Analysis of aromatic cut of neutral oil fraction by mass spectrometry (high boiling range)—Test No. 5375
12	Analysis of priority pollutants
13	Gas chromatography simulated distillation—Test No. 5210

Source: Radian Corporation, *Remedial Measures Plan for a Spill of SRC Liquid at the SRC Pilot Plant, Ft. Lewis, Washington, August 1980.*

Z.3.2 Comparison between SRC liquid product and petroleum fuel oil

The composition of SRC liquids is sufficiently different from petroleum that it is not possible to make predictions of composition or environmental effects based solely on experience with crude and refined oils. However, we may use what knowledge we have of the physical and chemical properties of SRC liquid fuel fractions to make some useful comparisons and point out potential problems that may be unique.

Z.3.2.1 Density

SRC liquid fuel fractions have a smaller percentage of hydrogen than crude oil does and are therefore more dense. Thus, a spill of this material into an open waterway would result in rapid sinking of some of the material, creating difficult cleanup problems. Any spilled oil that reaches the bottom of a waterway would undoubtedly mix with sedimentary material producing consequent impacts on benthic life, as well as creating a possible long-term source of water contamination. Any routine dredging operations would further complicate potential problems.

Z.3.2.2 Phenolic content

A major difference between petroleum crude oil (or its distillation products like No. 2 fuel oil) and SRC liquids is the high content of phenols in the SRC liquids.³ Some of the SRC liquid fuel fractions tested to date have shown a phenolic concentration of as much as 11%. The phenols in SRC liquids span a fairly wide molecular weight range, so that the smallest molecules would readily leach out of the fuel in the presence of water, whereas the larger molecules would perhaps leach out over a longer period of time, potentially creating a long-term source of chronically toxic materials. The high water solubility of phenols could lead to potential contamination of water supplies. This fact suggests that the immediate consequences of a spill of SRC liquids either on land or in waterways would be more severe than a petroleum spill from a direct chemical toxicity standpoint. Phenols, however, can be rapidly degraded naturally in the environment, and thus long-term effects after release of these compounds is not likely. Studies of the

environmental behavior, solubility, biodegradability, and toxicity of this important fraction of SRC liquid products are needed to accurately assess the long-term consequences of discharging them to the environment (see Sect. Z.5.2.1).

Z.3.2.3 Organic content

Based upon what is known of its hydrocarbon composition, a spill of SRC liquids, particularly in a waterway, would probably create more short-range problems than a crude oil spill over and above the problems created by phenols.³ Mixtures of SRC liquid and water could result in relatively high concentrations of naphthalene and phenanthrene compounds in the water. From oil-related studies, these compounds are known to be more toxic to fish than benzenes or saturated hydrocarbons (neither of which are found in SRC in appreciable amounts but which represent a substantial portion of petroleum crude oil and its products).⁴ The long-range problems to be encountered from the hydrocarbon portions of a commercial SRC product if discharged to the environment are not easily predicted at this time because the distribution of compounds is quite different from crude oils and is not well established (see Sect. Z.5.2.1).

Z.3.2.4 Heterocyclic nitrogen- and sulfur-containing molecules

At the present time, little is known about the composition of SRC-II liquids with respect to heterocyclic nitrogen- and sulfur-containing molecules. One of the environmental problems anticipated for the shale industry is the high concentration of nitrogen components (e.g., pyrroles, pyridines, indoles, amides, and amines) found in the shale oil. These compound classes have had limited study with respect to their toxicity to terrestrial and aquatic life, persistence, mutagenic potential, etc. Since SRC fuels also have a significant nitrogen content (petroleum is very low in nitrogen), this aspect of the material should be addressed through appropriate research programs.

In summary, properties of SRC liquids — high density, high phenol content, high concentration of biologically active hydrocarbons, and relatively high concentration of nitrogen components — make it likely that the environmental consequences of a spill of the material, whether on land or water, would be more severe in the short-term than a petroleum-type spill. The magnitude of these short-range effects and an assessment of the long-range effects can be estimated only through further research (see also Appendixes T and Y and Sect. 4.1 of the EIS).

Z.4 PROBABILITY AND VOLUME OF SPILLS

Because SRC-II liquid fuel is a new energy product, very few shipments have been made, and no accident data have been reported. To measure the probability of a possible accident involving future SRC-II shipments, an analysis of shipments of similar commodities and reported rail incidents involving hazardous materials is presented. The number of spills predicted for the SRC-II demonstration plant is presented in Table Z.15.

The discussion that follows offers an analysis of rail and barge data pertaining to hazardous liquids traffic, spill probabilities, and spillage volumes specifically involving waterways. Data for 1975-79 were supplied by the Federal Railroad Administration (FRA), the U.S. Army Corps of Engineers, and the U.S. Coast Guard.

Z.4.1 Accident probabilities

SRC-II liquids may be classified as hazardous because they contain naphtha, polynuclear aromatics (PNA), tar, and other chemical compounds previously determined to be hazardous. Three commodity classes from the Standard Transportation Classification Code (STCC) were chosen for analysis: Industrial Inorganic Chemicals, Miscellaneous Chemical Products, and Products of Petroleum Refining. These product groups contain hazardous materials and are considered a valid basis for comparison. The number of shipments for each of these product classes during 1976-78 is presented in Table Z.9.

Accident spill statistics for shipments of hazardous liquid cargos were determined for the 1976-78 period using the following data:

1. Carload Waybill Statistics (1976, 1977, and 1978), U.S. Department of Transportation, Federal Railroad Administration, Office of Rail Systems Analyses and Information. The data included aggregate commodity totals for three commodity classes: (a) Industrial Inorganic Chemicals (STCC number 281), (b) Miscellaneous Chemical Products (STCC number 289), and (c) Products of Petroleum Refining (STCC number 2919).

Table Z.9. Railroad statistics for hazardous commodities

STCC No. ^a	1976				1977				1978			
	Shipments	Tons	Ton-miles (×10 ³)	Car-miles (×10 ³)	Shipments	Tons	Ton-miles (×10 ³)	Car-miles (×10 ³)	Shipments	Tons	Ton-miles (×10 ³)	Car-miles (×10 ³)
281	702,400	55,560,700	38,743,900	484,100	779,200	56,825,500	38,822,800	485,100	759,700	61,628,200	41,940,400	516,500
289	110,900	6,917,400	5,146,800	89,300	110,330	6,848,000	4,851,800	84,200	108,500	6,757,900	4,882,400	82,200
291	315,000	21,522,600	10,930,700	172,600	333,400	22,995,100	11,913,700	183,700	313,800	21,616,800	11,418,600	174,800
Total	1,128,300	84,000,700	54,821,400	746,000	1,222,900	86,668,600	55,588,300	753,000	1,182,000	90,002,900	58,241,400	773,500

^a281, industrial inorganic chemicals; 289, miscellaneous chemical products; 291, products of petroleum refining.

Source: U.S. Department of Transportation, Federal Railroad Administration, *Carload Waybill Statistics*, 1976, 1977 and 1978.

2. RYMDSM Data Base, U.S. Department of Transportation, Federal Railroad Administration, Office of Hazardous Materials. Data used included numbers of reported accidents involving shipment of hazardous materials that resulted in losses/damages greater than \$2900.
3. Pollution Incident Reporting System (PIRS), U.S. Department of Transportation, U.S. Coast Guard. Data used included the number and volume of reported spills of hazardous liquids into bodies of water.

The data are presented in Tables Z.9, Z.10, and Z.11. Calculated accident probabilities are presented in Table Z.12.

Table Z.10. Reported accidents and spills of hazardous liquids into water bodies

	1976	1977	1978
Accidents ^a			
Number	982	899	1191
Spill incidents ^b			
Number	65	35	37
Volume, ^b tons	801.9	756.2	468.2
Probability of accident occurrence ^c	0.0009	0.0007	0.0010
Probability of spill occurrence ^c	0.0001	0.00003	0.00003

^aAccidents involving loss or damage totaling more than \$2900 as reported in the RYMDSM data base.

^bVolumes of spills into water bodies reported in the PIRS data base and converted to tons based on an average of 294 gal/ton.

^cProbability of accidents is calculated by dividing the number of accidents in a given year by the number of shipments in that year, shown in Table Z.9. Probability of spills calculated in the same manner, using the ratio of spills to shipments in a given year.

Table Z.11. Aggregate accident and spill statistics for hazardous commodity shipments, 1976-1978

(1) Shipments	3,533,200
(2) Tons shipped	260,672,200
(3) Ton-miles	116,234,100,000
(4) Car-miles	2,272,500,000
(5) Reported accidents	3,072
(6) Reported spill incidents (into water)	137
(7) Reported spill volumes (tons into water)	2,026

It is assumed that the SRC-II liquid products, produced at a rate of 13,800 bbl/d, will be shipped by unit train to Baltimore, Maryland (about 485 km), every 2.5 d. Each unit train will consist of 74 tank cars, each having a capacity of 75,800 liters (20,000 gal).

Summary statistics for projected SRC-II product movements are given in Table Z.13 and represent one of the bases for this spill probability analysis. Using the universe of accident and spill incident rates from Table Z.12, rates of SRC-II accidents and spills can be expressed in terms of the number of shipments, volumes shipped, ton-miles traveled, and car-miles traveled. These data are presented in Table Z.14.

Table Z.12. Aggregate accident and spill rates, 1976-1978

Derivation ^a		
No. of reported accidents per:		
Shipment	0.000869	(5) ÷ (1)
Ton shipped	0.0000118	(5) ÷ (2)
Ton-mile	0.000000019	(5) ÷ (3)
Car-mile	0.00000135	(5) ÷ (4)
No. of reported spill incidents into water per:		
Shipment	0.00003878	(6) ÷ (1)
Ton shipped	0.00000053	(6) ÷ (2)
Ton-mile	0.00000000118	(6) ÷ (3)
Car-mile	0.0000000603	(6) ÷ (4)

^aDerivation is keyed to the data elements in Table Z.11.

Table Z.13. Summary statistics for projected SRC-II movements per month^a

a. Volume shipped, tons	63,000
b. No. of shipments	12
c. Ton-miles	19,089,000
d. Car-miles	269,064

^a30 days.

Table Z.14. Aggregate statistics on SRC-II accidents and spills into water

No. of shipments per:	
e. Accident	1,150
f. Spill incident	25,786
Tons shipped per:	
g. Accident	84,746
h. Spill incident	1,886,793
Ton-miles per:	
i. Accident	52,631,579
j. Spill incident	847,460,000
Car-miles per:	
k. Accident	740,741
l. Spill incident	16,587,591

Using Tables Z.13 and Z.14, the frequencies of "reportable accidents" and "reportable spill incidences" for the projected shipments of SRC-II liquids can be determined. These frequencies are presented in Table Z.15.

Reportable spills (defined as resulting in loss or damage in excess of \$2900) can be expected to occur every 1.3 to 2.8 months. It is believed that the prediction of accidents based on

**Table Z.15. Predicted accident and spill frequencies
for shipment of SRC-II liquid products**

	Frequency ^a	Derivation ^b
Reportable accidents		
in terms of:		
No. of shipments	95.8	$e \div b$
Volume shipped	1.35	$g \div a$
Ton-miles	2.76	$i \div c$
Car-miles	2.75	$k \div d$
Reportable spill incidents		
to water bodies in terms of:		
No. of shipments	2,148.8	$f \div b$
Volume shipped	29.95	$h \div a$
Ton-miles	44.4	$j \div c$
Car-miles	61.65	$l \div d$

^aFrequency is defined in terms of months: for example, 95.8 equals 1 occurrence every 95.8 months; similarly, 1.35 equals 1 occurrence every 1.35 months.

^bDerivation is keyed to the data elements in Tables Z.13 and Z.14.

number of shipments significantly underestimates the spill likelihood because the shipments of SRC-II liquid products will be much larger than the average volume shipped. (The average weight of shipments during 1978 for the three commodity classes used in this analysis was 76 tons, and each shipment of SRC-II liquids will involve about 5300 tons). Reportable spills into bodies of water will be much less frequent; spills are predicted to occur once every 30 to 60 months.

Track characteristics and traffic conditions are not expected to increase accident or spill risks because of the relatively small volumes of shipments over normally heavily traveled lines. Both routes, however, pass through population centers, thus exposing citizens of these cities to the hazardous products. These risks cannot be expected to be significantly different from those of any other comparable petroleum product already moving along those corridors, however. The possibility of contamination of water supplies is expected to be highest along the section of the route that is adjacent to the Potomac River, particularly at river crossings.

Z.4.2 Marine traffic and spills into water

Based on U.S. Army Corps of Engineers statistics⁵ total traffic of crude petroleum and refined petroleum products on the Chesapeake Bay and associated rivers and estuaries (Baltimore, Maryland, and Norfolk, Virginia districts) was as follows:

1976 - 25,153,755 tons,
1977 - 23,916,814 tons, and
1978 - 33,277,884 tons.

Using an average of 8 barrels per ton (1 bbl = 42 gal), the following spill chances were determined:

1976 - slightly more than three barrels out of every 100,000 barrels shipped,
1977 - slightly less than one barrel out of every 100,000 barrels shipped, and
1978 - slightly more than four barrels out of every 1,000,000 barrels shipped.

The three-year average of 147 barrels spilled for each 100,000 shipped would result in an average of 74 barrels of SRC liquid spilled each year, assuming that the plant operates at 100% capacity.

Z.4.3 Spill volume distribution

The section that follows presents data on the volume-frequency distribution of rail and barge spills into water. Rail data were extracted from PIRS for 1975-1979. Barge data, also extracted

from PIRS, are for 1976-1978. Also included in this section is a discussion of the average spill size for both rail and barge only.

2.4.3.1 Rail spill volume distribution

Table Z.16 presents the frequency of rail spills of hazardous liquids into water for 1975-1979 based on PIRS. Table Z.17 is a more disaggregated presentation of the same data. Over the five-year period, 169 spills were reported. In both tables it can be seen that 42% of all spills are in amounts less than 1000 gal. Further, over half (53%) of the spills recorded were for amounts of less than 2000 gal.

Table Z.16. Volume-frequency distribution of rail spills into water for 1975-1979

Spill volume (gal)	Number of spills
0-1000	71
1,001-2,000	18
3,001-3,000	9
4,001-5,000	4
5,001-6,000	7
6,001-7,000	7
7,001-8,000	6
8,001-9,000	3
9,001-10,000	7
10,001-15,000	10
15,001-20,000	10
20,000+	10
Total	169

Source: U.S. Coast Guard, Pollution Incident Reporting System (PIRS).

Calculating a simple arithmetic average shows the average rail spill size to be 8780 gal. The weighted mean size of a spill of hazardous liquids into water is calculated based on the formula:

$$\mu = \frac{\sum_{i=1}^n X_i f_i}{\sum_{i=1}^n f_i},$$

where

μ = average spill size,

X_i = spill gallonage interval midpoint,

f_i = frequency of the spill that falls into the interval,

n = number of intervals.

With regard to rail spills, this mean is 5041 gal. The arithmetic average spill size is higher because of the recording of six spills between 19,501 and 20,000 gal, and ten spills of volumes greater than 20,000 gal. Therefore, the worst-case analysis used in this report considers a volume of spill (20,000 gal) that is almost four times the volume of the average spill.

Table Z.17. Frequency and cumulative percentage of rail spills into water for 1975-1979

Spill volume (gal)	Number of spills	Percentage	Cumulative percentage
0-250	45	27	27
251-500	14	8	35
501-750	5	3	38
751-1,000	7	4	42
1,001-1,250	2	1	43
1,251-1,500	7	4	47
1,501-1,750	2	1	48
1,751-2,000	7	4	52
2,001-2,500	2	1	53
2,501-3,000	7	4	57
3,001-3,500	4	2	59
3,501-4,000	3	2	61
4,001-4,500	0	0	61
4,501-5,000	4	2	63
5,001-5,500	0	0	63
5,501-6,000	7	4	67
6,000-6,500	2	1	68
6,501-7,000	5	3	71
7,001-7,500	1	1	72
7,501-8,000	5	3	75
8,001-8,500	0	0	75
8,500-9,000	3	2	77
9,001-9,500	0	0	77
9,501-10,000	7	4	81
10,001-10,500	2	1	82
10,501-11,000	2	1	83
11,001-11,500	0	0	83
11,501-12,000	2	1	84
12,001-12,500	0	0	84
12,501-13,000	0	0	84
13,001-13,500	0	0	84
13,501-14,000	3	2	86
14,001-14,500	0	0	86
14,501-15,000	1	1	87
15,001-15,500	1	1	88
15,501-16,000	0	0	88
16,001-16,500	0	0	88
16,501-17,000	0	0	88
17,001-17,500	1	1	89
17,501-18,000	1	1	90
18,001-18,500	0	0	90
18,501-19,000	1	1	91
19,001-19,500	0	0	91
19,501-20,000	6	4	95
20,000+	10	5	100

Source: U.S. Coast Guard, Pollution Incident Reporting System (PIRS).

Z.4.3.2 Marine mode average spill size and distribution

Using PIRS data, the following volumes of crude oil and refined petroleum products were reported as spilled into the Chesapeake Bay and its surrounding rivers and estuaries:

1976 - 259,503 gal,
1977 - 79,707 gal, and
1978 - 47,999 gal.

The distribution of spill incident volumes was determined for each of the three years under analysis and is presented in Table Z.18.

In 1976 the average reported spill into the Chesapeake Bay was 11,898 gal. However, the 1976 data are heavily skewed by one spill of 249,858 gal; more than 71% of all reported spill incidents into the Chesapeake Bay were of less than 10 gal.

Table Z.18. Marine mode spill volume distribution

Volume (gal)	1976	1977	1978
0-10	15	41	17
11-50	3	19	14
51-100	0	8	9
101-200	0	4	5
200+	3	4	6
unknown	3	5	11
Total	24	82	62

Source: U.S. Coast Guard, Pollution Incident Reporting System (PIRS).

For 1977, the average reported spill size was 1035 gal. Once again, data were skewed by one large spill of 75,000 gal. In 1977 53% of all reported spills were less than 10 gal; more than 78% were less than 50 gal.

In 1978, the average reported spill was 941 gal. Two large spills (25,600 and 18,500 gal) dominated the data; 33% of the reported volumes were less than 10 gal and 61% were less than 50 gal.

For this analysis, a worst-case spill of 900,000 gal of SRC-II liquid is assumed, representing the entire cargo of one 3000-ton barge.

Data from the PIRS summary show that accidents are slightly more frequent at marine shore facilities and/or at modal interfaces (i.e., rail-to-barge transshipments) than they are for tank barges or tank ships. However, the average volume spilled from tank barges and tank ships is much greater. These results are summarized in Table Z.19.

Table Z.19. Spill incidence, source, and volume

Spill Source	1976		1977		1978		3-year total	
	Number of incidents	Volume (gal)	Number of incidents	Volume (gal)	Number of incidents	Volume (gal)	Number of incidents	Volume (gal)
Other transportation-related marine facility	1	1	15	551	9	621	25	1,173
Onshore bulk cargo transfer	0	0	19	767	7	588	26	1,355
Onshore fueling	7	9,115	14	377	7	440	28	9,932
Onshore non-bulk cargo transfer	1	1	2	130	0	0	3	131
Tank barge or ship	12	250,386	27	77,882	28	46,350	67	374,618

Source: U.S. Coast Guard, Pollution Incident Reporting System (PIRS).

Z.5 DISCUSSION OF IMPACT ISSUES AND DETERMINATION OF WORST-CASE SCENARIO

Z.5.1 Hazard ranking of the possible avenues of release

The resulting variety of potential routes for ecological effects may be qualitatively ranked as to degree of concern based upon the application of the following criteria:

1. likelihood of occurrence for the spill event;
2. adequacy of available information on possible physical, chemical, and biological effects;
3. severity of the effects; and
4. spatial dimensions of the area affected.

Although these criteria cannot be rigorously applied in this generic analysis, the application of these criteria to the possible avenues of release yields an approximate ranking, from highest to lowest degree of concern (and concomitant need for further research) as follows.

Z.5.1.1 Priority 1: SRC liquid products released directly to surface water

As discussed above, accidental spills of major and minor varieties may be expected to occur. Available information on the organic constituents of the SRC liquid products suggests resulting ecological effects greater than those for crude petroleum oil.³ There is a high potential for waterborne dispersal of these constituents over large areas and for long-term accumulations in bottom sediments. Consequently this route of release is regarded with the greatest degree of concern.

Z.5.1.2 Priority 2: indirect effects through leachates derived from SRC liquid products released on land

Soluble materials from SRC liquid product spills may penetrate to groundwaters and lead to secondary effects because of (1) uptake by plant roots or (2) discharge into surface water systems. Although groundwater transport can influence large areas, the mediating processes of dilution and transformation (e.g., soil attenuation) may act to moderate the ecological and hydrological effects, especially if groundwater movement is slow. As a result, this avenue of release is regarded with slightly less concern than are direct releases to surface waters. The direct effects to surface plants and animals are likely to be severe but extremely localized in comparison with other avenues of release. The possible severity suggests this avenue of release should receive some attention, but the localized nature suggests a lower priority than for other avenues of release.

Z.5.2 Impacts of spills and worst-case scenario

The worst-case scenario for a spill of SRC-II materials is believed to be a spill directly into the Potomac River because of (1) the high priority this avenue of release receives on a generic basis, (2) the large number of people that are dependent on the Potomac for water supplies, and (3) the proximity to sensitive environments in the Potomac estuary. Such a spill event is considered to be more serious than the maximum credible barge spill.

Z.5.2.1 Impacts to water quality and aquatic ecology

Spills of SRC-II product could occur at many locations; the size of spills could also vary greatly. Spilled SRC-II product might enter a water-course directly or, more probably, a spill on land might flow into a stream or river. The impacts of spills could vary enormously depending on streamflow, the accessibility of the site for clean-up, the substrate (rock, gravel, etc.), channel morphology (pool, riffle, channelized river, etc.) and many other factors. To illustrate the potential environmental consequences of a serious spill, a number of assumptions will be made to define a worst-case scenario.

Site of spill

It is assumed that a spill occurs near Harper's Ferry, West Virginia. Of the three sites where the rail line crosses the Potomac River (Table Z.4), this site clearly constitutes the worst case, because it is roughly 80 km (50 miles) upstream from the water supply intake for the Washington, D.C., metropolitan area.

Size of spill

Table Z.13 indicates that only 5% of the rail spills into water exceed 75,700 liters (20,000 gal), the capacity of a single rail tank car. For this analysis, it is assumed that the rupture of one tank car spills the entire contents (75,700 liters) directly into the Potomac River.

Dispersion of spilled material

We assume that the soluble components of spilled material are dispersed in the entire flow of the Potomac below its confluence with the Shenandoah River, as gauged at Point of Rocks, Maryland (USGS Station No. 01638500), River Mile 159.5.

Streamflow

Average discharge at Point of Rocks is 262.6 m³/s; minimum stream flow 15.0 m³/s. For this analysis, the mean 7-day low flow for 78 years of record, 39.4 m³/s (1392 cfs), is assumed. This is a typical stream flow for low-flow periods such as might occur in August or September.

Dissolution of phenolics

The SRC-II product includes a wide array of phenolic constituents (Table Z.20) with varying solubilities. Collectively these phenolic materials constitute 11% of the fuel (Table Z.6). We examine the short-term impacts to water quality by assuming that all the phenolic compounds enter solution at a constant rate over a 24-h period. Thus, we assume an effective release rate for phenolics of 0.096 kg/s, resulting in an instream concentration of phenolics of 2.44 mg/liters (Table Z.21). Although some phenolics (e.g., phenol, cresols, and xylenols) are very soluble and will enter pollution rapidly, this estimate provides a rough indication of the average concentration.

Transport and fate of hydrocarbons

Most of the hydrocarbons in the SRC-II fuel have low solubilities. Although small quantities would enter the solution, hydrocarbon components of the spilled fuel would generally form bottom or surface slicks and, perhaps eventually, a colloidal suspension. Following a large spill, most hydrocarbons would be at concentrations close to saturation (Table Z.22). These dissolved hydrocarbons would add to the toxicity of the dissolved phenolic compounds. It is assumed for this analysis that much of the spilled hydrocarbons would disperse slowly and become trapped on the substrate (sand, gravel, and rock), forming a tarlike coating of the river bottom and shoreline.

Cleanup effort

Cleanup efforts would be difficult because the SRC-II fuel sinks rather than floats. However, it is assumed that marginally successful cleanup efforts would recover 50% of the spilled material within one week.

Given the above scenario for a serious spill of SRC-II product, a very rough assessment of impacts can be made. Short-term and long-term impacts are considered separately, and only the most significant impacts are considered.

Short-term impacts

As the river flowed past the spill area, a slug of highly contaminated water would form and be carried downstream. Contaminants in solution would be rapidly carried downstream at roughly the velocity of stream flow; insoluble material might contaminate only a limited area (perhaps 1-2 km of river channel). The combination of many dissolved contaminants (Table Z.23) would be acutely toxic, killing many or most of the organisms in the river near the spill area. Phenolic compounds (especially xylenols) and basic compounds (such as the aromatic amines) would make the largest contribution to the toxicity of the contaminated water. The projected concentrations for phenolics and basic compounds are estimated averages for a 24-h period. The most soluble compounds, however, would dissolve rapidly, possibly causing higher concentrations in the first hours after a spill. As the contaminated slug of water moved downstream, the concentrations of pollutants would be reduced by dilution, uptake by organisms, and adsorption to sediments. The PNA compounds would probably also decline in concentration due to photolysis and volatilization (see Appendix S). Massive mortality of river biota might therefore be limited to 5-15 km immediately downstream from the spill.

Table Z.20. Phenolic compounds identified in the middle/heavy distillate SRC-II product

Compound	Concentration (mg/100g)
Dimethylphenol	33
Phenol	450
o-Cresol	620
o-Ethylphenol	37
<i>m-/p</i> -Cresols	95
Dimethylphenol	420
C ₃ -Alkyl phenol (isomer 1)	48
2,3-Xylenol and <i>m-/p</i> -Ethylphenol	960
C ₃ -Alkyl phenol (isomer 2)	110
3,5-Xylenol	370
C ₃ -Alkyl phenol (isomer 3)	170
C ₄ -Alkyl phenol (isomer 1)	13
3,4-Xylenol	91
C ₃ -Alkyl phenol (isomer 4)	730
C ₄ -Alkyl phenol (isomer 2)	8.8
C ₃ -Alkyl phenol (isomer 5)	37
C ₄ -Alkyl phenol (isomer 3)	22
C ₄ -Alkyl phenol (isomer 4)	130
Methyl indanol (isomer 1)	24
4-Indanol	400
Methyl indanol (isomer 2)	55
C ₄ -Alkyl phenol (isomer 5)	26
Methyl indanol (isomer 3)	70
5-Indanol	40
Methyl indanol (isomer 4)	240
Methyl indanol (isomer 5)	47
o-Phenylphenol	23
1-Naphthol	6.4
2-Naphthol	19
Methyl naphthalene (isomer 1)	7.2
Methyl naphthalene (isomer 2)	5.1
Methyl naphthol (isomer 3)	5.2
<i>m-</i> or <i>p</i> -Phenylphenol	7.6
<i>m-</i> or <i>p</i> -Phenylphenol	11
Hydroxyfluorene	3.5

Source: Radian Corporation, *Remedial Measures Plan for a Spill of Solvent Refined Coal Liquid at the SRC Pilot Plant*, Fort Lewis, Wash., 1980, Appendix I.

Table Z.21. Assumptions and calculations for estimating short-term impacts of phenolic compounds on water quality

Location of spill	Harpers Ferry, West Virginia
Density of spilled material	1 kg/liter
Size of spill	1 tank car = 75,700 liters $\approx$ 75,700 kg
Quantity of phenolics released	75,700 kg X 0.11 = 8327 kg
Duration of release	24 h = 86,400 s
Average release rate	8327 kg / 24 h = 0.096 kg/s = 96,000 mg/s
Stream flow	39.4 m ³ /s = 39,400 liters/s
Predicted average concentration of phenolics	$\frac{96,000 \text{ mg/s}}{39,400 \text{ liters/s}} = 2.44 \text{ mg/liter}$

Table Z.22. Published values for the solubility of PAH in distilled water at 25-27°C^a

Compound	Number of aromatic rings	Solubility ($\mu\text{g/liter}$)
Naphthalene	2	12,500, 22,000, 31,200, 31,300, 34,000
1-Methylnaphthalene	2	25,800
1,5-Dimethylnaphthalene	2	2,740
2-Ethylnaphthalene	2	8,000
Acenaphthalene	2	3,470
Fluorene	2	1,685
Anthracene	3	30, 44.6, 75, 75
2-Methylanthracene	3	21.3
Phenanthrene	3	1,002, 1,070, 1,180, 1,600, 1,600
1-Methylphenanthrene	3	269
4,5-Methylenepheneanthrene	3	1,110
Fluoranthene	3	206, 236, 240, 265
Pyrene	4	132, 165, 171, 175
Naphthacene	4	1.0, 1.5
Chrysene	4	1.5, 1.8, 6
Triphenylene	4	38, 43
Benz[a]anthracene	4	9.4, 10, 11
10-Methylbenz[a]anthracene	4	55
10-Ethylbenz[a]anthracene	4	45
10-Butylbenz[a]anthracene	4	8
10-Amylbenz[a]anthracene	4	0.8
9,10-Dimethylbenz[a]anthracene	4	43
Dibenz[a,c]anthracene	5	0.5, 0.6
Benzo[a]pyrene	5	0.172, 0.5, 4.0, 6.05
5-Methylbenzo[a]pyrene	5	0.8
Benzo[e]pyrene	5	~4
Perylene	5	<0.5
Picene	5	2.5

^aData compiled from numerous sources in Table 30, from J. M. Neff, *Polycyclic Aromatic Hydrocarbons in the Aquatic Environment: Sources, Fates, and Biological Effects*, Applied Science Publishers Ltd., London, 1979.

Table Z.23. Estimated concentration of contaminants following spill of SRC-II fuel compared with draft criteria or estimated permissible concentrations, in $\mu\text{g/liter}$

Constituent	Estimated concentration ^a (μg/liter)	Draft criteria ^b			Estimated permissible concentration ^c
		Freshwater aquatic life		Human health	
		24-h average	Not to exceed		
Phenolic compounds	2440 ^d	600	3400	340	
Basic compounds	1530	Various criteria for individual compounds			
Naphthalene	40			143	
Acenaphthene	27	110	240	20	
Fluoranthene	3	250	560	200	
Fluorene	12				none
Anthracene	1				2000
Phenanthrene	11				280
Pyrene	0.3				8333
Benz[a]anthracene	0.8				4
Benzo[a]pyrene	0.3				20
Benzo[e]pyrene	0.11				109

^aConcentration for phenolics from Table Z.21; PNA concentrations are assumed to saturated solution, average of values in Table Z.22.

^bDraft criteria from Table S.3.

^cEstimated permissible concentrations from Table S.4.

^dConcentration of phenolics is the estimated average for 24 h; higher maximum concentrations would probably occur at the start of the spill event.

Downstream from the zone of massive mortality would be a zone of selective mortality, in which only the more sensitive species would be killed. Farther downstream, organisms would suffer sublethal effects of contamination rather than outright mortality. As the contaminated slug moved downstream, the decline in concentration of contaminants would depend on many unknown factors. Therefore the size or location of the above zones of impact cannot be estimated.

The water intakes for the Washington, D.C., metropolitan area are located near Little Falls, Maryland, River Mile 117.4. At this point average stream flow is 323 m³/s, indicating roughly 1.3-fold dilution between Point of Rocks and Little Falls. If phenolic concentrations were reduced by dilution only, an average concentration of 2.0 mg/liter could be expected when the contaminated slug reached this point.

In all probability, the spill of SRC-II fuel described above would result in a minor water supply emergency for the Washington, D.C., metropolitan area. The time of transit from the spill area to Washington (1-3 d) would allow for advance preparation. With such advance notice the local authorities would have adequate time to build up a reserve so that intake from the Potomac could be terminated until the contaminated slug had passed the intake. Households could also be instructed to store drinking water. However, most uses for water other than drinking and cooking would be unaffected. Following the passage of the most contaminated slug of water, public health assessments would be needed to determine the risks associated with the residual contamination levels. Many unknown factors would be involved, and it is not possible to estimate how much time would be needed until the water supply would be safe to drink.

Long-term impacts

Long-term impacts would result largely from the less-soluble compounds in the SRC-II product. Close to the spill site, the gross contamination would cause significant aesthetic damage. Oil-covered rocks and shoreline could cause limited mortality to birds. Substantial quantities of spilled product would be mixed with gravel, sediment, and other debris in the river. Contaminants adsorbed to fine sediment and organic detritus could be transported downstream, thus allowing dispersion of low-solubility PNAs.

The high molecular weight PNAs, although unlikely to be acutely toxic (see Fig. S.2 and Table Z.22), are susceptible to bioaccumulation and bioconcentration. Some of the PNAs could become serious contaminants in downstream ecosystems. Benzo[a]pyrene, for instance, is a potent carcinogen that could cause cancer in fish or people who ate them. Both the soluble and the less-soluble phenolics would cause taste and odor problems in fish and shellfish of the Potomac River and its estuary. Recreational fishing in the Potomac could be eliminated for one or more years, and contamination of shellfish beds in the estuary might cause economic impact. Because of the many unknown factors affecting the distribution of organic contaminants in aquatic ecosystems, it is not possible to estimate the severity of these impacts.

Z.5.2.2 On groundwater and soils

The effect on groundwater quality of a spill in the Potomac River would depend on the nature of the bottom sediments, soils, and aquifers and on the flow in the river. The SRC-II product liquid is primarily composed of (1) substantially insoluble aromatic and aliphatic hydrocarbons, (2) more soluble phenolic compounds, and (3) basic nitrogenous compounds such as amines (see Sect. Z.3). A subgroup of particular concern, because of its suspected carcinogenic properties, is the polynuclear aromatic hydrocarbons (PNAs). These various chemical constituents may be evaporated, carried in the surface water (either floating or dissolved), oxidized chemically or biologically, or leached into the sediments and underlying rock.

The insoluble hydrocarbons (from classes 1 and 3 above) that do not float on the surface may be sorbed by soil particles and bottom sediment or may seep into underlying aquifers, coating the rock surfaces. Sorption by soil has been found by Hassett et al.⁶ to be related to the organic matter content of the soil. Other soil properties such as pH, cation exchange capacity, and clay content are poorly correlated with sorption. Because the water solubility of such compounds is very low, only minute quantities are to be expected in the groundwater pumped from a contaminated aquifer. If the spill is large enough or the surface area of the rock small enough, underground "pools" of hydrocarbons (analogous to oil field deposits) may form. If wells intersect such pools, the product liquid would be pumped out before the water. This situation is most likely to occur in gravel deposits and aquifers with fracture flow, both of which are known to occur in the Potomac River valley.

Phenolic compounds are more soluble in water than are the hydrocarbons discussed above and have been found in the groundwater beneath the spill area at the Fort Lewis pilot plant.² Groundwater concentrations rose from less than 1 mg/liter (background) to approximately 10 mg/liter at wells

within 60 m of the spill.² Under the Clean Water Act recommended concentration limits on the basis of human health criteria is 3.4 mg/liter; the recommendation for aquatic life standards is a maximum 24-h average of 0.6 mg/liter. The quantity spilled at the Fort Lewis plant was calculated to be 8840 liters (2336 gal); the quantity contained in one car of a 74-car unit train is 75,680 liters (20,000 gal) and loss of one car is used as the worst-case release because it exceeds the highest average volume released during 1976-1978 (see Sect. Z.4.3.1).

The Fort Lewis site probably represents a worst-case situation with respect to soils because the surface layers are composed of gravel with low clay contents. The aquifer below is composed of sand and gravel, which would provide little attenuation of the contaminants but which would provide some physical dispersion and surface area for formation of oily coatings. A worst case with respect to the aquifer would be a cavernous limestone, which provides little surface area or chemical attenuation but has high groundwater flow rates. The Conococheague limestone, supplying water to central Maryland and eastern West Virginia, is an example of such an aquifer.⁷

Several PNA compounds were also monitored in the groundwater near Fort Lewis.² Increases over the background concentrations were noted for several compounds. Species whose concentrations increased near the spill included acenaphthene, fluorene, anthracene, fluoranthene, and chrysene. All concentrations remained below recommended levels.² Increasing the amount spilled (from 8840 liters at Fort Lewis to 75,680 liters in one car of a unit train) could increase PNA concentrations to above the recommended standards. The final concentrations in the groundwater would depend upon the site geology, the microbial activity in the soils, and the effectiveness of the cleanup operations.

Spills of oily substances and application of oil wastes to soils have occurred in the past. In a laboratory simulation of a crude oil spill in Alaska, T. E. Loynachan⁸ found that 5.9% of the hydrocarbons were degraded by soil microorganisms at 10°C at an application rate similar to that which would be expected by a train spill. Disking of the soil and application of fertilizer and sawdust increased the amount of decomposition to 12.9%. Successful treatment of oily residues by land application and microbial degradation has been demonstrated.⁹ However, application rates were considerably lower than that anticipated in a train spill. In a survey of existing land application systems, loading rates ranged from 10 to 2020 lb acre⁻¹ d⁻¹ of BOD.⁹ Assuming a complete degradation of three representative compounds (methylnaphthalene, *o*-cresol, and quinoline), one car's contents would contain approximately 480,000 lb BOD. The maximum loading rate of 2020 lb acre⁻¹ d⁻¹ would require approximately 240 acres per car load spilled.

In summary, a spill due to a train accident could increase the concentrations of phenols and PNAs in groundwater above acceptable levels. This excess would be most likely to occur in areas with shallow gravel or cavernous limestone aquifers and thin or sandy soils. Such deposits are known to occur in the Potomac River valley.

Z.5.2.3 Air quality effects

Spills on land or water, either at the storage sites or while in transit in unit trains or barges, would have the immediate effect of releasing high concentrations of nonmethane hydrocarbons into the atmosphere. Those light, insoluble distillates that would remain above the water surface would also evaporate. Some of the vapors released are known toxic gases, such as the vapors from naphthalene and phenol portions of the SRC-II product; proper protective respiratory equipment should be worn near such spills.

Spills on land would have a temporary effect on air quality because the liquid would be absorbed by the soils in the area or cleaned up as quickly as possible. Spills on water would also have a temporary effect on air quality because they would be contained, recovered, and cleaned as soon as possible.

If the vapors of a spill ignited, the resulting combustion would emit various other compounds into the atmosphere, such as carbon monoxide and sooty particulates from the incomplete combustion of organics. Such an event would also be temporary in nature.

Because of the unpredictability of such accidents, the unknown components released by the uncontrolled combustion of SRC-II liquid, and the temporary nature of such accidents, it is not possible to quantify the releases of pollutants and their effects on air quality except to state that the emissions would be large until the spills were absorbed or recovered and any fire associated with the spill were extinguished.

Z.6 LIQUID SPILLS AND CONTROL

This section first analyzes past rail bulk liquid spills that have affected bodies of water in a three-state region: West Virginia, Maryland, and Pennsylvania. The data on historical spills

are collected through the Coast Guard's Pollution Incident Reporting System. The second part of this section explains the techniques for controlling a bulk liquid spill. The techniques are designed by the U.S. Navy for the containment and recovery of spills of oil, which is the bulk liquid most similar to SRC-II liquid products. DOE will collaborate with the Coast Guard, EPA, and state and local agencies to develop strategies for minimizing the likelihood of spills and to develop plans for action if spills of SRC-II liquid occur.

2.6.1 Bulk liquid spills and a hypothetical SRC spill

The Federal Water Pollution Control Act of 1970 (Sect. 311) requires that any discharge of an oil or a hazardous substance in a harmful quantity be reported to the "appropriate agency of the United States Government;" Executive Order 11735, March 5, 1970, designated the U.S. Coast Guard as one such agency. The Pollution Incident Reporting System (PIRS) is a computerized data base developed as an adjunct to the Coast Guard's Marine Environmental Protection Program. Initially designed for the collection and maintenance of discharge data, the program was subsequently modified to permit the inclusion of additional data on cleanup (response) activities and penalty actions. Following are the data PIRS has collected since 1973 for pollution incidents:

1. discharge: time of occurrence, location, state, water body, source, cause, operation, material, quantity, affected resources, weather, and notifier;
2. response: cleanup party, equipment used, personnel, cleanup duration, amount recovered, and cleanup cost;
3. penalty: initiating agency, authority, action against, action date, penalty proposed, penalty collected, hearing results, appeal results, and cause status.

In order for a spill to be recorded, it must: (1) be water connected, (2) occur within the territorial boundaries of the United States, (3) be reported by an interested party, and (4) reveal a sheen on the water (generally recorded to be a quantity of at least one gallon of material).

A request was made to the U.S. Coast Guard for a printout of rail and barge spills of liquid shipments in a zone between Morgantown, West Virginia, and Baltimore, Maryland, that included the states of Pennsylvania, West Virginia, Maryland, and Virginia for 1975 to present. These data were used to develop an initial understanding of spill problems in the vicinity of the route analyzed.

Hypothetical SRC spill

The technique to clean up, an SRC spill would be similar cleanup techniques for a heavy No. 6 petroleum fuel oil. For the purpose of this analysis, it is assumed that the chemical compositions of No. 6 fuel oil and SRC liquid are similar.

Since SRC-II liquid has not been commercially produced, there is not a history of spills. When oil is spilled on water, a variety of processes occur, as weathering, dissolution, emulsification, chemical reaction, biological degradation, and formation of tar lumps. Collectively, these tend to disperse the oil into a thin film. It can be assumed that most of the SRC-II liquid is a complex mixture of many varying compounds, each of which may have a different density; however, on the average the overall density would most likely be less than that of water (see Sect. 2.2.3).

With the SRC-II liquid floating and spreading in water, light-end naphthas and single-ring phenolic compounds would probably evaporate; this evaporation would be enhanced by increased wind speed and water temperature. Some of the heavier naphthas that do not evaporate may mix with the water to form an emulsion; some may undergo oxidation under the influence of the ultraviolet band of sunlight. Oxidation is also enhanced by wave action or swift current. The remainder of the naphthas would probably mix with the heavier phenolics, polynuclear aromatics, and tar compounds.

Biological degradation may occur with the phenolic compounds, but would probably take months or years with the polynuclear aromatics, if it ever occurred at all. In any case, cleanup operations would be undertaken, because this remaining mixture of the heavier naphthas, phenolics, polynuclear aromatics, and tar compounds could combine under oxidation or polymer formation to form tar balls, which create a serious problem upon reaching the shore. It is assumed that some of the SRC-II liquid would settle to the bottom of a river or other body of water, but the chemical fraction and quantity cannot be identified at the present time.

Z.6.2 Oil spill control

This section presents general information on corrective action to be taken on an oil spill. Because SRC-II liquid is essentially an oil, it is considered to be responsive to normal oil spill treatment. There is no single system or procedure for cleaning up oil spills that can be applied in all locations regardless of the characteristics of the water body and terrain. Geographic differences, exposure, and ease of access, and other variables require that each system be carefully designed for a specific area.

An oil spill sets in motion the following operational phases that are basic to all spills:

1. discovery and notification;
2. evaluation and initiation of action;
3. containment and countermeasures;
4. recovery, mitigation, and disposal;
5. cleaning and repositioning equipment; and
6. documentation and cost recovery.

These phases are not necessarily sequential and usually overlap. The degree of application of each phase is dictated by the spill conditions and severity.

This EIS cannot address all of the operational phases of soil spills but will concentrate on the state of the art of oil spill removal equipment that has possibilities for use on inland waterways for containment, countermeasures, and recovery.

Participation in the Manufacturing Chemist Association's CHEMTREC program should be of additional assistance in the event of a transportation accident involving SRC-II liquids; CHEMTREC provides 24-h access to information concerning specific chemical materials and provides guidance on what to do in case of a spill, fire, or exposure to those chemicals.

Spills on land

Spills of hazardous materials on land have received considerably less legislative and programmatic attention than spills into water bodies, although the potential for significant contamination of soil, groundwater, and air in the vicinity of a spill is of concern as well. The surface spill of SRC-II fluid that occurred at Fort Lewis, Washington, on December 19, 1979, provides valuable insight into the effects of a spill on land. The measures developed to counteract the effects of that spill will be of help in designing spill mitigation procedures for other sites, although site-specific differences in soil, geology, and groundwater conditions will require certain variations in the mitigation plans.²

The remedial measures plan for treatment of the Fort Lewis spill site included the following:

1. excavation of contaminated soil,
2. sealing of the land surface at the spill site to prevent further infiltration of precipitation,
3. pumping of groundwater near the spill site to control groundwater transport of contaminated groundwater, and
4. implementation of a long-term surface and groundwater monitoring program.

Z.6.2.1 Containment and countermeasures

These measures are perhaps the most important in the removal of an oil spill. They are the first corrective actions taken and should be initiated as soon as possible. Countermeasures are usually of four types:

1. isolation and evacuation of spill area to protect life or health,
2. shutting off the source of the spill,
3. placing booms or other physical or adsorbent barriers to prevent contamination of surrounding terrain or adjacent waterways by spreading, and

4. preplanned construction of trenches or ditches to isolate potential spill areas on land.

Containment is the critical first step of any coordinated spill cleanup activity. Quick response time is important and is dependent upon variables such as geography that limits access to a spill, equipment design and availability, personnel capability, the size of the spill, and its physical and chemical properties.

Containment is accomplished through four principal methods: booms, containment dams, air barriers, and surface tension modifiers. All four are currently state of the art.

Booms are man-made barriers to the movement of oil. There are many different types of booms, and research continues to improve their use and performance. Booms are designed to either contain or direct flow of an oil spill and consist of five principle components: float, skirt, tension member, ballast or weighting member, and coupling.

The selection of the proper boom must be carefully made. Many variables of construction, materials, and operation are available and must be considered in the design of a system. Booms are the most effective containment device. They are available in various sizes (in 50-ft lengths), which are joined to form a continuous barrier. They may be used in either a dynamic mode or fixed position. Booms can be used to direct the flow to a skimming device that removes the oil.

Streams, creeks, and other small drainage channels are often too narrow and fast flowing or steep sided for proper boom deployment. Containment dams then offer a good choice for trapping the oil. They can be earthen, straw, or sorbent. An earthen dam can be constructed in a dry creek bed or moving stream by either mechanical or manual methods. A site must be selected sufficiently downstream to allow completion before the oil arrives. A sorbent dam can be readily built with locally available materials such as wire mesh or fencing stretched across a stream and straw or other sorbent materials placed on the upstream side.

Air barriers are an alternative to booms for spill containment. The principle is simple: a stream of air bubbles rises in the water to form a turbulent barrier of elevated water that can effectively block the flow of floating oil. The air barrier is formed by placing a perforated pipe across the bottom of the water area to be isolated and injecting air into the pipe. This system has the advantages over floating booms of being traversable by marine traffic and of being operated when desired by simply switching on an air source.

Air barriers are normally installed as a permanent system where continuous or intermittent control of surface pollution is necessary. They are generally not economically feasible where currents exceed 1.7 fps or 1.2 mph or where wind and wave action is high.

An oil spill spreads over a large surface of water; the size of the spill surface is a function of the difference between the surface tensions of water and oil. Surface tension modifiers, or collecting agents, are chemicals that have high surface activity and spread rapidly over water. The spreading force of the chemical is sufficient to overcome the spreading forces of the oil. The chemical will push the oil layer back until it reaches a limiting oil thickness which the chemical cannot exceed. The collecting agent can be spread around an oil spill for containment, or the oil spill can be moved ahead of the chemical towards a collecting device.

Several such chemicals are now available; two are marketed by oil companies: Oil Herder from Shell Oil Company and OC-5 from Exxon Corporation. The U.S. Navy uses an agent known as "piston film," which is a sorbent monooleate similar to the oil company products. Several companies manufacture this agent.

Collecting agents must be approved on a case by case basis. It is advisable to obtain the consent of the state and Federal agency having jurisdiction in such matters.

Another type of collecting agent is the gelling agents. They are not widely used because of their expense, difficulty to pump and separate from water, and more difficult disposal problems.

Z.6.2.2 Removal

Removal of an oil spill can be accomplished in several ways, including evaporation (gasoline, jet fuel, light distillates), physical removal, biodegradation, burning, dispersion (emulsification), and pumping into landfills. The latter three methods are not desirable because of their detriment to the environment and hazard to life and property. Reliance on biodegradation is not recommended because of its lengthy reaction time and the possibility of toxic products. Evaporation is a naturally occurring phenomenon for light, highly volatile products.

Physical removal is extensively used and is benefiting from intensive research. Principal methods of mechanical removal are vacuuming and skimming by mechanical skimmers or suction.

Vacuum units

Vacuuming is one of the most acceptable methods for removing a contained oil spill unless the oil is too viscous to be sucked into the unit. Truck-mounted units vary in capacity from 50 to 100 bbl. Skid-mounted units are good for small oil spills. Vacuum units are most effective when a spill has been contained in thick pockets of relatively pure oil.

Some of the disadvantages of the vacuum truck that should be considered are as follows:

1. It is large, expensive, and mechanically complicated.
2. Its size and weight preclude accessibility to many oil spill areas.
3. Proper maintenance is mandatory and is expensive if the truck is not used regularly.
4. It is not the most cost effective method for removal of small or widely dispersed thin-layer oil spills.

Skimmers

Skimmers are obtainable in small, medium, and large sizes. The small unit is suitable for harbor areas and is based on the weir principle. It floats on the water and permits oncoming oil to pass over the weir plate into a tank where the confined oil is sucked or pumped off.

The medium-sized skimmer employs the endless belt principle and is operated from a pier or stream bank by hand-held controls. The rotating belt submerges the oil and directs it to a collection well where it concentrates and can be pumped to temporary storage. The principle is called the dynamic inclined plane (DIP), in reference to the rotating and pitched belt.

The large skimmer is a larger version of the medium DIP model and is vessel mounted for use in protected open waters in the moving mode.

A unique skimmer has been developed in France and is available in the United States. Called the Cyclonnet, it operates on the principle of oil-water separation by rotation. The skimmer is attached to the side of a boat and moved through a spill. Oil and small amounts of water are forced into the device, causing a rotation of internal parts that separate the two components.

Another suction type utilizes three types of enlarged suction heads that float on the water with the opening at the oil-water interface. These units are portable and quickly deployable. They work well on small spills of medium to light oil; they are not good for heavier black oils.

Another type of mechanical skimmer operates on the principle that oil rather than water will adhere to an oleophilic material. These oleophilic type skimmers have a continuous belt that dips into the oil spill and carries the oil in the material into a collection tank where small amounts of oil and water are squeezed out. The oil and water separate and are pumped out of the collecting tank.

Z.6.2.3 Site-specific cleanup and containment procedures

Authority for cleanup and containment procedures used in case of a spill along the proposed route are found in the National Oil and Hazardous Substances Pollution Contingency Plan (the Plan). The Plan provides for coordinated Federal action to try to prevent discharges of oil and hazardous substances and to protect the environment from damage when discharges occur. The Plan promotes Federal-state coordination and encourages local governments and private firms to build capabilities for cleaning up spills. Developed in compliance with Section 311(c)(2) of the Clean Water Act, the Plan provides for:

1. assignment of responsibilities among Federal agencies, in coordination with state and local agencies;
2. identification, procurement, maintenance, and storage of equipment and supplies;
3. establishment or designation of a strike force to carry out the Plan and trained and adequately equipped emergency task forces at major ports;
4. a system of surveillance and reporting to give responsible Federal and state agencies the earliest possible notice of discharges of oil and hazardous substances or imminent threats of such discharges;

5. establishment of a national center to provide for coordination and direction of operations in carrying out the Plan;
6. procedures for identifying, containing, dispersing, and removing oil and hazardous substances;
7. a schedule, prepared in cooperation with the states, identifying any dispersants or other chemicals that may be used in carrying out the Plan;
8. a system for reimbursing states for reasonable costs incurred in removing discharges;
9. a procedure for coordinating scientific support of cleanup operations, assessment of damage after a spill, and research efforts; and
10. a system for referral and appeal of decisions of the Regional Response Teams and On-Scene Coordinator.

Based on the Plan, depending upon where a spill of SRC-II liquid occurs along the proposed route, either EPA or U.S. Coast Guard officials would be called in to oversee the procedures. The Coast Guard would handle spills in the Baltimore area; EPA Region III is consulted for spills along the Potomac River.

The Plan designates five sequential steps to be taken by Federal authorities once the spill is reported:

1. investigate the report to determine pertinent information such as the threat posed to public health or welfare, the type and quantity of material discharged, and the source of the discharge;
2. notify Regional Response Teams and the Scientific Support Coordinator in accordance with the applicable regional plan;
3. determine whether the person or activity responsible for the pollution is properly carrying out removal actions;
4. officially classify the severity of the discharge and determine the course to be followed; and
5. determine whether state action to effect removal is necessary within the meaning of the Clean Air Act.

In general, according to the Plan, the company spilling the hazardous substance is fined \$5000 (regardless of the amount spilled) and is responsible for instituting timely and effective cleanup. In addition, the company is required to call the National Response Center at (800) 424-8802. Once the center is notified, actions are taken as specified in the Plan to both ensure a proper cleanup and assess possible environmental damage (e.g., contamination of the water supply). In the event that the company does not satisfactorily clean up the spill, Federal, state, or local authorities would intervene, clean up the spill, and charge the cleanup cost to the company.

Regional Coast Guard and EPA officials, asked to discuss the response they would execute in the event of an SRC-II liquid spill, offered two site-specific criteria for determining cleanup and containment procedures: climatic conditions (season and geographic setting) and type of water body. The basic assumption in these discussions was that SRC-II will behave when spilled like heavy petroleum No. 6 fuel oil.

Regarding the time of year, it was pointed that No. 6 fuel oil spilled on water behaves differently in summer than in winter. In the summer, No. 6 fuel oil will remain on the surface. In this case, cleanup and containment would usually involve booming the area for containment, then skimming, vacuuming and mopping with absorbent materials for cleanup. On the other hand, in cold winter weather, heavy No. 6 fuel oil will sink to the bottom of the water. This fact, in conjunction with the second criteria mentioned above (type of water body), could cause containment and cleanup to be difficult. For example, if the oil were to spill into a small, slow-moving stream and sink to the bottom, it would not be difficult to locate the oil and clean it up. However, if the oil were to spill in a fast-moving river (like the Potomac) and sink to the bottom, it would be much harder to locate and clean up, as it would be moving downstream. Neither the EPA nor the Coast Guard spokesperson could be more specific in regard to potential spills.

Z.7 HYDROTREATING AS A MEANS OF MITIGATING SPILL IMPACTS

Preliminary findings from an Ames test indicate that hydrotreating may result in significant reduction of the mutagenic activity of the SRC-II liquid product.¹¹ If these results are confirmed, it would appear that the potential health effects of spilled SRC-II liquids could be significantly reduced by such treatment.

Distillate coal liquid from the SRC-II process was hydrotreated in a bench-scale process unit at the Bartlesville Energy Technology Center to provide a range of mildly upgraded products for compositional characterization and subsequent screening of biological activity by the Ames test. The process increased hydrogen content from 8.4 to 10.8 wt %, while 30 to 100% of the combined nitrogen was removed. When 35% of the nitrogen was removed, mutagenic activity was reduced by an order of magnitude. Removal of 65% of the nitrogen from the SRC-II product resulted in a level of mutagenic activity that was indistinguishable from that of a control test. See Sect. 4.1 of the EIS for further discussion of hydrotreating.

Z.8 TRANSPORTATION REGULATIONS

The U.S. Department of Transportation (DOT), Office of Hazardous Materials (OHM), is assigned the responsibility of regulating hazardous materials similar to SRC-II liquid while in transport. An extensive set of regulations covering all phases of transportation from the time the material leaves the shipper to the time it reaches the consignee has been created by OHM to protect the public interest. The following section presents the regulations pertinent to the shipment of SRC-II liquid, as well as the most likely means by which it will be shipped.

Since the primary equipment for SRC-II liquid shipments are rail tank cars, a description of the unit tank car train is presented in the second part of this section.

The DOT regulations most closely applicable to transport of SRC-II products are new and amended regulations and do not yet specifically include SRC-II products. The miscellaneous category "not other specified" (N.O.S.) would apply to SRC-II liquid transport at this time. The component elements of SRC-II liquid are similar to both the middle and heavy petroleum distillates. For the purpose of this preliminary analysis, federal regulations for distillate transport can be assumed to be applicable for SRC-II liquid shipments.

The DOT regulations dealing with the shipment of hazardous materials are stated in 49 CFR Parts 100-177. There are five subsections of the Federal Code that are applicable to shipments of SRC-II products:

1. Subsection 172.100 for shipping proper name,
2. Subsection 172.200 for description of hazardous materials on shipping papers,
3. Subsection 172.300 for marking and labeling requirements,
4. Subsection 172.400 for packaging specifications, and
5. Subsection 173.119 for specification of tank cars.

It will also be necessary to mark each tank car with either the proper shipping name or the common name of the chemical. The markings must be of a specific size, 4 in. or more in height and a minimum of 3/4 in. between each letter. They must be affixed to both sides of the tank car and in plain view. Finally any tank car marked in this way may not be used to transport any other material unless the markings are removed.

The last regulation that would apply to SRC-II liquid shipments is the use of placards. Placarding only applies to volumes over 640 ft³ and/or 1200 lb and requires that the shipper identify the hazardous material by means of the appropriate placard. The placard must be displayed at each end and each side of the shipping container. For SRC-II liquid shipments the placard would identify the contents as either combustible or flammable, depending on the exact chemical composition of the product.

Z.9 DESCRIPTION OF TRANSPORTATION EQUIPMENT AND SAFETY FEATURES

The transportation analysis is based upon specific assumptions regarding production and shipping quantities of the SRC-II liquid products. Although the proposed Fort Martin demonstration plant is capable of producing a mix of usable energy products, the transportation analysis examines the largest possible production (13,800 bbl/d) for transport requirements and/or transportation-related accidents.

It is assumed that the 13,800-bbl/d production capacity is of a single homogeneous product for transport. Plans are to use two unit trains of 74 tank cars each; the capacity of each tank car is 20,000 gal, or 72.4 net tons, making each 74-car unit train capable of hauling 5357.6 tons of SRC-II products. Each unit train is capable of hauling 2-1/2 days' production from the Fort Martin demonstration plant with extra capacity of 112.2 tons, or approximately 1.55 tank cars.

It has been established, however, that actual production rate during the first four to five years of operation will be considerably less than 100% of full plant capacity. During the first year of operation, the plant is expected to operate at only about 18% of capacity. Production is expected to increase to 50% in the third year and to 80% in the fifth year of operation (see Appendix C). Because of the limited production rate during those years, impacts considered in this section are somewhat overstated.

Z.9.1 Unit tank car train

The specific transportation requirements of the Fort Martin plant suggest the utilization of tank car unit trains for the shipment of SRC-II liquid. The current state of the art for the shipment of homogenous bulk liquids is a system of interconnected tank cars developed by General American Transportation Corporation (GATX) (Dominic Conova, GATX Terminal Corporation, personal communication, Oct. 28, 1980). The system, whose registered trademark is "TankTrain," offers a wide range of advantages over conventional unit train design. The unique interconnection system of elbow pipes and flexible hose enable the unit train to be loaded and unloaded from an individual tank car, an appreciable improvement over the conventional method of loading and unloading each car individually.

This modification, it is thought, would have a positive impact on both the human environment and the environment in general, as well as providing a number of cost advantages for the shipper. Because of the single product line connection feature, the number of persons handling loading and unloading operations is dramatically reduced. The harmful effects of climbing on cars, opening manways, handling fittings, and being exposed to the commodity and its harmful vapors are all minimized. This same feature allows direct transfer of the liquid commodity to holding facilities or subsequent transportation modes, reducing the possibility of spillage or vapor loss that is usually associated with conventional unit trains. The capital costs are reduced through this system by minimizing loading and unloading time and thus minimizing turnaround times.

Z.9.2 Specification for rail tank car and barge construction design and required safety features

Z.9.2.1 Rail

Title 49 Code of Federal Regulations Part 179, Subparts (A), (B), and (D) deal exclusively with the design requirements for rail tank cars. There are several areas in tank car design that must meet the specifications outlined in these regulations. The most important areas are the thickness of the tank walls, the type of wall materials, and the types of loading-unloading and safety relief valves.

A major manufacturer of rail tank cars was contacted to determine which DOT specifications are the current standard for petroleum tank cars and would therefore be acceptable for SRC-II liquid products. The manufacturer identified three designs that are in use today for petroleum products (Dominic Conova, GATX Terminal Corporation, personal communication, Oct. 28, 1980). The DOT specifications for these three designs are 103W, 111A60W1, and 111A100W1 (Table Z.24). Design 103W rail cars are too heavy and costly compared to cars built in accordance with the other two specifications. The majority of petroleum rail cars are built to meet specification 111A100W1 because they can then be downrated to a 111A60W1 car by using a 35-psi valve in lieu of a 75-psi valve. This system permits greater car utilization by upgrading to a 111A100W1 car, when necessary. This flexibility in car design makes possible the maintenance of a lower inventory of cars. Thus, either of the two designs is acceptable for the shipment of SRC-II liquid, a fact that increases the availability of rail tank cars. These are examples of available equipment used to ship similar commodities. DOE will select equipment with equivalent or greater safety features as deemed appropriate.

Z.9.2.2 Barges

The barges that will haul the SRC fuel to consuming utilities will probably be converted oil barges. The standard sizes of liquid cargo (tank) barges used in the inland and coastal waterway trade are listed in Table Z.25.

Table Z.24. Individual rail tank car specification requirements

	103W	111A60W1 ^a	111A100W1 ^a
Material (see 179.200-7)	Steel	Steel	Steel
Insulation (see 179.200-4)	Optional	Optional	Optional
Bursting pressure, psi (see 179.200-5)	240	240	500
Minimum plate thickness, in.			
Shell (see 179.200-6)	170.201-2	7/16	7/16
Heads (see 179.200-6 and 179.200-8)	179.201-2	7/16	7/16
Dome	Required	None	None
Minimum expansion capacity (see 179.200-14) ^b	2% in dome	2% in tank	2% in tank
Test pressure, psi (see 179.200-22)	60	60	100
Safety relief devices (see 179.200-18)	Valve or vent	Valve or vent	Valve or vent
Valve start-to-discharge pressure, psi (± 3 psi)	35	35	75
Valve vapor tight pressure (minimum psi)	28	28	60
Valve flow rating pressure (maximum psi)	45	45	85
Vent bursting pressure, psi ^b	60	60	100
Gaging devices (see 179.200-16)	Optional	Required	Required
Top loading and unloading devices (see 179.200-16)	Optional	Optional	Optional
Bottom outlet [see 179.200-17(a)]	Optional	Optional	Optional
Bottom washout [(see 179.200-17(b))]	Optional	Optional	Optional
Closure for manway (see 179.200-15)	179.201-6(a)	179.201-6(a)	179.201-6(a)
Postweld heat treatment (HT) (see 179.200-11)	HT	HT	HT
Special references	179.202-1	179.202-2	179.202-1
	179.202-2	179.202-3	179.202-2
	179.202-3	179.202-5	179.202-5
	179.202-4	179.202-6	179.202-6
	179.202-6		
	179.202-19		

^aTanks converted to DOT-111A series from existing forge-welded specification. DOT-105A300, 400, or 500 tanks, by modification using conversion details complying with DOT-111A specification requirements, shall be stenciled by substituting the letter "F" for the letter "W" in the specification designation.

^bMandatory compliance with 49 CFR Part 179.201-1 is Jan. 1, 1979.

Source: *Hazardous Materials Regulations of the Department of Transportation*, Tariff No. BOE-600, Association of American Railroads, Dec. 3, 1979, p. 453.

Table Z.25. Standard sizes of liquid cargo barges used in inland and coastal waterway trade

Length	Breadth	Draft	Capacity ^a	
			Tons	Gallons
175	26	9	1,000	302,000
195	35	9	1,500	454,000
290	50	9	3,000	907,200

^aBased on an average 7.2 bbl/ton and 42 gal/bbl.

Source: The American Waterway Operators, Inc., *Big Load Afloat*, Washington, D.C., 1973, p. 27.

Z.10 FATE AND EFFECTS OF COAL LIQUEFACTION PRODUCTS IN AQUATIC ECOSYSTEMS

Z.10.1 Introduction

Spills of liquid products are among the major potential environmental hazards of coal liquefaction technologies. It has been estimated that a commercial liquefaction industry producing 500,000 barrels per day of synthetic oil would result in accidental releases of from 1000 to 150,000 barrels per year into aquatic ecosystems.¹² Based on these considerations, the Advanced Fossil Energy Program (AFEP) of Oak Ridge National Laboratory's Environmental Sciences Division has been conducting research on the transport, fate, and effects of synthetic oils in freshwater ecosystems. This section presents the major results to date from the AFEP research.

Objectives of the synthetic oils research program are: (1) comparison of the toxicity of coal liquefaction products, shale oils, and petroleum products to aquatic plants and animals; (2) identification of the principal water-soluble toxic constituents of synthetic oils, (3) examination of the effects of refining and process conditions on the toxicity of synthetic oils, (4) examination of the influence of weathering processes (especially dissolution, photodegradation, and evaporation) on the toxicity of synthetic oils, and (5) investigation of the long-term fate, and the possible effects on aquatic organisms, of synthetic oil residues incorporated into sediments.

Objectives (1) through (3) have been investigated to some depth to date. Preliminary results that address objective (4) have been obtained; work on objective (5) has not yet been initiated.

Z.10.2 Experimental approach

Z.10.2.1 Water-soluble fractions (WSFs)

The first two years of this research have focused on water-soluble fractions (WSFs) of oils for several reasons. (1) Studies with petroleum products indicate that the water-soluble components of oils are responsible for most of the oil's acute effects on phytoplankton, zooplankton, and fish.^{13,14} (2) The components of an oil that dissolve rapidly into water after a spill are liable to affect a larger area than the oil slick itself. (3) Exposure of organisms to dissolved oil components will occur even if the undissolved oil is recovered. (4) Bioassays with WSFs avoid the experimental difficulties inherent in tests with insoluble and immiscible materials.

After a review of the literature, a procedure was selected that has been widely used in studies on petroleum for WSF preparation. Oil is floated on water in a closed glass vessel at a ratio of 1:8, a ratio widely used in petroleum toxicity testing. The mixture is stirred gently for a predetermined length of time, and the aqueous phase (the WSF) is then separated from the oil and filtered to remove oil droplets. Except in experiments on photodegradation, WSFs are prepared in the dark (or under gold fluorescent lights) to avoid photochemical changes in the oils or WSFs. This procedure results in reproducible, easily handled solutions that can be compared with many published studies on petroleum.

A similar experimental apparatus has been used to quantitate concentrations and rates of dissolution of synthetic oil contaminants. Oil is layered onto water in a closed glass vessel at a volumetric ratio of 1:140 to permit the oil added (25 ml) to spread to a thickness of no more than 2 mm to simulate a thin oil slick in the environment. A reciprocating stirrer is used to prevent vortex formation. Water samples are withdrawn at intervals, and dissolved contaminants are extracted with solvents into acid/neutral and base fractions. Contaminants are quantified after gas chromatographic separation; identifications are made by co-chromatography of standards and by gas chromatography-mass spectrometry (GC-MS) analysis.

Gentle equilibration of petroleum with underlying water in a closed system may not model accurately either the mode of toxicant introduction into seawater or the final contaminant compound distribution.¹⁵ However, oceanic turbulence is far greater than that of most navigable rivers, where synthetic oil spillage is most likely, and dissolution of synthetic oil toxicants is far more rapid than toxicant dissolution from petroleum (as will be presented in later sections of this appendix). Therefore, the experimental dissolution system employed is more likely to simulate correctly contaminant movement from oils into fresh water than is an experimental system dominated by emulsification (i.e., rapid and violent agitation). Further modeling of actual synthetic oil spills may be required to demonstrate conclusively the validity of this assumption.

Z.10.2.2 Oils tested

Most of the oils used in this research were received from the Fossil Fuels Research Materials Facility of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) located at the Oak Ridge National Laboratory. These oils and their EPA/DOE identification numbers are listed in Table Z.26. Further information can be found in ref. 16.

Table Z.26. Oils tested

Oil	EPA/DOE No.
SRC-II product	CRM-1
SRC-II fuel oil blend	1701
Coal liquid A	^a
Coal liquid B	1116
Coal liquid C	1101
Coal liquid D	1308
Coal liquid E	1309
Coal liquid F	1310
Coal liquid G	1312
Coal liquid H	1313
Coal liquid I	1314
Coal liquid J	1601
Coal liquid K	1602
Coal liquid L	1603
Coal liquid M	1604
Coal liquid N	^a
Petroleum crude oil	CRM-3
Petroleum No. 2 diesel fuel	^b
Petroleum marine diesel fuel	4616
Petroleum JP-5 jet fuel	4614
Petroleum residual A	5401
Petroleum residual B	5402
Petroleum residual C	6101

^aObtained from producer.

^bObtained from local distributor.

Table Z.27 shows densities and viscosities of the oils used in dissolution studies. Two SRC-II products were tested as well as three other coal-derived liquids and a petroleum crude oil. The SRC-II products (which were collected from different pilot plant production runs) are intermediate in viscosity between a raw coal liquid (A) and light and heavy distillates of a hydro-treated oil (B and C, respectively); they are considerably less viscous than the petroleum crude tested. The SRC-II products were the densest of the six oils. At 5°C the densities are greater than that of water, and at 25°C the densities are less; thus at temperatures below about 15°C the SRC-II oils sink, and at higher temperatures they float.

Table Z.27. Characteristics of oils tested for dissolution of water-soluble contaminants

Oil	Viscosity at 25°C (cS)	Density	
		5°C	25°C
Coal liquid A	2.82	0.9168	0.9111
Coal liquid B	1.23	0.8276	0.8125
Coal liquid C	21	0.9731	0.9581
Petroleum crude	202	0.9453	0.9320
SRC-II product	7.42	1.0088	0.9940
SRC-II fuel oil blend	7.09	1.0094	0.9950

Z.10.3 Comparative toxicology of oilsZ.10.3.1 Algae

Water-soluble fractions (WSFs) of natural and synthetic oils were tested for their effects on photosynthesis by freshwater algae. The test organisms were *Selenastrum capricornutum*, a unicellular green alga that has been recommended by the EPA for chemical hazard assessment,¹⁷ and *Microcystis aeruginosa*, a nonnitrogen-fixing unicellular blue-green alga. The bioassays measured effects of WSFs on organic carbon uptake in 4-h exposures.^{18,19} Results are expressed as percentages of controls. In some experiments, EC₂₀ values (WSF concentrations causing 20% inhibition of photosynthesis) were estimated by interpolation on a plot of photosynthesis versus log concentration.

Table Z.28 lists EC₂₀s for all WSFs tested.²⁰ Values for coal liquid WSFs were one to two orders of magnitude below those for petroleum WSFs. Crude petroleum was not tested, but petroleum crudes are generally less toxic than refined petroleum products.^{14,21,22}

Table Z.28. Acute toxicity of WSFs to freshwater algae

Oil	EC ₂₀ ^a	
	<i>Selenastrum capricornutum</i>	<i>Microcystis aeruginosa</i>
SRC-II fuel oil blend	0.83	0.63
Coal liquid A	0.29	
Coal liquid D	0.25	0.46
Coal liquid E	0.30	0.26
Coal liquid F	0.063	0.13
Coal liquid G	0.019	1.4
Coal liquid H	0.16	0.15
Coal liquid I	0.019	0.13
Coal liquid J	0.42	0.91
Coal liquid K	0.57	0.75
Coal liquid L	0.68	1.4
Coal liquid M	0.60	1.6
Coal liquid N	0.63	1.1
Petroleum No. 2 diesel fuel	15	25
Petroleum marine diesel fuel	13	
Petroleum JP-5 jet fuel	100	
Petroleum residual A	100	14
Petroleum residual B	100	100
Petroleum residual C	100	63

^aWSF concentration (percent dilution) causing 20% inhibition of photosynthesis.

Z.10.3.2 Daphnia magna

Water-soluble fractions (WSFs) of oils derived from coal and petroleum were tested for acute toxicity to the freshwater crustacean *Daphnia magna* in 48 standard bioassays.²³ Several of the WSFs were also examined in 28 static-renewal experiments to measure chronic effects on *D. magna*. The responses measured in the chronic tests included life span, day of first brood release, number of broods per female, number of young per female, and number of young per brood. Results are summarized in Table Z.29. WSFs of two refined petroleum products were slightly toxic to *D. magna* with 48-h LC₅₀ values of 30 and 67% respectively. Petroleum residual C was nontoxic. In contrast, the WSFs of the coal liquefaction products had LC₅₀s ranging from 0.2 to 4.6%. The SRC-II fuel oil blend was the second most toxic product tested with an LC₅₀ of 0.3%.

At much lower WSF concentrations, more chronic effects than acute effects were observed. The number of young produced per female (over her entire lifetime) was the most sensitive parameter measured in the 28-d tests. Coal Liquid G affected reproduction at a concentration of 0.016% WSF. Petroleum No. 2 diesel fuel produced no chronic effects below 20% WSF. Thus, the differences between the toxicities of coal liquids and petroleum were greater in the chronic bioassays than in the acute bioassays. In separate studies, low concentrations of Coal Liquid A WSF reduced respiration rates and grazing rates in *D. magna*.

Table Z.29. Acute and chronic toxicity of WSFs to *Daphnia magna*

Oil	48-h LC ₅₀ ^a	28-d LOEC ^b
SRC-II fuel oil blend	0.3	
Coal liquid A		
Coal liquid E	4.6	0.58
Coal liquid F	2.5	0.92
Coal liquid G	0.24	0.016
Coal liquid H	1.0	0.25
Coal liquid I	2.5	
Coal liquid J	0.4	
Coal liquid K	0.5	
Coal liquid L	1.5	
Coal liquid M	1.7	
Petroleum No. 2 diesel fuel	30	20
Petroleum marine diesel fuel	67	
Petroleum residual C	100	

^aWSF concentration (percent dilution) that killed 50% of the test organisms in 48 h.

^bLowest WSF concentration (percent dilution) at which significant effects on reproduction were observed in 28 d.

Z.10.3.3 Sediment microbial communities

Sediment microbial communities in laboratory microcosms were treated with Coal Liquid G and petroleum marine diesel fuel semi-continuously for three months. Dehydrogenase activity (a measure of microbial respiration) and adenosine triphosphate (ATP, a measure of microbial biomass) were significantly reduced by the liquefaction product; only dehydrogenase was affected by the marine diesel fuel. At the end of the experiment, four other structural features and seven other microbial functions were assayed in the microcosm sediments. None of the structural measurements showed significant effects from the oil treatments. However, many of the microbial functions (mineralization of glucose, protein, starch, lipid, and naphthalene) were significantly higher in the microcosms treated with the liquefaction product than in the controls. Starch, protein, and lipid mineralization were also stimulated by the marine diesel fuel.²⁴

Z.10.3.4 Pond ecosystems

The WSF of the SRC-II fuel oil blend was applied to two 80-liter pond microcosms containing water, sediment, and a complex biotic community. The WSF concentration immediately after treatment was 1%, near the threshold for photosynthetic inhibition as determined by algal bioassays (Sect. Z.10.3.1) and approximately three times the 48-h LC₅₀ for *Daphnia magna* (Sect. Z.10.3.2). The treatment resulted in a gradual decline in primary production to very low levels over a two-week period. A large portion of the dominant plant population (the pondweed *Elodea*) was destroyed, and the major algal taxa (*Spirogyra* and benthic diatoms) were eliminated; zooplankton disappeared. Snails moved out of the water and remained above the waterline on the walls of the microcosms. For two to four weeks after the WSF was added, the systems were nearly anaerobic. A gradual recovery ensued. *Elodea* resumed growth, and blue-green algae replaced the benthic diatoms. The snails returned to the water and began producing egg masses. Primary production rebounded, reaching pretreatment levels after 6 to 8 weeks. These experimental ecosystems thus responded more dramatically than the simple algal bioassays to this WSF, but the major effects were transient. Ecosystem function (energy and nutrient flow) recovered from the treatment, but certain changes in community structure (such as the replacement of diatoms by blue-green algae) persisted until the experiment was terminated at eight weeks.²⁵

Z.10.3.5 Summary

Water-soluble fractions (WSFs) of the SRC-II product and other coal liquids were toxic to freshwater algae and invertebrates at much lower concentrations than WSFs of petroleum products. Effects on *Daphnia magna* reproduction occurred at WSF concentrations as low as 0.016% for coal liquids, compared with 20% for petroleum No. 2 diesel fuel. Coal liquids and their WSFs produced significant effects on primary production, microbial activity, and other functions of aquatic ecosystems.

Z.10.4 Composition of WSFs

Z.10.4.1 Chemical analyses

In contrast to the well-known complexity of synthetic oils, WSFs are relatively noncomplex; more than 99% of the total water soluble material (on a mass basis) consists of about 30 compounds. Analyses of WSFs of several oils are shown in Table Z.30. Major constituents include phenol, cresol isomers, CH₂-phenols, aniline, toluidines, and C₂-anilines; C₃- and C₄-phenols and aniline isomers have also been detected at low concentrations. In contrast, virtually no phenolic or basic compounds were measured in water equilibrated with a petroleum crude oil (consistent with reports by other investigators). Gas chromatographic scans of the WSFs of coal liquids were nearly identical, indicating little qualitative difference among the various synthetic oils. In no case was chromatographic or mass spectrometric evidence for naphthols or polyhydric phenols (e.g., resorcinol or catechol) found, although these compounds may be present at concentrations below the procedural detection limit (1 mg/liter). In the Coal Liquid A base fraction, pyridine and alkylpyridines were tentatively identified on the basis of elution position but at concentrations of less than 0.1 mg/liter; they were not observed in the SRC-II fuel oil blend.

Table Z.30. Concentrations (mg/liter) of contaminants in 3500 milliliters of water equilibrated with 25 milliliters of oils in laboratory extraction apparatus at 22°C

	Coal liquid A	Coal liquid B	SRC-II product	SRC-II fuel oil blend	Petroleum crude
Acids					
Phenol	39	35	175	210	< 1
<i>o</i> -Cresol	26	48			
<i>m</i> -/ <i>p</i> -Cresol	57	62	260	456	< 1
2-ethylphenol	1.6	5.2			
2,4-/ <i>p</i> -2,5-dimethylphenol	16	31			
4-ethyl-/ <i>p</i> -3,5-dimethylphenol	27	24	140	178	< 1
2,3-dimethylphenol	1.8	2.9			
C ₂ -phenols (2 isomers)	13	17	46	58	< 1
Indole	0.2	1.8	a	21	< 1
C ₃ -phenols (2 isomers)	< 0.1	1.1	a	15	< 1
Neutrals					
Toluene	2.6	9.2	0.5	< 0.1	0.2
Xylenes	1.6	3.9	< 0.1	0.6	0.1
Naphthalene	5.1	1.5	a	a	0.03
Methylnaphthalenes	0.3	0.7	a	a	< 0.03
Bases					
<i>n</i> -Ethylaniline	1.5	a	a	1.6	< 0.03
Aniline	5.3	a	a	13.6	< 0.03
<i>o</i> -Toluidine	4.6	a	a	35	< 0.03
<i>m</i> -/ <i>p</i> -Toluidine	8.0	a	a	23	< 0.03
2,4-dimethylaniline	1.5	a	a	6.9	< 0.03
2,3-/ <i>p</i> -3,5-dimethylaniline	3.2	a	a	7.6	< 0.03
<i>m</i> -Ethylaniline	1.1	a	a	4.4	< 0.03
C ₃ -anilines (5 isomers)	3.9	a	a	8.0	< 0.03

^aNot determined.

Although *m*- and *p*-cresol isomers are not distinguishable under the gas chromatographic conditions employed, the two compounds partition to similar extents between oil and water and thus should be present in water in the same proportions as in the oil. In Coal Liquid A, relative concentrations of *m*- and *p*-cresol isomers were about 3:2 (M. R. Guerin, ORNL, personal communication), which implies a similar ratio between *m*- and *p*-isomers in the WSF.

Both SRC-II product oils tested produced concentrations of phenolics in underlying water three- to five-fold higher than for either Coal Liquid A or B. Similarly, levels of anilines were several-fold greater in the SRC-II fuel oil blend WSF than in that of Coal Liquid A. Concentrations of mono- and diaromatics were an order of magnitude lower in the SRC-II WSFs than in either of the other coal liquids.

Z.10.4.2 Contribution of WSF constituents to toxicity

As a first step towards identifying the principal toxic constituents of WSFs, acute bioassays were conducted with algae and *Daphnia magna* on the ether-soluble acid, ether-soluble base, and neutral subfractions of WSFs (prepared using an oil:water ratio of 1:8) from Coal Liquids E, F, G, H, and I, and Petroleum No. 2 diesel fuel. Table Z.31 presents the results of the algal bioassays. Photosynthetic inhibition of the two test species was most severe during exposure to the ether-soluble bases; the neutral subfractions were the least toxic, except in the case of petroleum diesel fuel. These trends were less consistent in the *D. magna* bioassays, but the basic components were still the most toxic subfraction in three of the WSFs (Table Z.32). The neutral subfraction was the most toxic to *D. magna* in one WSF, and in one case the fiducial limits for the 48-hr LC₅₀s of the three subfractions overlapped completely.

Table Z.31. Acute toxicity of acid, base, and neutral subfractions of WSFs to two freshwater algae^a

	<i>Selenastrum capricornutum</i>	<i>Microcystis aeruginosa</i>
Coal liquid E		
Acids	66	89
Bases	22	43
Neutrals	88	(98)
Coal liquid F		
Acids	(87)	50
Bases	25	30
Neutrals	(90)	(97)
Coal liquid G		
Acids	32	8
Bases	21	34
Neutrals	44	60
Coal liquid H		
Acids	17	33
Bases	4	9
Neutrals	94	(94)
Coal liquid I		
Acids	56	(100)
Bases	23	41
Neutrals	(103)	(98)
Petroleum No. 2 diesel fuel		
Acids	(97)	(99)
Bases	71	88
Neutrals	87	91

^aPhotosynthesis (as percent of controls) in two algal cultures exposed for 4 h to acid, base, and neutral subfractions of WSFs prepared from five unrefined coal liquids and one refined petroleum product. Each fraction was tested at one-tenth its concentration in the original WSF. Numbers in parentheses indicate photosynthetic rates not significantly different from controls ($P \geq 0.05$) (from K. E. Cowser, H-Coal Pilot Plant Project Quarterly Progress Report for Period Ending June 30, 1980, ORNL TM-7469, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1980).

To test for loss of toxicity during the fractionation procedure, the subfractions were combined to form a reconstituted WSF and assayed with *D. magna*. For all five Coal Liquids, the 48-h LC₅₀s of the reconstituted WSFs were not significantly different from those of the original WSFs. These results confirmed earlier findings that the fractionation process does not significantly alter the toxicity of the individual subfractions.²³

Further insight into the relative contributions of WSF constituents to WSF toxicity comes from a comparison of the concentrations of organic compounds in WSFs with the acute toxicities of these compounds to algae and *D. magna* (Table Z.33). The concentrations of phenols and anilines in these WSFs are in most cases higher than the 48-h LC₅₀ for *D. magna* or the EC₂₀ for algae. Of the neutral WSF components, only naphthalene approaches the acute toxicity concentrations for

Table Z.32. Acute toxicity to *Daphnia magna* of acid, base, and neutral subfractions of water extracts of five coal liquids

Subfraction	Acute toxicity (LC ₅₀ ^a)		
	Acids	Bases	Neutrals
Coal liquid E	6.4 (5.6-7.4)	2.74 (2.3-3.3)	4.60 (3.5-7.0)
Coal liquid F	11.4 (10.2-13.5)	5.6 (4.8-6.8)	7.0 (6.2-8.0)
Coal liquid G	0.48 (0.42-0.56)	0.18 (0.03-0.28)	2.70 (2.44-3.00)
Coal liquid H	1.96 (1.80-2.16)	4.14 (1.46-13.4)	2.08 (1.58-2.50)
Coal liquid I	2.62 (2.26-3.08)	3.84 (3.24-4.62)	0.62 (0.32-1.2)

^aThe percentage of the fractionated material from 1 liter of water extract that, when dissolved in 1 liter of dilution water, was estimated to have killed 50% of the test animals in 48 h. Numbers in parentheses are 95% fiducial limits (from K. E. Cowser, *H-Coal Pilot Plant Project Quarterly Progress Report for Period Ending June 30, 1980*, ORNL/TM-7469, Oak Ridge National Laboratory, Oak Ridge, Tenn. 1980).

Table Z.33. Concentrations of organic compounds in WSFs compared with acute toxicity concentrations for algae and *Daphnia magna*

Values are in mg/liter

Compound	Concentration in WSF ^a		Acute toxicity		
	Coal liquid A	SRC-II fuel oil blend	<i>Selenastrum capricornutum</i> ^b	<i>Microcystis aeruginosa</i> ^b	<i>Daphnia magna</i> ^c
Phenol	39	210	174	54	30
o-Cresol	26	456		25	16
m-Cresol	57			46	18
p-Cresol				251	1.4
2,4-dimethylphenol	16	178		21	2.3
2,5-dimethylphenol					
C ₃ -phenols	13	58		148 ^d	0.28 ^d
Toluene	2.6	0.1	115	80	646
Naphthalene	5.1	^e	5.7	0.85	8
			3.8	3.6	1.2
1-methylnaphthalene	0.1				
2-methylnaphthalene	0.2	0.7			
Anilines	29.1	100	21 ^f	24 ^f	0.54 ^f

^aData from Table DD.23.

^b4-h EC₂₀ [J. M. Giddings, "Acute Toxicity to *Selenastrum capricornutum* of Aromatic Compounds from Coal Conversion," *Bull. Environ. Contam. Toxicol.* 23: 360-364 (1979); and unpublished data].

^c48-h LC₅₀ (Parkhurst, unpublished data).

^dData for 2,4,6-trimethylphenol.

^eNot determined.

^fData for aniline.

these organisms. These data are incomplete, but they are consistent with the acid-base fractionation results in identifying the acids and bases rather than the neutral compounds as the major toxic constituents of synfuels' WSFs.

Z.10.4.3 Summary

Chemical analyses of WSFs from several synthetic oils were qualitatively very similar. Major constituents in each case were phenol, aniline, and their C₁-, C₂-, and C₃-substituted derivatives. The two SRC-II WSFs contained substantially higher concentrations of phenols and anilines than did two other coal liquid WSFs tested. Neither phenols nor anilines were detected in the ESF from a petroleum crude WSF. Consistent with the high degree of toxicity of anilines and phenols, these two fractions accounted for nearly all the toxicity observed in coal liquid WSFs to aquatic organisms.

Z.10.5 Dissolution of oil constituents

Z.10.5.1 Dissolution kinetics

Three factors largely control the rates at which compounds in an oil layer dissolve into underlying water: characteristics of the oil (primarily viscosity), characteristics of the water (primarily turbulence), and the equilibrium partition coefficient of the compounds between oil and water. In laboratory studies, water turbulence was essentially held constant for all oils (by use of the same stirring speed); dissolution rates were thus controlled primarily by oil viscosity and the oil-water partition coefficient of each contaminant.

Table Z.34 summarizes dissolution rate data for several phenolic compounds for the different oils tested. Dissolution rates are indicated by the time required for 50% approach to equilibrium ($t_{1/2}$), (i.e., for the contaminant concentration in underlying water to reach 50% of its final value). Thus a small $t_{1/2}$ indicated rapid dissolution of a contaminant. Several trends are apparent in Table Z.34. For each oil, phenol dissolves most rapidly; substituted phenols of increasing molecular size dissolve more and more slowly. This trend is due to the tendency of larger phenols to partition increasingly into the oil phase. For the one oil (SRC-II Fuel Oil Blend) for which dissolution rates of anilines were measured, they followed the same pattern as phenols but dissolved somewhat more slowly: $t_{1/2}$ values for aniline and C_1 -, C_2 -, and C_3 -anilines were 2.6, 4.6, 6, and 12 h respectively. The second apparent trend in Table Z.34 is that phenol dissolution rates are inversely related to oil viscosity; thus, phenol dissolves most rapidly from the light distillate oil B and most slowly from the highly viscous petroleum crude. Third, differences in dissolution rates among oils are most readily apparent for phenol (the most water-soluble compound) and become smaller as the phenols become more highly alkylated (and thus less water soluble): while $t_{1/2}$ values for phenol differ forty-fourfold among the oils tested, corresponding ranges for C_1 -, C_2 -, and C_3 -phenols are fourteenfold, sixfold, and fourfold respectively.

Table Z.34. Time (in h) required for dissolution of phenolics from oils to reach 50% of equilibrium concentrations in underlying water in laboratory extractor (22°C, reciprocating stirrer speed: 600 rpm)

	Oil viscosity at 25°C (cS)	Phenol	C_1 -Phenols	C_2 -Phenols	C_3 -Phenols
Coal liquid A	2.82	0.3	0.8	2.0	6.7
Coal liquid B	1.23	0.10	0.25	0.9	2.3
Coal liquid C	21	2.3	3.4	3.4	4.1
Petroleum crude	202	4.4 ^a	^b	^b	^b
SRC-II product	7.42	0.4	0.7	1.7	5.2
SRC-II fuel oil blend	7.09	1.2	3.1	5.7	9.1

^aObtained from ¹⁴C-labeled phenol added to oil.

^bNone detected.

Z.10.5.2 Dissolution and WSF toxicity

Formal studies of the influence of differential dissolution rates on the toxicities of WSFs have not yet been undertaken, but results of several preliminary experiments were consistent with other findings relative to the dissolution and toxicity of specific compounds. Comparisons of compound concentrations in WSFs with acute toxicity concentrations for algae, together with bioassays on acid, base, and neutral subfractions of WSFs, pointed to anilines and phenols as the principal toxic constituents of synfuels' WSFs (Sect. Z.10.4.2). Because these classes of organics dissolve out of soils rapidly, the toxicity of a WSF would be expected to increase relatively rapidly at first and then to increase slowly or not at all with continued extraction time. Two experiments with Coal Liquid A were performed to test this hypothesis. In one experiment, an oil:water ratio of 1:8 was used in WSF preparation, and algal bioassays were run after 2, 4, and 8 h of extraction. In the second experiment, the oil:water ratio was 1:140, and extraction times ranged from 1 to 6 d. In both experiments, the toxicity of the WSF with the shortest extraction time was nearly as great as that with the longest extraction time (Table Z.35). Thus, results were consistent with the hypothesis of rapid, rather than gradual, initial increase in WSF toxicity.

Table Z.35. Influence of extraction time on the toxicity of coal liquid A WSF to *Selenastrum capricornutum*

Tabulated values are relative photosynthesis expressed as percentages of controls

	WSF concentration (%)		
	0.1	1	10
Experiment 1 (oil:water 1:8)			
2-h extraction	98	71	4.1
4-h extraction	103	62	3.7
8-h extraction	99	58	6.1
Experiment 2 (oil:water 1:140)			
1-d extraction			63
2-d extraction			53
4-d extraction			52
6-d extraction			48

Another implication of the solubility data is that successive extractions of the same oil should produce WSFs that decrease in toxicity as phenols and (to a lesser extent) anilines are depleted from the oil. This was in fact observed in four successive 2-h extractions of Coal Liquid A (using a 1:8 ratio). Photosynthesis by *Selenastrum capricornutum* in 10% WSFs of the first, second, third, and fourth extracts was 10, 27, 29, and 37% of the controls respectively. These WSFs were not analyzed chemically, but on the basis of the kinetic studies it may be inferred that the concentrations of unsubstituted and C₁-anilines and phenols in the fourth extract were much lower, perhaps by an order of magnitude, than the concentrations in the first extract. The fact that considerable toxicity remains in the fourth extract is consistent with the supposition that more highly substituted anilines and phenols (whose concentrations would decline more slowly than unsubstituted aniline and phenol in successive extractions) are important contributors to the toxicity of the WSF.

Z.10.5.3 Summary

In five coal liquids tested, dissolution rates of phenols decreased as the compounds increased in molecular size (and decreased in water solubility). The dissolution rate of phenol was most rapid for a light distillate and decreased as oils increased in viscosity. The toxicity of the WSF of two coal liquids increased rapidly during the initial period of extraction and only slowly thereafter, which suggests that the major components of coal liquids causing acute toxicity would dissolve during the period immediately following a spill in a river.

Z.10.6 Effects of weathering

Z.10.6.1 Evaporation

Preliminary experiments to determine losses of compounds from synthetic oils were undertaken by exposing a 2-mm thick oil film (identical to the dissolution rate experiment) on a 30- by 30-cm glass plate to a wind of constant velocity (about 1 m/sec) and measuring both weight loss from the film and loss of added ¹⁴C-labeled compounds. SRC-II product lost 10% of weight within 6 h; contaminants continued to evaporate at a decreasing rate until, after 70 h, over 37% had evaporated. When radiolabeled benzene was added to a film, 50% evaporated within 6 min; evaporation half-times for phenol, naphthalene, and aniline were 6, 16, and 68 h. Although more studies are needed to examine effects of wind speed, temperature, and oil film thickness and viscosity, the initial results indicate that, under gentle wind conditions, benzene (and probably toluene) would evaporate far too rapidly to permit dissolution into underlying water. In contrast, phenol and aniline dissolve sufficiently rapidly that evaporation would probably not substantially reduce expected concentrations in the water.

The influence of evaporation of components of oils on the toxicity of WSFs to algae was examined by extracting the SRC-II fuel oil blend in open and sealed flasks using a 1:8 oil:water ratio. The extractions were performed in the dark and in the light. Exposure to light had a dramatic effect on WSF toxicity (see Sect. Z.10.6.2), but there were no differences between WSFs prepared in open or closed flasks. Evaporation was therefore apparently not significant in reducing the toxicity of the WSFs, as anticipated from the measured evaporation rates of aniline and phenol.²⁵

Z.10.6.2 Sunlight

To assess the effect of sunlight on contaminants dissolved from coal liquids into the underlying water, oils were layered onto water (1:140 volume ratio) in the laboratory extraction apparatus, covered with quartz glass to permit transmittance of ultraviolet radiation, and exposed to midsummer sunlight on the laboratory roof for periods of up to seven days. A circulating cooling bath maintained the oil-water temperature below 28°C. Samples were collected at intervals and tested for formation of oxidants using an amperometric technique. Additional samples were analyzed for dissolved contaminants using ultraviolet, visible, and infrared spectrophotometry, and gas chromatography.

As found previously for No. 2 fuel oil, oxidants were observed by amperometry to accumulate in the water below each coal-derived oil tested.²⁶ Oxidant formation occurred only during daylight and was most pronounced during clear, bright days. As reported previously, no oxidants were measured in water underlying the petroleum crude oil.²⁶

Although oxidant levels increased linearly in water underlying a Coal Liquid A sample when tested, few other chemical changes were observed. Gas chromatographic scans of acid, base, and neutral fractions of light-exposed and nonexposed water samples collected each day over seven days were identical, although infrared scans indicated the presence of carbonyl functionality in the light-exposed samples which was not present in the dark controls.

Two experiments were performed to measure the effect of sunlight on the toxicity of WSFs to algae. The experiments are summarized in Table Z.36. In both cases, exposure of the oil to sunlight during WSF extraction caused the toxicity of the WSF to increase, although the magnitude of the increase was different in the two experiments. Toxicity of the Coal Liquid A WSF to *Daphnia magna* was also about two-fold greater after eight days' exposure to sunlight; the LC₅₀ declined steadily from 2.85% dilution on day 2 to 1.60% on day 8. The effect of sunlight on the WSF of a petroleum crude was considerably more pronounced. The LC₅₀ was decreased sevenfold below that of a dark control after five days' exposure.

Table Z.36. Influence of sunlight on the toxicity of WSFs to algae

Oil	Oil:water	Extraction time	Test organism	EC ₂₀ ^a (%)	
				Light	Dark
SRC-II fuel oil blend	1:8	7 h	<i>Microcystis aeruginosa</i>	0.17	1.3
Coal liquid A	1:140	8 d	<i>Selenastrum capricornutum</i>	3.3	5.6

^aWSF concentration (percent dilution) causing 20% inhibition of photosynthesis, estimated by interpolation on a plot of photosynthesis vs log concentration.

Further studies are underway to characterize oxidants produced by irradiation of coal liquids by sunlight. Rates of reaction with iodide indicate that at least two different oxidants are produced in water underlying irradiation Coal Liquid A, of which only the minor constituent appears to be organic. Hydrogen peroxide appears to be the dominant oxidant produced, comprising about 75% of total oxidant in the water. The organic hydroperoxides produced by action of sunlight on fuel are considerably more toxic than hydrogen peroxide, which may explain at least in part why exposure to sunlight appears to have relatively less effect on toxicity of coal liquid extracts than on toxicity of petroleum products during the initial stages of weathering.²⁶

Z.10.6.3 Summary

In initial experiments, evaporation of benzene from an SRC-II product film was sufficiently rapid to prevent benzene from dissolving into underlying water. Phenol and aniline, however, dissolved considerably more rapidly than they evaporated, and thus at least under gentle wind conditions evaporation would not be expected to reduce their toxicity to aquatic organisms substantially. Bioassays of SRC-II fuel oil blend WSFs prepared under sealed and open conditions support this conclusion. Although WSF toxicities of several coal liquids were increased several-fold by exposure by sunlight, apparently caused by formation of water-soluble oxidants (and possibly quinones), the relative toxicity increase is not as great as has been reported previously for petroleum oils.

Z.10.7 Implications

Oil spilled onto a body of water will spread over the water's surface; less viscous oils (such as SRC-II produce and light distillates) spread more rapidly than more viscous oils (such as many petroleum crudes and heavy distillates). If the density of the oil is near that of the water, substantial mixing of oil into water will occur. Water turbulence or river traffic will also promote the mixing of oil into water.

Phenols and anilines, which are highly toxic to aquatic life, are present in substantial amounts in coal liquids but are not abundant in petroleum. These compounds will dissolve from light oils within minutes after a spill has occurred. Dissolution will be slower from raw synconides or heavy distillates; but aniline, phenol, and their C_1 -substituted derivatives will still dissolve within several hours. Dissolution will be more rapid in well-mixed areas and slower in poorly mixed environments such as impoundments. Mono- and diaromatic hydrocarbons (such as toluene and naphthalene), which are the major soluble components of petroleum, dissolve much more slowly and reach lower equilibrium concentrations than anilines and phenols and are therefore less important contributors to the toxicity of water in contact with spilled coal liquids. The rapid dissolution of toxic components from coal liquids suggests that clean-up efforts would have to be undertaken immediately to mitigate the impacts of a spill.

Although wind will cause evaporative losses of nonaromatic hydrocarbons from oils, phenols and anilines will not be substantially reduced. Therefore, the influence of evaporation on the toxicity of coal liquids will be much smaller than is the case with petroleum spills. Sunlight will cause chemical changes in coal liquids that may slightly increase the toxicity of water under a spill during the initial several days.

Depending on the initial density of the oil, the temperature of the water, and rates of dissolution and evaporation of the lighter oil constituents, some or all of the spilled product may eventually sink and become incorporated into the sediments. The chemical nature of this material, its fate in natural sediments, and the long-term consequences for aquatic life and for human health are matters that urgently need investigation.

The physical and chemical differences between coal liquefaction products and petroleum have important implications in the event of an oil spill in an aquatic environment, as described above. One potential strategy for reducing the impact of liquefaction product spills would be to remove anilines and phenols (by hydrotreating, for example) before transporting the products from the liquefaction site. Because the concentration of phenols and anilines in liquefaction products are partially dependent on coal type and on plant operating conditions, these factors might also be manipulated to reduce the hazards of product transportation. The feasibility of mitigation strategies such as these is another topic for further research.

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Appendix AA

HAZARDS EVALUATION PROGRAM AND PRELIMINARY HAZARDS IDENTIFICATION

Appendix AA

HAZARDS EVALUATION PROGRAM AND PRELIMINARY HAZARDS IDENTIFICATION

AA.1 HAZARDS EVALUATION PROGRAM FOR THE SRC-II DEMONSTRATION PLANT

The SRC-II Project will incorporate a formalized Hazards Evaluation Program even though such formalized programs are not normally used in the hydrocarbon processing industries. The program is being prepared and will be described in a report entitled "Safety Program Summary" scheduled to be submitted to the DOE on January 31, 1981. This report will describe the elements of the formalized Hazards Evaluation Program, including the methods and procedures used for performing such evaluations at each stage of the program.

A series of evaluation steps will be used in sequence to provide increasing detail in the hazards evaluations. The first step will include procedures to rank and quantify the hazards using preestablished tables with which the designer ranks the process material and equipment for specific hazard potential such as temperature, pressure, explosive range, fire, toxicity, quantity, and internal energy.

The second step includes Failure Modes and Effects Analysis (FMEA) and begins with a component identification, its function, possible failure modes, impacts on the system, and measures planned for mitigating the effects. This tool is very useful to the designer in establishing the needed protective equipment in a systematic fashion.

The last step in ensuring that the SRC-II Demonstration Plant design does, in fact, meet the goal of achieving the hydrocarbon process industry safety level is to perform an accident initiation and progression analysis based upon fault tree analysis (FTA) and event tree analysis (ETA). These types of analyses are used to quantify the risks during plant operation by incorporating previous operating experience, delineating dominant accident sequences, and quantifying their consequences. The result, when compared with the current hydrocarbon-processing-industry safety experience, will reveal safety issues needing further attention and will identify interfacing issues that influence plant safety.

The procedures, methods, and standard forms for performing these analyses will be provided in the "Safety Program Summary." Examples of past safety problems in hydrocarbon processing plants and how these problems were corrected by using hazards evaluation will be included in the report to provide training information for the designers. The report will define the auditing and record-keeping activities of the program.

The use of the "Safety Program Summary" will commence with a preliminary safety analysis made from a systematic evaluation of the Process Flow Diagrams (PFDs). A PFD is an initial engineering document showing major equipment and interconnecting piping but lacking details of, for example, drains, relief valves, minor instrumentation, etc. Many PFDs will be required to describe the entire demonstration plant.

Each PFD will be reviewed by a hazards evaluation team consisting of the SRC-II safety representative and various representatives from the SRC-II operations and engineering groups. Periodically, these teams will be augmented by representatives from the process design subcontractor and/or the detailed design subcontractor. The hazards evaluation teams will be trained and procedurally supervised by the designers of the "Safety Program Summary."

The ranking and quantifying analysis will be the major activity during this preliminary safety analysis because the PFDs lack the details required to conduct in-depth FMEAs, FTAs, or ETAs. The results from these analyses will provide management with information to decide which identified hazards require further consideration beyond normal industrial practice or sound engineering judgment. Those hazards that require further consideration will be resolved by additional engineering design, incorporating limits or directions in the operating instructions, and/or specifying a quality assurance procedure.

All identified hazards will be documented during the review, and auditable documentation will result from the hazards evaluation team's activities. This documentation will be assembled, analyzed, and provided to the DOE after the review of the last PFD that is issued for this

evaluation. This documentation will show the hazards that have been identified, that risks have been quantitatively assessed, and that measures or equipment have been selected to eliminate, control, or mitigate the impacts.

At the next level of engineering detail, additional safety analyses will be made from a systematic evaluation of the process and instrument diagrams (P&IDs). A P&ID is an engineering document showing all equipment, piping, and instrumentation. The level of detail available from the P&IDs is significantly greater than that available from the PFDs. Those hazards that were identified as requiring further consideration during the preliminary safety analysis can be analyzed in greater detail by FMEAs, FTAs, or ETAs. These detailed analyses will be conducted by the design engineer using procedures established in the "Safety Program Summary." The hazards evaluation team will review the design engineer's FMEAs, FTAs, and ETAs for completeness and compliance with the "Safety Program Summary."

Results of the design engineer's FMEAs, FTAs, and ETAs will provide to management a quantitative evaluation of the major risks. These levels of risks can be compared to the project objectives to determine if the demonstration plant engineering design meets the safety objectives.

Auditable documentation will also result from these safety reviews. This documentation will be assembled and analyzed after the P&ID safety approval cycle and will be included in the "Safety Analysis Report" to DOE. The report will contain the FMEAs, FTAs, ETAs, a quantitative assessment of the risks, and measures incorporated to eliminate, control, or mitigate the impacts.

AA.2 PRELIMINARY HAZARDS IDENTIFICATION FOR THE SRC-II DEMONSTRATION PLANT

A preliminary hazards identification has been performed for the SRC-II demonstration plant. The basis of the analysis was the Phase 0 deliverables and minutes of the technical status review meetings for the SRC-II demonstration plant.

The analysis has been directed toward an identification of the potential hazards that could lead to serious events such as fires, explosion, or releases of toxic materials. These events could be serious enough to result in major equipment damage or loss of life to the public or employees.

No attempt has been made to itemize all normal industrial hazards inherent in operation of the facility. Long-term exposures to toxic materials released during normal or upset operation were not considered within the scope of the analysis.

No evaluation of the severity of these accidents or the probability of occurrence has been made. In addition, no consideration of the methods of controlling or eliminating the accidents has been made.

A list of the major process stream components and associated hazards is presented in Table AA.1. These materials represent hazards to the public or to personnel because flammable, explosive, or toxic properties. The systems considered in this analysis and defined in other parts of the EIS are presented in Fig. AA.1. The level of detail considered and the materials considered present in each subsystem are shown in Figs. AA.2-AA.7.

The presentation of the results of the analysis (Table AA.2) includes the potential hazards, accidents, result or effect of an accident, and remarks where information allows. Generally, the facility consists of conventional systems and components that are designed to meet national consensus standards (ASME Code, etc.). The need to address natural phenomena (seismic, wind, and flood) is recognized, and project criteria do reflect that need.

Table AA.1. Hazardous materials in SRC processes

Material	Assumed hazardous property
Coal dust	Explosive, flammable, toxic
Slag	Pyrophoric, possibly carcinogenic
Hydrogen	Flammable, explosive, asphyxiant
Methane	Flammable, explosive, asphyxiant
Carbon monoxide	Flammable, toxic
Carbon dioxide	Asphyxiant
Carbonyl sulfide	Flammable, toxic
Oxygen	Reactive, increased fire hazard
Nitrogen	Asphyxiant
Argon	Asphyxiant
Hydrogen sulfide	Flammable, toxic
Light oil (naphtha)	Flammable, toxic, explosive, carcinogenic
Medium oil	Flammable, toxic, explosive, carcinogenic
Heavy oil	Flammable, toxic, carcinogenic
Vacuum bottoms	Toxic, flammable, carcinogenic
Ammonia	Flammable, toxic
Sulfur	Flammable, toxic combustion products
Sulfur dioxide	Flammable, toxic
Hydrogen chloride	Toxic
DEA/MEA	Flammable, toxic
Selexol solvent	Flammable, toxic
Phenolics	Toxic
Hydrogen cyanide	Toxic, flammable
Liquified petroleum gas	Flammable, explosive

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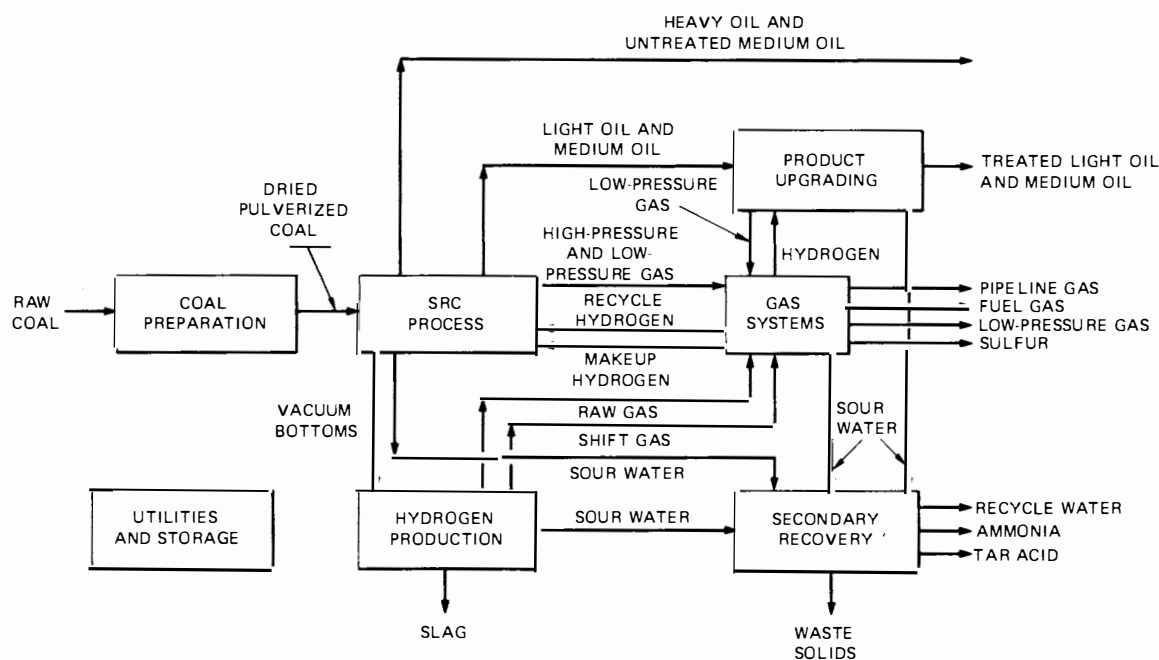


Fig. AA.1. SRC-II demonstration plant simplified block diagram.

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Fig. AA.2. Coal preparation system block diagram.

ES-5608

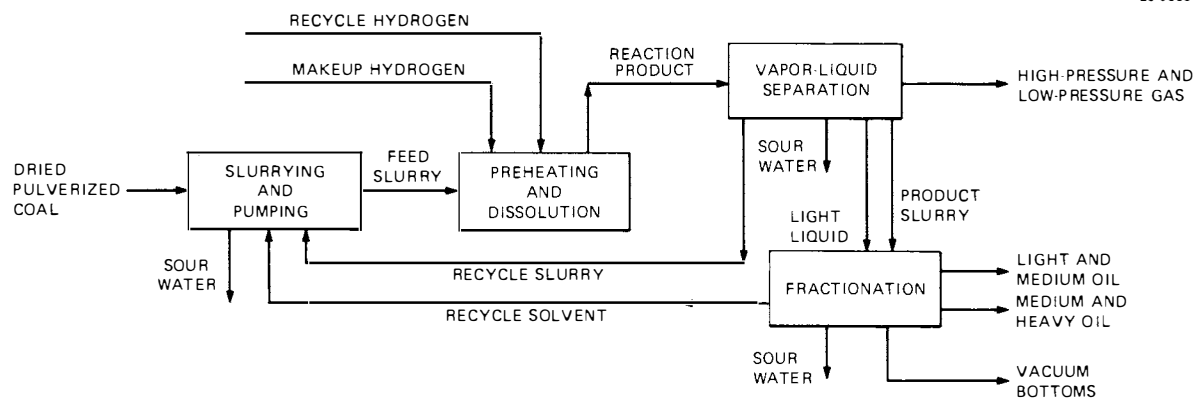


Fig. AA.3. SRC process system block diagram.

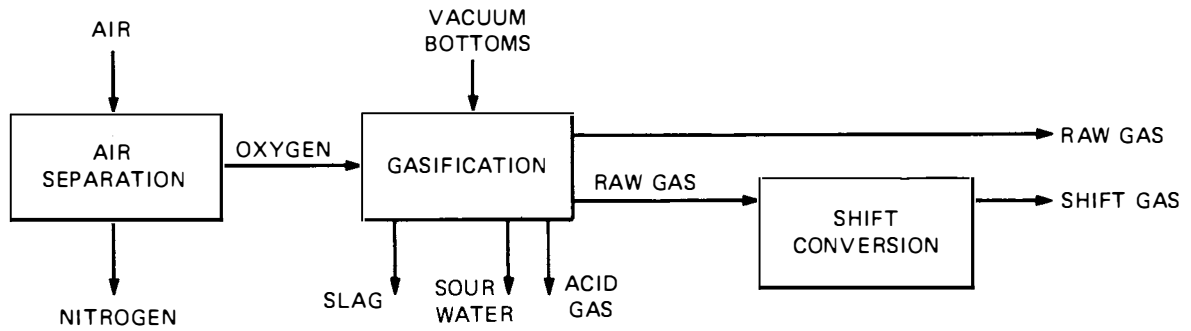


Fig. AA.4. Hydrogen production system block diagram.

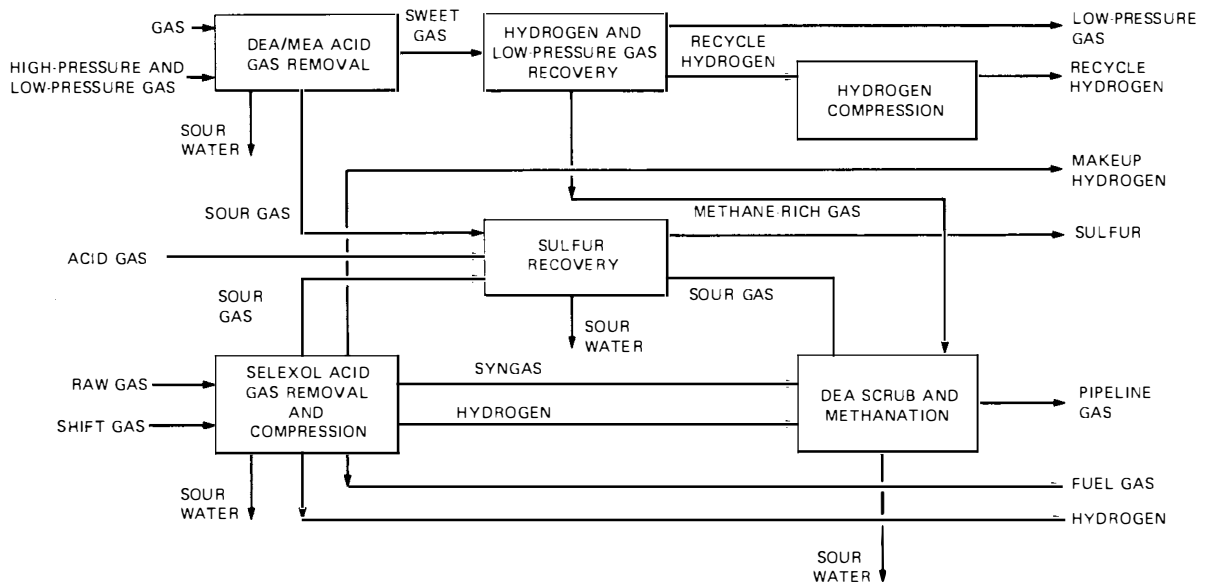


Fig. AA.5. Gas systems block diagram.

ES-5605

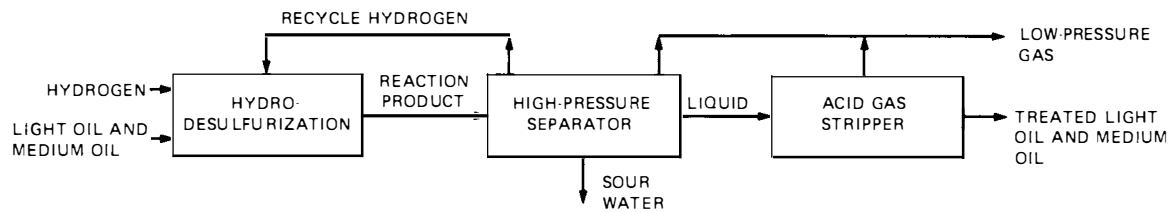


Fig. AA.6. Product upgrading system block diagram.

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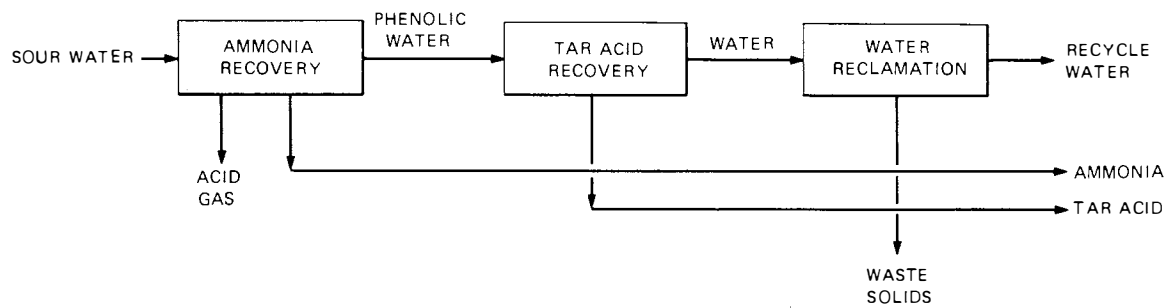


Fig. AA.7. Secondary recovery system block diagram.

Table AA.2. SRC-II demonstration plant preliminary hazards identification system

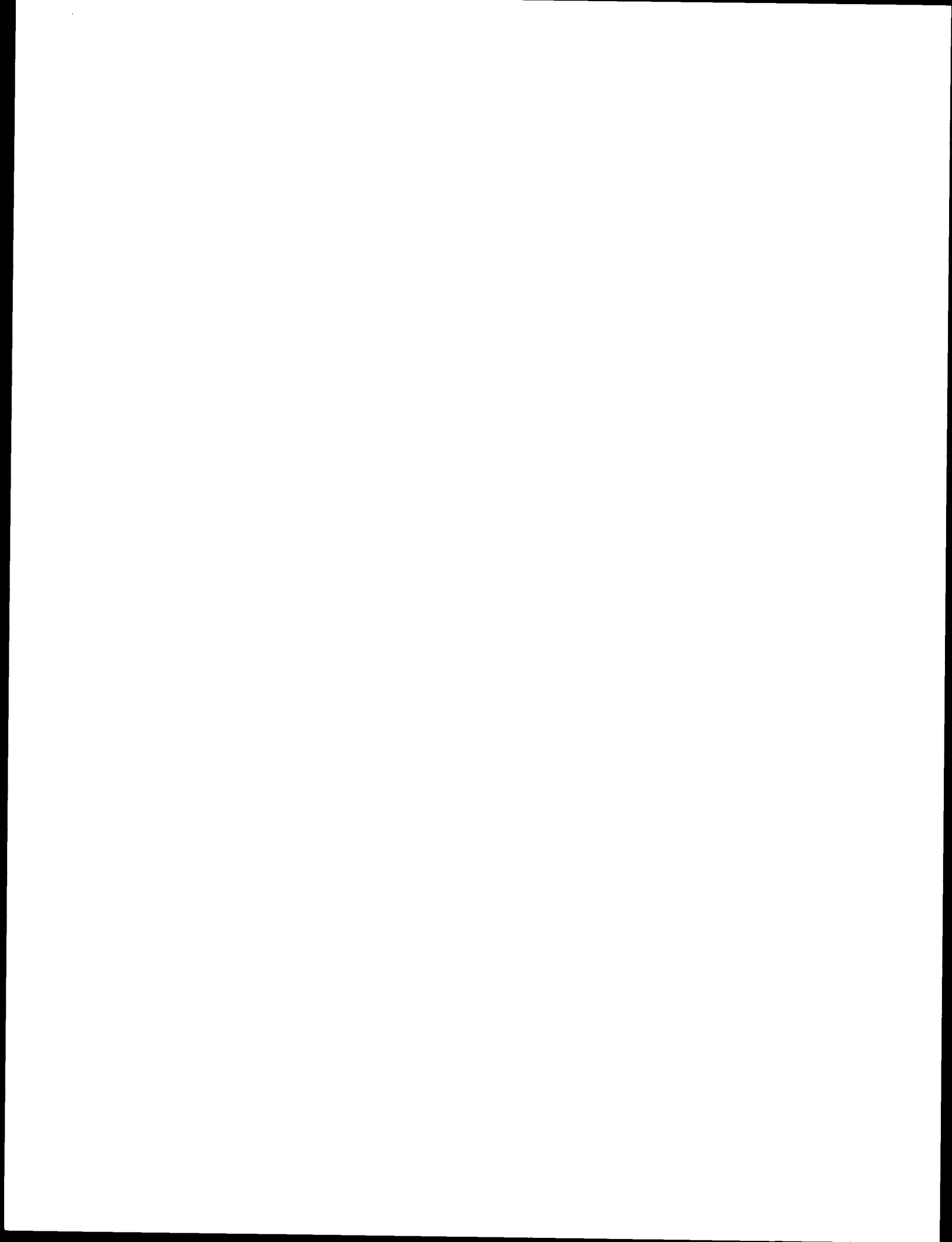
System	Hazard	Accident	Result	Remarks
Coal preparation				
Storage and handling	Coal	Fire	Release of smoke, CO, CO ₂ , and other coal combustion products	This is a conventional system, used at many coal-fired power plants
Pulverizing and drying	Coal dust	Explosion	Large release of energy; fire with its release of coal combustion products; damage/injury to nearby equipment/personnel	This is a conventional system, used at many coal-fired power plants
SRC process				
Slurrying and pumping	Coal slurry	Piping, mix tank, or feed pump rupture	Release of process solvent, coal slurry, and fumes; minor fire; damage to equipment	
Preheating and dissolution	Coal slurry and hydrogen	Slurry preheater tube rupture and backflow from the reactor	Fire; explosion; release of coal slurry, hydrogen, and reaction products (hydrocarbon vapor, liquids and solids, toxic fluids)	This system will be designed based on pilot plant experience
	Fuel gas or fuel oil	Explosion of furnace of slurry preheater or hydrogen preheater	Equipment damage; injury to personnel	
	Reaction product	Coal dissolver rupture	Fire; explosion; release of toxic materials (H ₂ , CO, CH ₄ , H ₂ S, COS, NH ₃ , HCl, HCN)	
	Recycle and make-up hydrogen	Tube rupture in hydrogen preheater	Fire; explosion	
Vapor liquid separation	Reaction product	Flash tank or letdown valve rupture	Fire; explosion; release of toxic reaction products	
	High-pressure reaction gas	Heat exchanger tube rupture	Venting of steam and toxic reaction gases	
Fractionation	Reactor product	Atmospheric tower charge heater system leak or rupture	Fire; explosion; release of reactor products (hydrocarbon vapor, liquids, solids)	This is a conventional process used at many refineries
	Fuel gas	Atmospheric tower heater lightoff, explosion	Equipment damage; injury to personnel	
	Liquid products, coal-derived recycle solvent and liquified coal	Atmospheric tower leak or rupture	Fire; release of naphtha, light fuel oil, heavy fuel oil, and tower bottoms slurry	
	Tower bottoms slurry	Vacuum tower charge heater leak or tube rupture	Fire; release of atmospheric tower bottoms slurry	
	Fuel gas	Charge heater lightoff, explosion	Equipment damage; injury to personnel	This is a conventional process, used at many refineries
	Atmospheric tower bottoms slurry	Vacuum tower leak or rupture	Fire; release of atmospheric tower bottoms, naphtha, and vacuum bottoms	
	Vacuum bottoms slurry	Vacuum tower bottoms pump seal leaks or system rupture	Spillage of tar-like slurry	This process will be designed based on pilot plant experience

Table AA.2 (continued)

System	Hazard	Accident	Result	Remarks
Hydrogen production				
Air separation	Liquid oxygen	Rupture of liquid oxygen vessels/heat exchangers	Formation of explosive gel in the presence of liquid hydrocarbons;creation of fire hazard; low-temperature hazard; oxygen-rich atmosphere	The system design is based upon an existing, commercially demonstrable cryogenic air separation process
	Hydrocarbon contaminants	Explosion of vessels	Damage to equipment; injury; possible fire	
	Liquid nitrogen	Rupture of liquid nitrogen vessels/heat exchangers	Vapor fog with possible hazardous concentration of nitrogen (asphyxiant)	
Gasification	Vacuum bottoms slurry	Vacuum bottoms pump leak or rupture	Spill of tar-like slurry	This process will be designed based on pilot plant experience
	Fuel gas	Gasifier lightoff, explosion	Equipment damage; injury to personnel	
	Feed/oxygen imbalance	Gasifier explosion	Equipment damage; injury to personnel	
	Ash/hydrocarbon slurry and/or coal slurry	Gasifier rupture or explosion	Fire or explosion; release of toxic material (CO, H ₂ S); injury; equipment damage	Waste heat boiler may be removed in later design
	Coal	Coal dust explosion	Explosion damage; injury to personnel	
	Raw synthesis gas	Waste heat boiler rupture	Fire; explosion; release of toxic gas (CO, H ₂ S); injury; equipment damage	
Shift conversion	Raw synthesis gas	Shift reactor rupture	Release of pyrophoric catalyst and toxic gas; possible fire and explosion	This is a conventional, commercially available system
		Rupture of heat recovery equipment	Release of toxic gas; high-temperature steam; possible fire or explosion; damage to equipment; injury to personnel	
	Shift gas	Rupture of equipment	Release of hydrogen and toxic gases (H ₂ S, CO); fire; explosion	
Gas systems				
DEA/MEA acid gas removal	High-pressure gas (H ₂ S, COS, CO ₂ , H ₂ , HCl, NH ₃ , hydrocarbon gases)	Rupture of contactor	Release of toxic process gases (H ₂ S, COS, HCl, NH ₃); fire; explosion	This is a conventional, commercially available system
	Hydrocarbon solvents (DEA, MEA, butane)	Rupture of absorbers and strippers	Fire; explosion	
	Sour gas	Rupture of stripper	Release of toxic gases (H ₂ S, COS, HCl, NH ₃)	
	Low-pressure gas	Rupture of absorber	Release of ethane-rich fuel gas and toxic sour gas; fire; explosion	
Hydrogen and LPG recovery	Hydrogen and hydrocarbons (liquid and vapor)	Rupture of equipment	Explosion; fire; release of hydrocarbons	Amount of LPG in this system should be modest. This is a conventional commercially available system
Hydrogen compression	Hydrogen	Compressor rupture or massive seal failure	Release of asphyxiant; fire; explosion	Lube oil could feed fire. This is a conventional system
Selexol acid gas removal and compression	Hydrogen	Compressor rupture or massive seal failure	Release of asphyxiant; fire; explosion	This is a conventional, commercially available system
	Selexol solvent	Rupture of absorbers and strippers	Release of toxic hydrocarbons; fire	
	Syngas and shift gas	Rupture of absorbers and other equipment	Fire; explosion; release of toxic gases (CO, H ₂ S, COS, NH ₃)	

Table AA.2 (continued)

System	Hazard	Accident	Result	Remarks
DEA scrub and methanation	Sour gas	Rupture of absorbers and other equipment	Release of toxic gases (CO, H ₂ S, COS, NH ₃)	This is a conventional, commercially available system
	DEA, sour gas, methane-rich gas, and syngas	Equipment rupture, rupture of stripper, and methanator rupture	Fire; explosion; release of toxic gases (CO, H ₂ S)	
	Methane	Compressor or seal failure	Fire; explosion	
Sulfur recovery (Claus unit)	Sour gas (CO ₂ , H ₂ S, NH ₃)	Fire, explosion, rupture of equipment	Damage to equipment; release of toxic gas (H ₂ S, SO ₂ , NH ₃); and possibly released reactor catalyst	The Claus unit is based on existing commercially demonstrated equipment
(Scot unit)	Fuel and air in combustor	Explosion in start-up mode	Damage of equipment; injury to personnel	The Scot unit is based on existing commercially available equipment
	Acid gas (H ₂ S and CO ₂)	Rupture of stripper vessel	Release of toxic gas at low pressure	
	Acid gas and reducing gas	Rupture of hydrogenation reactor	Release of toxic/flammable gas mixture; possible fire and explosion	
Product upgrading				
Hydrodesulfurization	Naphtha/fuel oil feed	System leak or heater tube leak	Fire; explosion; release of naphtha and fuel oil	The design of this system is based on existing commercially available equipment
	Hydrogen	Heater tube leak or compressor leak or rupture	Fire; explosion	
	Naphtha/fuel oil and hydrogen	Fixed bed reactor rupture or explosion	Fire; explosion; release of naphtha/fuel oil and catalyst	
	Catalyst	Catalyst handling system failure	Fire; release of reaction products and catalyst	
High-pressure separator	Reaction products	High-pressure separator rupture	Fire; explosion; release of high-pressure vapor and naphtha/fuel oil; release of toxic gas (H ₂ S, NH ₃ , CO)	
	Recycle hydrogen/low-pressure gas	Pipe rupture, valve failure, and compressor seal failure	Fire; explosion; release of toxic gas (H ₂ S, NH ₃ , CO)	
Acid gas stripper	Low-pressure gas	Rupture of stripper	Fire; explosion; release of toxic gas (H ₂ S, NH ₃ , CO)	
	Naphtha/fuel oil	Rupture of stripper	Fire; release of possibly carcinogenic material	
Secondary recovery				
Ammonia recovery	Acid gas	Rupture of still or piping	Release of toxic gas (CO ₂ , H ₂ S, NH ₃); possible explosion	This is a conventional, commercially available system
	Ammonia	Rupture of fractionator, fractionator condensor, or pump	Release of toxic gas; possible explosion	
Tar acid recovery	Tars	Rupture of storage vessel	Release of carcinogenic liquids to immediate area; damage to equipment; fire	
	Steam	Rupture of reboiler	Explosion	
Utilities and storage				
	Product oils (naphtha, middle distillate, heavy oil)	Storage tank rupture, spills or leak, fire	Damage to equipment; personnel injury	The design of this system is based on existing commercial design and practice
	LPG	Storage tank rupture, spill or leak, fire	Damage to equipment; personnel injury; explosion	Potential for large explosion exists if superheated liquid is released to form rapidly expanding vapor cloud
	Process chemical (DEA, Selexol, caustic, MEA, sulfuric acid)	Storage tank rupture, spill or leak	Damage to equipment; personnel injury	



Appendix BB
COAL-MINING-IMPACT ALGORITHMS

Appendix BB

COAL-MINING-IMPACT ALGORITHMS

BB.1 INTRODUCTION

In Sect. 1.4, loading factors were given for the SRC, H-Coal, and Exxon Donor Solvent (EDS) processes. Because of the variety of sources from which this information was collected and the variations in assumptions from these sources, it was concluded that cumulative impacts could best be identified on the basis of a composite liquefaction plant, represented by the average emission from the three processes. For those emissions for which a composite factor could not be calculated, the SRC-II emissions were assumed to be representative. In developing the commercialization scenario, it was assumed that all coal liquefaction would have the same Btu output as the composite baseline unit plant but that inputs and effluents would vary according to type and quality of coal used as feedstock. To estimate environmental impacts associated with unit plant operations, a series of algorithms was developed based upon the composite plant characteristics. State-level input and output loadings for the plant distribution scenario can be calculated by multiplying unit plant loadings by the number of plants located in a state.

Coal-mining-impact algorithms have been developed on the basis of coal input to a unit plant, calculated in terms of total Btu required to produce 100,000 bbl/d of solvent-refined solids or liquids. In terms of the composite unit plant, this amounted to a coal input of approximately 1.032×10^{12} Btu/d. To calculate state-level coal requirements and the effluent loadings associated with this level of coal production, multiply the number of unit plants supplied by a state coal by the unit plant coal requirement or the effluent loading factor. Unit plants are assumed to use intrastate coal.

BB.2 ALGORITHMS

BB.2.1 Unit plant construction and operation

BB.2.1.1 Coal requirements

Assumptions

- Each unit plant requires a coal input of 1.032×10^{12} tons per stream day, or 3.406×10^{14} Btu per year, based on 330 d (90% capacity) of plant operation per year.
- The Btu content (proximate analysis) of coal fed to a plant is 11,050 Btu/lb for plants in Kentucky, and 13,000 Btu/lb for plants in West Virginia.

Algorithms

- Unit plant coal requirement (tons per year) =

$$\frac{3.406 \times 10^{14} \text{ Btu/year}}{B},$$

where

B = the heat content (Btu/ton) of the coal (for each state); that is, Illinois = 2.21×10^7 Btu/ton, Kentucky = 2.58×10^7 Btu/ton, and West Virginia = 2.74×10^7 Btu/ton.

BB.2.1.2 Air emissionsAssumptions

- The efficiency of particulate matter control is 98%.
- The efficiency of sulfur oxides control is 98%.
- The efficiency of nitrogen oxides control is 75%.

Algorithms

- Atmospheric emissions per plant (tons/year) = $C \times 330$ days of operation per year,

where

C = average emission by pollutant (particulates, SO_2 , NO_x , CO, and hydrocarbons) in tons per day from Table 1.2.

BB.2.1.3 Water use

Water use for a unit plant is assumed to be equivalent to water consumption for the SRC-II plant, 12,000 gal/min. This equals about 20,000 acre-ft/year.

BB.2.1.4 Solid wasteAssumptions

- Each plant will produce over 100,000 bbl of fuel oil equivalent per day (106,700 bbl/d residual fuel equivalent).
- For plants producing 100,000 bbl/d fuel oil equivalent, the following amounts of waste materials will be generated annually (365-d operating year):
 1. approximately 180,000 tons of wastewater solids and
 2. approximately 1,000,000 tons of other waste solids.

Algorithm

- Total solid wastes produced per plant per year (assuming 90% capacity) =

$$\frac{0.90 \times 106 \times 10^3 \text{ bbl/d} \times A}{100 \times 10^3 \text{ bbl/d}},$$

where A = tons per year of solid waste generation.

BB.2.1.5 Employment

- Each plant will receive a peak construction force of 10,000 workers.
- Each plant will require 480 operational workers.
- The number of miners has been calculated using state productivity data in which the

$$\text{number of miners} = \frac{\text{tons of coal consumed per day}}{\text{average tons mined per day per man}}.$$
- All indirect employment is based on the same direct/indirect ratios used for SRC-II.

BB.2.1.6 Population

- Migration factors for all workers are assumed to be the same as the SRC-II case.
- Family size for both direct and indirect workers was assumed to be 3.2 members.
- No further secondary impact is assumed for the operation population beyond that expected for the construction period.
- Mining manpower factors were derived from operational work-force characteristics.

BB.2.2 Coal miningBB.2.2.1 Coal mining by stateAssumptions

- Each state (Illinois, Kentucky, and West Virginia) contains two facilities each requiring 3.406×10^{14} Btu/year of coal input.

Algorithm

- State coal requirements per year = $\frac{2 \times 3.406 \times 10^{14}}{\text{Btu ton}^{-1} \text{ state}^{-1}}$,

BB.2.2.2 Air emissionsAssumptions

- Emissions from underground mining are minor because of the predominance of electric-powered equipment.
- Emission factors for strip mining are listed in Table BB.1.

Algorithm

- Air emission by pollutant (tons/year) = $\frac{(A)(B)(C)}{10^5}$,

where

A = loading factor by state by pollutant (in tons per 10^5 tons of coal strip-mined),

B = coal mined per unit plant in tons per year,

C = percentage of coal strip-mined by state (Table BB.2).

BB.2.2.3 Water useAssumptions

- Coal mining activities that result in water consumption include dust control for roads, mines, and embankments and revegetation of reclaimed areas.
- Regional water use factors reflecting dust control and revegetation activities are from Table BB.3.

Table BB.1. Average seam thickness and percent of total coal strip-mined for selected states

State	Average seam thickness (ft)	Total strip-mined (%)
Illinois	6	45
Kentucky	5	55
West Virginia	5.5	22

Source: U.S. Department of the Interior, *Final Environmental Statement, Federal Management Program*, Report No. 1972(142), Bureau of Land Management, Washington, D.C., 1979.

Table BB.2. Strip-mining air pollutant loading factors for selected states

	Strip-mining pollutants (tons per 10 ⁶ tons of coal mined)				
	Particulate matter	Sulfur oxides	Nitrogen oxides	Carbon monoxide	Organics
Illinois	0.50	0.45	6.25	3.80	0.70
Kentucky	0.50	0.45	6.25	3.80	0.70
West Virginia	0.15	0.30	4.55	2.80	0.40

Source: U.S. Department of the Interior, *Final Environmental Statement, Federal Coal Management Program*, Report No. 1972(142), Bureau of Land Management, Washington, D.C., 1979.

Table BB.3. Water use factors for dust control and revegetation

State or region	Water use factor (Acre-ft per 10 ⁶ tons of coal)	
	Surface mining	Underground mining
Eastern states	4.460	5.88

Algorithms

- Surface mining water use (acre-ft/year) = $(A)(C)/100,000$

where

A = surface mining use factor in acre-feet per 100,000 tons of coal mined (4.46),

C = coal input to unit plant from surface mines in tons per year.

- Underground mining water use (acre-ft/year) = $(B)(C)/100,000$

where

B = underground mining water use factor in acre-feet per 100,000 tons of coal (5.88),

C = coal input to unit plant from underground mines in tons per year.

BB.2.2.4 Solid wastesAssumptions

- For surface mining, solid wastes generated are returned to mining pits and are not considered a solid waste for disposal calculations.
- For underground mining, the amount of solid waste generated is approximately 3% of the coal extracted.
- The percentage of a state coal supplied for liquefaction that is underground-mined is equivalent to the percentage of all coal mined in a state that is underground-mined.

Algorithm

- Mining wastes (tons/year) = $0.03(A)(B)$,

where

0.03 = solid waste generation factor for underground-mined coal,

A = percentage of underground-mined coal (by state),

B = coal supplied to unit plant in tons per year.

BB.2.2.5 Land disturbed by surface miningAssumptions

- Land disturbed by underground mining is minimal.
- The density of coal in a seam is 1750 tons/acre-ft,
- The average seam thickness equals the following (by State):

Illinois	6.0 ft
Kentucky	5.5 ft
West Virginia	5.5 ft

- The proportion of coal strip-mined (by State) equals the following:

Illinois	47%
Kentucky	54%
West Virginia	18%

Algorithm

- The surface area disturbed = $\frac{1 (B)(C)}{1750A}$,

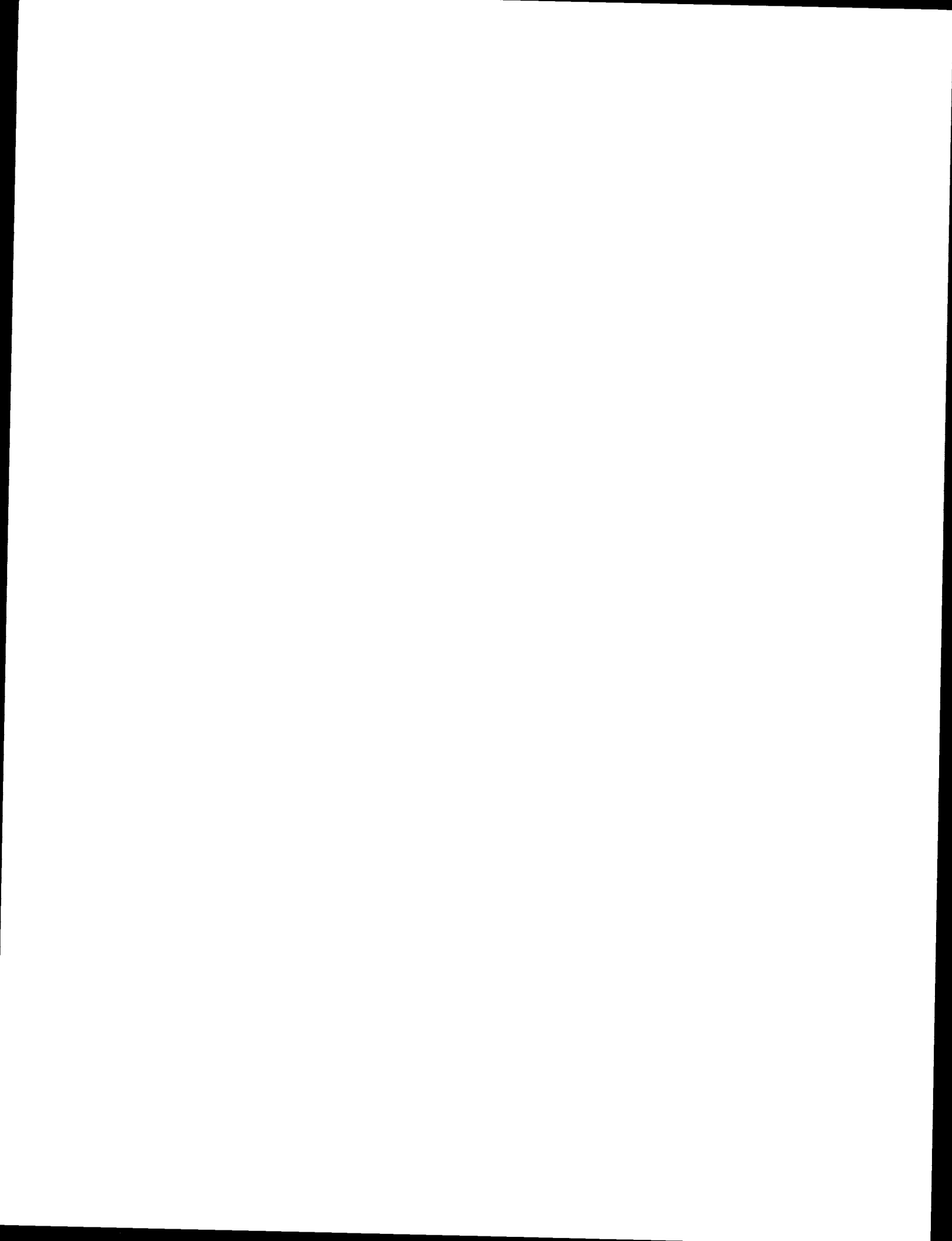
where

A = average seam thickness,

B = proportion of coal strip-mined,

C = coal input to unit plant in tons per year.

Appendix CC
CONVERSION FACTORS



Appendix CC
CONVERSION FACTORS*

<u>To convert</u>	<u>To</u>	<u>Multiply by</u>
ft	m	0.3048
miles	km	1.609
in.	cm	2.54
cfs	m ³ /s	0.0283
cfs	liters/s	28.317
gal	m ³	0.0038
gal	liters	3.785
gal/min	m ³ /s	0.000063
gal/min	liters/s	0.063
gal/min	m ³ /d	5.451
gpd	m ³ /s	0.000000044
bbl	m ³	0.159
m ³	liter	1000
acre	ha	0.4047
sq miles	km ²	2.59
ft ²	m ²	0.0093
acre-ft	m ³	1233
ft ³	m ³	0.0283
yd ³	m ³	0.7646
bu	m ³	0.035
lb/acre	kg/ha	1.12
short ton	metric ton	0.907
bu/acre	m ³ /ha	0.08707
lb	kg	0.4536
lb/ft ³	kg/m ³	16.018
tons/year	g/s	0.0288
Btu/h	J/h	1055
Btu/h	W	0.293
psig	MPa	0.006895
psig	Pa	6895
Δ°F	Δ°C	0.555
Δ°C	Δ°F	1.8
<u>To convert</u>	<u>To</u>	<u>Use this formula</u>
x°F	y°C	(x - 32)/1.8
y°C	x°F	1.8 y + 32

*For additional conversion factors, see the following source: American Society for Testing and Materials, *Standard for Metric Practice*, E380-79, Philadelphia, Pa., 1980.

