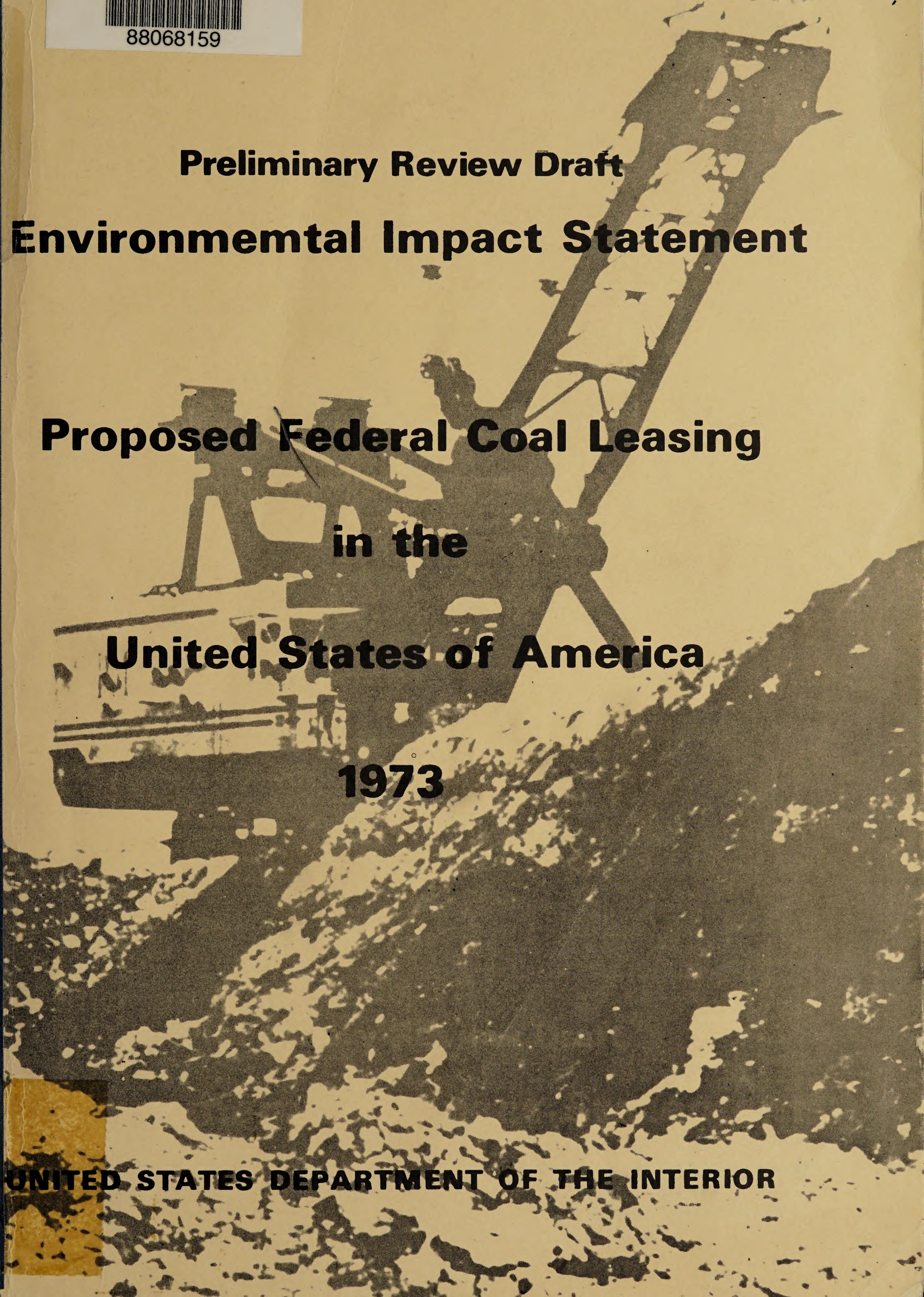

Preliminary Review Draft

Environmemtal Impact Statement

Proposed Federal Coal Leasing in the United States of America

1973

UNITED STATES DEPARTMENT OF THE INTERIOR

FEDERAL COAL LEASING

DRAFT ENVIRONMENTAL IMPACT STATEMENT

PROPOSED FEDERAL COAL LEASING

In The

UNITED STATES OF AMERICA

1973

UNITED STATES DEPARTMENT OF THE INTERIOR

Bureau of Land Management

DEPARTMENT OF THE INTERIOR

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DRAFT

ENVIRONMENTAL STATEMENT

Proposed

FEDERAL COAL LEASING

In The

UNITED STATES OF AMERICA

Prepared By

Bureau of Land Management
Department of the Interior

Date:

____
Director

SUMMARY

(X) Draft, ( ) Final Environmental Impact Statement

Responsible Federal Agency: Department of the Interior
Bureau of Land Management

1. Type of Action: (X) Administrative, ( ) Legislative

2. Name of Action: Proposed resumption of nationwide coal leasing by the Bureau of Land Management, upon acceptance of final environmental impact statement.

3. Summary of Environmental Impacts: Extraction of Federal coal from lands based to purchasers results in varying degrees of ecological disruption and environmental impact depending on the mining method -- surface, underground, or other. Surface mining involves translocation of the overburden, removal of the exposed coal seam, recontouring of the spoil banks, restoration of vegetative cover, and subsequent management of the surface resources. Environmental disruptions involved in the other methods are limited to relatively small mine entrance areas, plus the possibility of subsidence. All methods require plant sites. During mining operations and until preventive measures become effective, some erosion is likely. Ecological change and topographic alteration are inevitable results of coal mining, particularly surface mining. These must be weighed against the environmental benefits where coal is used.

4. Alternatives Considered: Major alternatives described are: (1) No further Federal coal leasing; (2) Federal coal leasing in response to applications, and (3) interdisciplinary planning with public participation for the multiple use management of Federal lands bearing coal and for the extraction of Federal coal from non-Federal lands. Opportunities for supplying energy needs from various combinations of energy sources also were considered.

5. <u>Comments have been requested from the following</u>:

<u>Federal Agencies</u>

Department of Agriculture
- Agricultural Research Service
- Forest Service (Participated in preparation of statement)
- Soil Conservation Service

Atomic Energy Commission

Department of Health, Education, and Welfare

Environmental Protection Agency

Department of the Interior

- Bureau of Mines (Participated in preparation of statement)
- Bureau of Outdoor Recreation
- Bureau of Sport Fisheries and Wildlife
- National Park Service
- Geological Survey (Participated in preparation of statement)
- Bureau of Reclamation
- Office of Energy Conservation

National Aeronautics and Space Administration

Department of Transportation
- Assistant Secretary for Systems Development and Technology
- Federal Highway Administration
- Federal Railroad Administration

Department of Commerce
- National Bureau of Standards
- National Oceanic and Atmospheric Administration

Department of Housing and Urban Development
- Federal Housing Administration

General Services Administration

Federal Power Commission

River Basins Commissions (all)

Tennessee Valley Authority

Department of Defense
Corps of Engineers

Water Resources Council

Advisory Council on Historic Preservation

<u>State Agencies</u>

Governors of all 50 states

<u>Non-Agency Organizations</u>

Natural Resources Council of America (all member organizations)

6. <u>Date draft statement made available to Council on Environmental Quality and the public:</u>

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FEDERAL COAL LEASING

ENVIRONMENTAL IMPACT STATEMENT

C O N T E N T S

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ENVIRONMENTAL IMPACT STATEMENT FOR
PROPOSED FEDERAL COAL LEASING

I. FEDERAL COAL LEASING PROGRAM

A. Proposed Action -- Federal Coal Leasing

The development of this programmatic environmental impact statement is the first step in Secretary Rogers C. B. Morton's announcement (February 17, 1973) for a long range program to fully assess the Federal coal resources and the environmental impact of a coal leasing program, looking toward implementation of a program for the orderly management of the Federal coal resource.

This statement will provide a forum for public involvement in the analysis and review of Federal leasing policies and procedures which impact the environment. This is of particular significance since the majority of the Nation's coal reserves are in Federal jurisdiction, and the Department of the Interior has the varied obligations to preserve and enhance the environment, manage the lands within its jurisdiction for multiple uses, and also achieve orderly development of the natural resources.

B. Coal Leasing Environmental Impact Statement

This draft coal leasing environmental impact statement has been prepared pursuant to Section 102 (2) (c) of the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et esq.*). It is a programmatic statement describing the cumulative impacts of the Bureau of Land Management's national coal leasing program prior to 1973 and the anticipated environmental impacts of coal leasing subsequent to 1973.

1. Objectives

The issuance of Federal coal leases is a program of the Bureau of Land Management, U.S. Department of the Interior. The program is designed to help meet the Nation's demand for energy resources. Specific environmental impacts anticipated under individual coal lease proposals, as well as within larger geographic areas, are evaluated in accordance with the National Environmental Policy Act. However, neither level of analysis provides a nationwide perspective for the entire coal leasing program.

The primary objective of this draft is to provide a nationwide overview of the impact of the entire Federal coal leasing program on the quality of the human and natural environment.

It also will serve as the foundation and framework for subsequent environmental analysis and statements prepared for coal management actions within a State, coal region, or relating to an individual lease.

2. Scope

This statement describes in a general way the environmental impacts resulting from exploration, development, production, and transportation of the coal resources managed by the Bureau of Land Management and methods of restoring values.

It is important to note at the outset that this analysis is focused on the onsite and immediate offsite environmental impacts of coal leasing. Neither coal utilization nor the costs and benefits of coal mining technology are treated.

The statement is limited to impacts of actions which occur on Federal lands or underlain by coal resources under the administrative jurisdiction of the Bureau of Land Management. It discusses in a general way the major primary and secondary impacts resulting from mining Federal coal where that activity occurs. The impact of onsite coal beneficiation and of mine-mouth electric generation plants is discussed, but the environmental impacts of sulfur dioxide emissions from Midwestern plants consuming Federal coal has not been analyzed in any detail.

Similarly, a detailed environmental analysis of the impacts of coal conversion processes such as coal gasification is beyond the scope of this statement. While in the future such facilities may be located on or near Federal lands, it serves no useful purpose to speculate about impacts caused by such processes until specific proposals using identified technologies at specific sites are made.

This statement relates to all Federally administered lands underlain by coal. It also relates to non-Federal lands on which minerals have been reserved to the United States and are subject to leasing under the Mineral Leasing Act of 1920 (30 U.S.C. 181 et. esq.) and the Acquired Lands Minerals Leasing Act of 1947 (30 U.S.C. et. esq.).

Coal leasing of Indian tribal lands and coal mining on such lands is beyond the scope of this statement.

Although a continuous spectrum of administrative alternatives for coal leasing exists, the statement analyzes three basic leasing regimes: (1) no coal leasing, (2) leasing in response to application (as prior to June 1971), and (3) managed leasing in accordance with publicly developed multiple use plans.

Analysis of legislative proposals concerning surface mining, land use planning, mineral development, energy research, utilization, transportation, etc. are beyond the scope of this statement.

3. Assumptions

It is assumed that there will be no sudden major shifts in the American economic system. It also is assumed that the private sector will continue to extract coal and other mineral resources owned by the United States.

Assessment of environmental impacts is limited to the period prior to 1985. Uncertainties surrounding the economic, social, and technological aspects of energy production and consumption make more lengthy projections impractical for the purpose of this statement.

It also is assumed that energy consumption patterns will undergo gradual change, but that no precipitous changes resulting from unforeseen technologies or restructured lifestyles will occur before 1985.

To estimate the cumulative number of acres of Federal lands which could be directly affected by surface mining through 1985, certain assumptions were made in appropriate sections regarding energy demands and adoption of coal gasification technology.

It must also be assumed that any coal leases now or hereafter issued will be developed and coal produced. This is an essential element in the assessment of cumulative nation-wide impacts.

In addition, it is assumed that present legislation (NEPA, etc.) set the stage for a land use policy which characterizes coal mining as as "interim" use of the land, rather than and "end product" land use.

C. History of Federal Coal Leasing

1. Early Legislation

Coal has been the subject of special legislation, beyond the scope of the general mineral location laws of 1866, 1870, and 1872. Because of its vegetative origin, coal was not classed as a mineral by the Land Department until Congressional legislation declared it to be such.

Before 1864, coal lands were disposed of under settlement and other laws. However, the General Preemption Act passed in 1841 contained a provision that "no lands on which are situated any known salines or mines shall be liable to entry under and by virtue of the provisions of this act." Congress, on July 1, 1864, assuming that coal land had been excluded from the Preemption Act of 1841, passed legislation providing for the preemption of coal lands in legal subdivisions, at a minimum price of $20 per acre to the highest bidder at public sale. Legislation enacted March 3, 1865 modified the acreage and payment provisions at the 1864 statute to give a preemption right to 160 acres of coal land to a person and 320 acres to an association upon payment of not less than $10 per acre where the lands lay more than 15 miles from a railroad, and $20 per acre where the lands lay within 15 miles thereof. Finally, in 1873, Congress enacted what may be called the "Coal Lands Act," which, with its amendments, governed the disposal of coal deposits on the public domain until the passage of the Mineral Leasing Act of 1920.

The 1873 act re-enacted the acreage and payment provisions of the Act of March 3, 1865; but added the provision that when any association of not less than four persons had expended $5,000 in working and improving any mines located within the limits thereby established, they might make an additional entry on 640 acres at the appropriate limit price.

The Coal Lands Act of 1873 was merely an extension of the legislation of 1864 and 1865. Coal quickly acquired value with the extension of the railroads into the west.

One of the chief objects of the Act of 1873, with its restrictions as to the quantity of coal lands which could be acquired by a single purchaser or association of purchasers was to prevent monopolies in coal lands on the public domain, an object fully respected by the courts.

The Coal Lands Act of 1873 embraced the public lands in the thirteen precious metal-bearing states of the West, together with the public domain in Arkansas, Florida, Louisiana, Mississippi, and parts of Oklahoma. Legislation in 1900 and in 1904, extended the coverage of the act to Alaska, but the act had little or no practical operation there.

The Coal Lands Act of 1873 was further amended in 1909 to permit a person who in good faith had or should locate, select, or enter under the non-mineral land laws of the United States any lands which subsequently should be ascertained to be valuable for coal to elect to receive a patent therefore containing a reservation of the coal to the United States. Such coal deposits would then be subject to disposal by the United States under the coal land laws in force.

The following year, Congress provided that unreserved lands of the United States, exclusive of Alaska, already withdrawn or classified as coal lands, or valuable for coal, be entered under the homestead laws by actual settlers, or under the desert-land act, with a view of obtaining or passing title, with a reservation to the United States of the coal in such lands.

In 1912, Congress provided that unreserved lands of the United States, exclusive of Alaska, withdrawn or classified as coal lands should be subject to selection by the States containing them, under grants made by Congress, the coal deposits, however, being in all such cases reserved to the United States. The same statute gave the Secretary of the Interior discretionary authority to sell, with a reservation of the coal, isolated or disconnected tracts of public lands theretofore withdrawn or classified as coal lands.

Other legislation enacted in 1912 provided: "Unreserved public lands containing coal deposits in the State of Alabama which on April 23, 1912 were being withheld from homestead entry could be entered under the homestead laws of the United States."

Section One of the Coal Lands Act of 1873 gave a right of entry by legal subdivisions upon not to exceed 160 acres of vacant coal lands of the United States, not otherwise appropriated or reserved by competent authority. An association of persons could enter upon 320 acres of such lands. The requirement that entry of legal subdivisions resulted in the construction that the act had no application to unsurveyed coal lands on the public domain.

The Supreme Court of the United States decided early, in Colorado Coal & Iron Co. vs. United States, that the Act of 1873 removed from the operation of the General Preemption Act of 1841 and from the later homestead law only those lands upon which, were situated "known mines" coal.

In the first decade of this century, the Director of the United States Geological Survey classified many thousands of acres of land as being valuable for coal. Those who had previously located, selected, or entered such lands under the non-mineral land laws of the United States were now in the position of having their entries cancelled. This situation was corrected by an act of March 3, 1909, which gave good faith entrymen under the non-mineral land laws the option to receive a patent to their lands which would contain a reservation to the United States of the coal therein contained.

In 1910, Congress authorized entry under the homestead laws and the desert-land law and selection under the Carey Act of unreserved public lands of the United States exclusive of Alaska which had been withdrawn or classified as coal lands or were valuable for coal.

Authority to dispose of coal deposits reserved in patents issued under the foregoing legislation actually was not given the Secretary of the Interior until 1917, and then only in accordance with the coal land laws in force at the time of such disposition.

Further, legislation in 1912 provided that, subject to reservation of the coal deposits to the United States, unreserved public lands, exclusive of those in Alaska, withdrawn or classified as coal lands might either be (1) selected by the several states under grants theretofore made by Congress of lands within their borders, or (2) sold, in the discretion of the Secretary of the Interior, under the laws providing for the sale of isolated or disconnected tracts of public lands.

The Coal Lands Act of 1873 provided two procedures by which coal lands might be acquired. The first was by the application of a duly qualified person or association to the register of the proper land office, and payment for the lands in the sum of $10 per acre if situated more than 15 miles from a railroad or $20 if more closely situated. The maximum acreage permitted to an individual was 160 acres and to a group of individuals 320 acres. An entry under this section has been declared to be a sale, with no elements of preemption.

The second procedure was the same as the first, except that a preference right-of-entry was granted to a person or association of persons who had opened and improved coal mines upon the public lands and were at the time of the application in actual possession; and, if consisting of a group of four or more persons who had expended at least

$5,000 in work and improvements, might enter up to 640 acres. The practical differences between the two proceeding sections would appear to be that, under the second procedure, the entrant would have to prove the known character of the land as coal land.

Enactment of the Mineral Leasing Act of 1920 provided for the disposal of coal lands by leasing rather than by entry and sale. The Coal Lands Act of 1873 ceased to control the future disposition of coal lands. This was true both as to coal deposits within unoccupied public lands, and as to those deposits reserved to the United States.

Sections 2 through 8 of the Act of February 25, 1920, authorize the Secretary of the Interior to (1) divide coal lands and coal deposits owned by the United States into leasing units and award leases thereon, (2) issue permits to prospect unclaimed and undeveloped areas of coal lands and coal deposits, and (3) issue limited licenses or permits to prospect for, mine and take for use, coal from public lands. Where lands included in a permit, lease or license have been disposed of with a reservation of coal deposits, a permittee, lessee, or licenses must make full compliance with the law under which such reservation was made. Where any part of the lands embraced in an application for a coal lease, permit, or license is within a withdrawal which does not preclude disposition of the coal deposits, the head of the Government agency having jurisdiction over the lands will be called upon for a report as to whether there is any objection to the granting of a coal lease, permit, or license.

In awarding leases for coal lands improved and occupied or claimed in good faith, prior to February 25, 1920, the Secretary of the Interior is authorized to consider and recognize the equitable rights of such occupants or claimants. The issuance of competitive coal leases and prospecting permits is entirely discretionary with the Secretary of the Interior.

2. Coal Prospecting Permits

Where prospecting or exploratory work is necessary to determine the existence or workability of coal deposits in an area, the Secretary of the Interior is authorized to issue prospecting permits for a term of two years. The permit entitles the permittee to the exclusive right to prospect for coal on the land described therein. A coal prospecting permit may be extended for a period of two years if the authorized official of the Interior Department finds that the permittee has been unable, with the exercise of reasonable diligence, to determine the existence or workability of coal deposits in the area covered in the permit. Such a coal prospecting permit is a prerequisite to the issuance of a preference-right lease.

3. Limited Coal Licenses

Section 8 of the Mineral Leasing Act of 1920 authorized the Secretary of the Interior, under such rules and regulations as he may describe, to issue limited licenses or permits for a period of two years to individuals or associations of individuals to prospect for, mine, and take for their use, but not for barter or sale, coal in the public lands and this without payment of rent or royalty. Such licenses or permits may also be issued to municipalities to mine and dispose of coal, without profit, to their residents for household use.

4. Preference Right Leases

A permittee who shows, prior to the expiration of his permit, that the land included in the permit contains coal in commercial quantities, is entitled to a preference right lease for all or part of the land, the area to be taken in a reasonably compact form.

5. Competitive Leases

Section 2 of the Mineral Leasing Act of 1920, authorizes the Secretary of the Interior, upon the petition of any qualified applicant, to divide any of the coal lands or the deposits of coal owned by the United States into leasing tracts of 40 acres each, or multiples thereof, in such form as, in his opinion, will permit the most economical mining of the coal in such tracts, but not to exceed 2,560 acres in any one leasing tract. Thereafter, the Secretary, in his discretion, upon the request of any qualified applicant or on his own motion may offer such lands or deposits of coal for lease, awarding such leases by competitive bidding or by such other methods as he may by general regulations adopt. These leasing tracts or units may be established either as a result of an application or when it is deemed advisable by the Interior Department that additional coal units be established.

6. Modifications and Leasing of Additional Lands or Coal Deposits

Under Section 3 of the Act, a lessee may secure a modification of his lease so as to include contiguous coal lands or deposits if the authorized officer determines that such will be to the advantage of the lessee and the United States.

A rental of $ .25 per year is required for a coal prospecting permit and the application therefore must be accompanies by a $10 filing fee. Limited coal licenses are issued without payment of any rent or royalty. The Mineral Leasing Act of 1920 does not prescribe any royalty rate to be included in the prospecting permit.

Section 7 of the Mineral Leasing Act of 1920 provides that the royalty for the privilege of mining or extracting coal in lands covered by the lease shall be fixed in advance of the lease offer; this same section also prescribes an annual rental payable at the date of such lease and annually thereafter, at such rate as may be fixed by the Secretary of the Interior.

7. History of Coal Leasing in Alaska

In 1900, the coal-land laws were extended to Alaska, but since the 1873 Coal Act contemplated sales in governmental subdivisions, the act could have no practical effect because the territory remained largely unsurveyed. To remedy this, a 1904 statute extended coal locations to unsurveyed land in Alaska, the locations to be set off in rectangular tracts containing 40, 80, or 160 acres "with north and south boundary lines run according to the true meridian" and described with reference to natural or permanent artificial monuments.

A 1908 Act provided that persons locating coal lands prior to November 12, 1906, might consolidate their locations by including in a single claim not more than 2,560 contiguous acres of coal land. Apparently, no patents were issued under the 1908 Act. The result was that no coal lands were developed in Alaska from the date of the general withdrawal order on November 12, 1906, until 1914. At that time, the earlier statutes were repealed and leasing was authorized for the first time in Alaska.

With certain exceptions, the provisions of the Mineral Leasing Act of February 25, 1920, have always applied to Alaska as well as the continental United States. The most important exception is as to coal lands or deposits of coal, which are specifically excepted as to Alaska by Section 2 of the 1920 Act. Authority for the issuance of coal permits, leases, and licenses for the free use of coal in Alaska from October 1914 through September 1959, is found in the Alaska Coal Leasing Act of October 20, 1914, as amended.

The Alaska Coal Leasing Act of October 20, 1914, as amended, authorizes the Secretary of the Interior to (a) divide into leasing units and award leases of the coal, lignite, and associated minerals in the unreserved coal lands and coal deposits owned by the United

States in Alaska, (b) issue permits to prospect unclaimed and undeveloped areas of coal lands and coal deposits in Alaska, and (c) issue limited licenses or permits to prospect for, mine, and dispose of, for free use, coal on specified tracts belonging to the United States in Alaska.

The maximum acreage for a single lease or permit is 2,560 acres and the maximum aggregate holding by any person, association, or corporation is the same, except as relaxed under Section 4 of the act where satisfactory showing is made by a lessee that all workable deposits in his tract will be worked out within three years. Leases are for periods of not more than 50 years subject to renewal. They are not assignable or subject to reletting except with consent of the Secretary of the Interior. Prospecting permits are issued for a period of not to exceed four years. A permittee who shows, prior to the expiration of his permit, that the lands included in the permit contain coal in commercial quantities, is entitled to a preference right to lease all or part of the land.

Limited licenses or permits to provide for the supply of strictly local and domestic needs for coal are limited to specified tracts not to exceed ten acres to any person, association, or corporation, with the total life of any such license being limited to ten years.

Coal leases issued under the Act of October 20, 1914, provide for minimum royalties of two cents per ton, and annual rentals at the rate of $ .25 per acre for the first year after issuance of the lease,

$ .50 per acre for the second, third, fourth, and fifth years, and $1 per acre thereafter, such rentals for each year being credited however, against the royalties as they accrue for that year.

The Act of October 20, 1914 (38 Stat. 741) relating to the survey of coal lands in Alaska was repealed by Public Law 86-252, S 1, September 9, 1959,73 Stat. 490. The repealing act further amended the first sentence of Section 2 of the Act of February 25, 1920 (41 Stat. 437, 438), as amended (30 U.S.C., Sec. 201) by deletion of the words "outside of the Territory of Alaska."

This brought coal leasing in Alaska under the 1920 Mineral Leasing Act, (as amended).

D. Energy Requirements

A comprehensive report entitled "United States Energy Through the Year 2000" was completed in December 1972 by Walter G. Dupree, Jr. and James A. West for the Department of the Interior. This report covers the historic sources of energy, its use, and the quantifying units of production from the years 1947 to 1971. It also projects these data to the year 2000 with estimates for the years 1975, 1980, and 1985. A small portion of these data will be used to relate the use of coal with other energy producers.

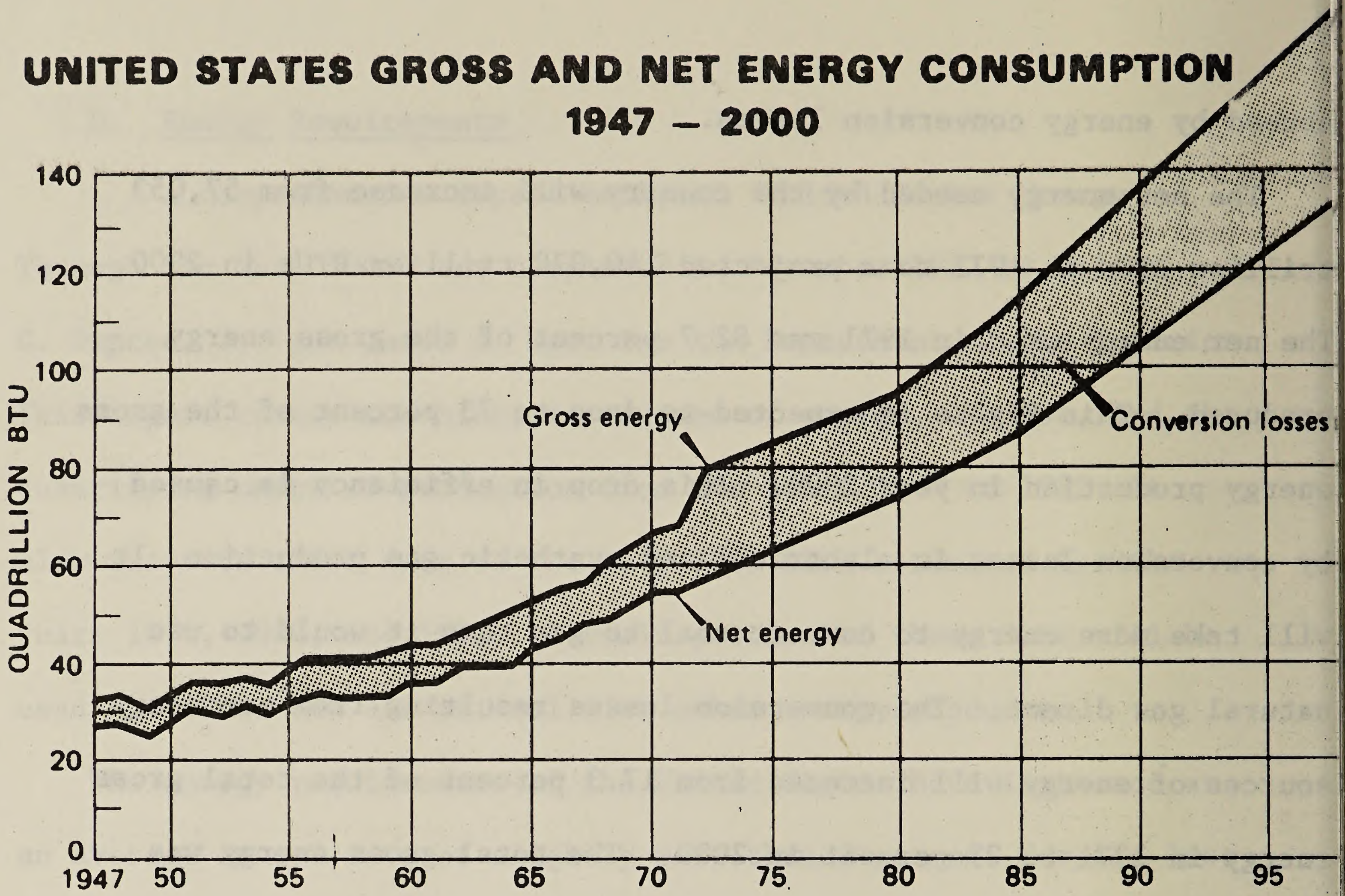
The energy requirements of the United States have increased at an average annual rate of slightly more than 3 percent for the last 24-year period. This means a gross energy consumption of 33 quadrillion BTUs (British Thermal Unit) in 1947 to 69 quadrillion BTUs in 1971. The average annual growth rate is expected to be 3.6 percent from 1971 until the year 2000. The total gross energy is expected to be 191.9 quadrillion BTUs in the year 2000.

Some of the reasons for the higher energy requirements are because of a larger population. The 1971 population of the United States was 207 million. The U.S. Department of Commerce, Bureau of Census, "Population Estimates and Projection," Series P-25, No. 420, November 1971, projects the United States population to be 280 million in the year 2000. The private home will require more service facilities. Industry will require more energy to operate environmentally acceptable plants. The largest increase in energy needs will be caused by energy conversion losses.

The net energy needed by the country will increase from 57,053 trillion BTUs in 1971 to a projected 140,070 trillion BTUs in 2000. The net energy used in 1971 was 82.7 percent of the gross energy produced. This figure is expected to drop to 73 percent of the gross energy production in year 2000. This drop in efficiency is caused by conversion losses in electrical and synthetic gas production. It will take more energy to convert coal to gas than it would to use natural gas direct. The conversion losses resulting from secondary sources of energy will increase from 17.3 percent of the total gross energy in 1971 to 27 percent in 2000. The total gross energy was 68,989 trillion BTUs in 1971. The forecast for year 2000 is 191,900 trillion BTUs.

Gross energy refers to the total amount of energy produced for the economy. Net energy is the amount of energy actually consumed. Net energy does not include the loss caused by converting the primary source to the secondary form. Net and gross energy consumption for the country and per capita from the year 1947 to 2000 are shown on graphs in Figures 1 and 2 .

In order to properly relate the use of coal in the future, it is necessary to know how much energy will be required and how this energy will be used. The tables given below are shown by major consuming sectors. The tables are in trillions of BTUs and refer to direct energy consumption. These tables represent the gross energy input:



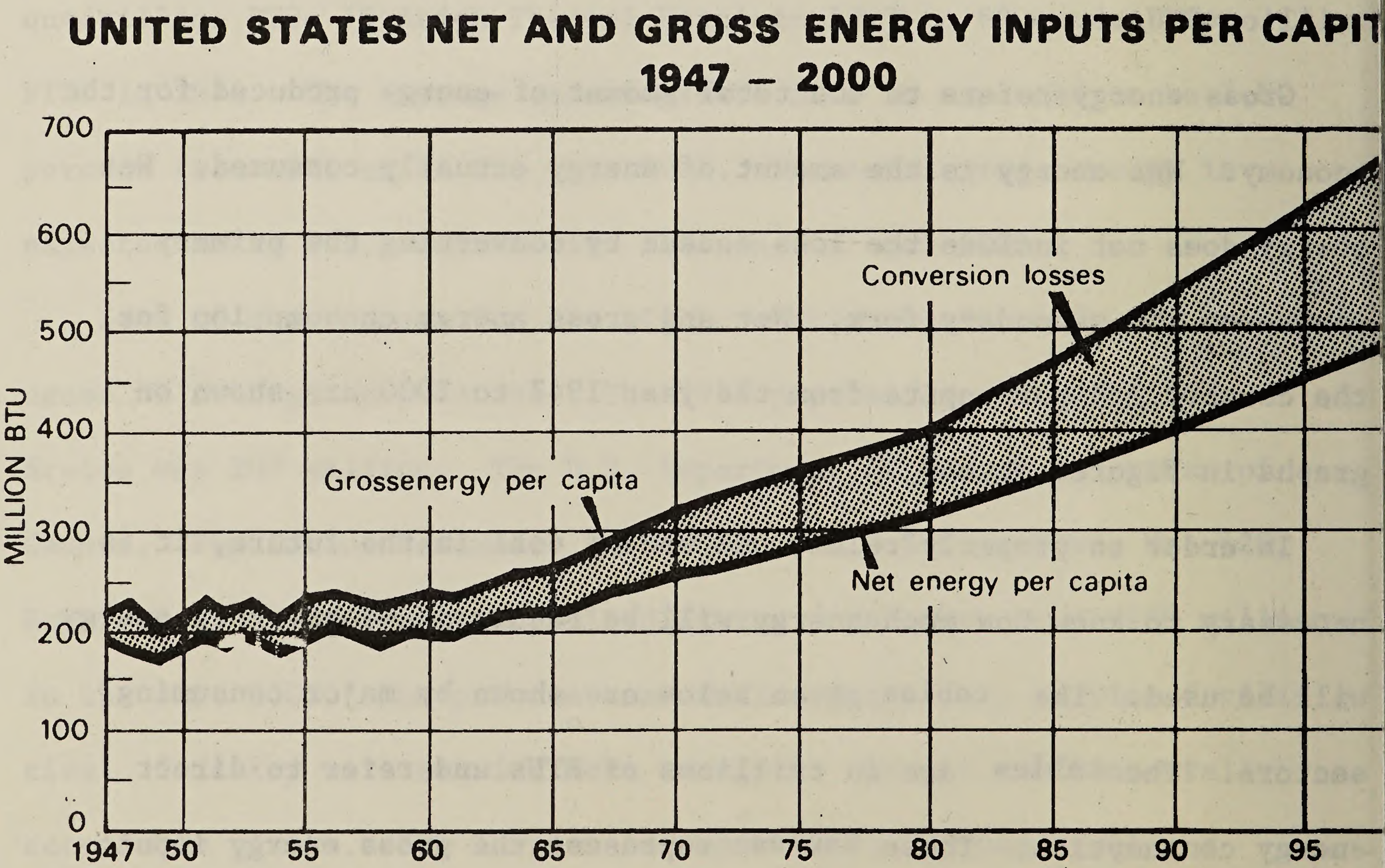


Figure 1
Figure 2

Table 1

Sector	Actual 1971	Estimated 1975	1980	1985	2000
		Trillions of BTUs Needed			
Household & Commercial	14,281	15,935	17,500	18,960	21,920
Industrial	20,294	22,850	24,840	27,520	39,300
Transportation	16,971	19,070	22,840	27,090	42,610
Electrical Generation	17,443	22,410	29,970	40,390	80,380
Synthetic Gas	-	-	870	2,670	7,690
Total	68,989	80,265	96,020	116,630	191,900

When electricity and synthetic gas are distributed to the final consuming sectors, the resulting figures give the net energy input to the economy. The difference between the gross energy and net energy shows the losses in converting primary to secondary energy sources. The table below shows the final net energy consuming sectors:

Table 2

Consuming Sector	Actual 1971	Estimated 1975	1980	1985	2000
		Trillions of BTUs Needed			
Household & Commercial	17,441	20,175	23,860	27,700	39,630
Industrial	22,623	25,860	29,390	34,870	57,780
Transportation	16,989	19,090	22,870	27,130	42,660
Total	57,053	65,125	76,120	89,700	140,070

The following table illustrates the forecast of what energy sources will feed the country's needs.

Table 3

Energy Source	Actual 1971	Estimated 1975	1980	1985	2000
		Trillions of BTUs Needed			
Coal	12,560	13,825	16,140	21,470	31,360
Petroleum	30,492	35,090	42,190	50,700	71,380
Natural Gas	22,734	25,220	26,980	28,390	33,980
Nuclear Power	405	2,560	6,720	11,750	49,230
Hydropower	2,798	3,570	3,990	4,320	5,950
Total	68,989	80,265	96,020	116,630	191,900

In the energy requirements of the United States, certain assumptions have been made:

1. Until the year 1980 energy sources will be much the same as they are in 1973.

2. The development of hydropower is finite. There are only so many available sites and these are limited by environmental and economic considerations.

3. The use of petroleum will increase between 1971 and 1985, and decrease thereafter. The nation is importing larger quantities of petroleum every year to meet the energy needs.

4. The nation is using more petroleum each year than new reserves are being discovered. In other words, our reserves are getting smaller each year.

5. Inflationary trends will raise the price of all fuels, and fuel prices will rise faster than other commodity prices.

6. Major changes in energy technology are expected between 1973 and 1985. Commercial techniques will be developed for coal gasification and liquefaction, commercial oil shale use, and sulphur dioxide emission control.

7. The nuclear breeder reactor is not expected to be available until after 1985. If nuclear power sources are not available by 1985 as projected, fossil fuels will have to supply the needed energy.

8. Solar and geothermal energy may replace other energy sources for a small portion or local area.

The following two tables compare energy source for actual use in 1971 to projected use in 2000.

Table 4 shows the projected U.S. total of gross consumption of energy resources by major sources and consuming sectors. One factor to note is the commercial production of synthetic gas by 1980. This will come from strip-mined coal areas.

Table 5 shows the major energy resources and gives a percentage that each resource will have during the period from 1971 to 2000. For instance, all forms of coal represented 18.2 percent of the gross energy input in 1971. The percentage of the gross energy input for coal is expected to drop to 16.3 percent in the year 2000, and yet the tonnage mined and number of BTU produced from coal would be 2-1/2 times greater than in 1971.

Table 4 - United States consumption for energy resources by major sources, 1971, actual, with projections to the year 2000

	1971	1975	1980	1985	2000
Petroleum (includes natural gas liquids)					
Million barrels.......................	5,523	6,340	7,615	9,140	12,985
Million barrels per day...............	15.1	17.4	20.9	25.0	35.6
Trillion BTU..........................	30,492	35,090	42,190	50,700	71,380
Percent of gross energy inputs........	44.1	43.8	43.9	43.5	37.2
Natural Gas					
Billion cubic feet....................	22,050	24,462	26,169	27,537	32,959
Trillion BTU..........................	22,734	25,220	26,980	28,390	33,980
Percent of gross energy inputs........	33.0	31.4	28.1	24.3	17.7
Coal (bituminous, anthracite, lignite)					
Thousand short tons...................	510,800	565,000	665,000	893,000	1,310,000
Trillion BTU..........................	12,560	13,825	16,140	21,470	31,360
Percent of gross energy inputs........	18.2	17.2	16.8	18.4	16.3
Hydropower					
Billion kilowatt-hours................	266.3	350	420	470	700
Trillion BTU..........................	2,798	3,570	3,990	4,320	5,950
Percent of gross energy inputs........	4.1	4.4	4.2	3.7	3.1
Nuclear Power					
Billion kilowatt-hours................	37.9	240	630	1,130	5,470
Trillion BTU..........................	405	2,560	6,720	11,750	49,230
Percent of gross energy inputs........	.6	3.2	7.0	10.1	25.7
Total Gross Energy Inputs					
Trillion BTU					

Table 5 - United States total gross consumption of energy resources by major sources and consuming sectors, 1971, actual, and projections to year 2000 (trillions of BTUs)

		Coal 1/	Petroleum 2/	Natural Gas	Total Fossil Fuels
1971	Household & Commercial	390	6,545	7,346	14,281
	Industrial..............	4,465	5,391	10,438	20,294
	Transportation..........	7	16,139	825	16,971
	Electric Generation.....	7,698	2,417	4,125	14,240
	Synthetic Gas...........	-	-	-	-
	Total...........	12,560	30,492	22,734	65,786
1975	Household & Commercial..	325	6,950	8,660	15,935
	Industrial..............	4,600	6,510	11,740	22,850
	Transportation..........	-	18,050	1,020	19,070
	Electric Generation.....	8,900	3,580	3,800	16,280
	Synthetic Gas...........	-	-	-	-
	Total...........	13,825	35,090	25,220	74,135
1980	Household & Commercial..	300	7,720	9,480	17,500
	Industrial..............	4,750	7,590	12,500	24,840
	Transportation..........	-	21,440	1,400	22,840
	Electric Generation.....	10,660	5,000	3,600	19,260
	Synthetic Gas...........	430	440	-	870
	Total...........	16,140	42,190	26,980	85,310
1985	Household & Commercial..	100	8,800	10,060	18,960
	Industrial..............	5,150	9,130	13,240	27,520
	Transportation..........	-	25,450	1,640	27,090
	Electric Generation.....	14,220	6,650	3,450	24,320
	Synthetic Gas...........	2,000	670	-	2,670
	Total...........	21,470	50,700	28,390	100,560
2000	Household & Commercial..	-	11,120	10,800	21,920
	Industrial..............	6,700	14,660	17,940	39,300
	Transportation..........	-	40,010	2,600	42,610
	Electric Generation.....	17,520	5,040	2,640	25,200
	Synthetic Gas...........	7,140	550	-	7,690
	Total...........	31,360	71,380	33,980	136,720

1/ Includes anthracite, bituminous, and lignite.
2/ Petroleum products refined and processed from crude oil, including still gas, liquefied refinery gas, and natural gas liquids.

Source: United States Energy Through the Year 2000

Table 5 - (Continued)

		Nuclear Power	Hydro Power	Total Gross Energy Inputs
1971	Household & Commercial..	-	-	14,281
	Industrial..............	-	-	20,294
	Transportation..........	-	-	16,971
	Electric Generation.....	405	2,798	17,443
	Synthetic Gas...........	-	-	-
	Total............	405	2,798	68,989
1975	Household & Commercial..	-	-	15,935
	Industrial..............	-	-	22,850
	Transportation..........	-	-	19,070
	Electric Generation.....	2,560	3,570	22,410
	Synthetic Gas...........	-	-	-
	Total............	2.560	3,570	80,265
1980	Household & Commercial..	-	-	17,500
	Industrial..............	-	-	24,840
	Transportation..........	-	-	22,840
	Electric Generation.....	6,720	3,990	29,970
	Synthetic Gas...........	-	-	870
	Total............	6,720	3,990	96,020
1985	Household & Commercial..	-	-	18,960
	Industrial..............	-	-	27,520
	Transportation..........	-	-	27,090
	Electric Generation.....	11,750	4,320	40,390
	Synthetic Gas...........	-	-	2,670
	Total.............	11,750	4,320	116,630
2000	Household & Commercial..	-	-	21,920
	Industrial..............	-	-	39,300
	Transportation..........	-	-	39,300
	Electric Generation.....	49,230	5,950	80,380
	Synthetic Gas...........	-	-	7,690
	Total............	49,230	5,950	191,900

Source: United States Energy Through the Year 2000.

Table 5 - (Continued)

		Synthetic Gas Distributed	Total 4 Sector Inputs	Utility Elec. Distributed	Total 3 Sector Inputs
1971	Household & Commercial..	-	14,281	3,160	17,441
	Industrial..............	-	20,294	2,329	22,623
	Transportation..........	-	16,971	18	16,989
	Electric Generation.....	-	17,443	(5,507)	-
	Synthetic Gas...........	-	-	-	-
1975	Household & Commercial..	-	15,935	4,240	20,175
	Industrial..............	-	22,850	3,010	25,860
	Transportation..........	-	19,070	20	19,090
	Electric Generation.....	-	22,410	(7,270)	-
	Synthetic Gas...........	-	-	-	-
1980	Household & Commercial..	320	17,820	6,040	23,860
	Industrial..............	380	25,220	4,170	29,390
	Transportation..........	-	22,840	30	22,870
	Electric Generation.....	-	29,970	(10,240)	-
	Synthetic Gas...........	(700)	-	-	-
1985	Household & Commercial..	940	19,900	7,800	27,700
	Industrial..............	1,060	28,580	6,290	34,870
	Transportation..........	-	27,090	40	27,130
	Electric Generation.....	-	40,390	(14,130)	-
	Synthetic Gas...........	(2,000)	-	-	-
2000	Household & Commercial..	2,640	24,560	15,070	39,630
	Industrial..............	2,860	42,160	15,620	57,780
	Transportation..........	-	43,610	50	42,660
	Electric Generation.....	-	80,380	(30,740)	-
	Synthetic Gas...........	(5,500)	-	-	-

Source: United States Energy Through the Year 2000

E. Environmental Concerns

Overall, the environmental concern is for the maintenance of high quality environment for all Americans, consistent with the optimum extraction and utilization of Federal coal resources.

Adverse effects on the natural and human environment resulting from the mining and utilization of coal have become major national concerns in recent years. Americans have become increasingly aware that they cannot take their environment for granted, because the quality of life in the United States is directly related to the quality of the environment. Ever-increasing demand for coal as a primary energy source, coupled with great technological development in extraction techniques and abilities have led to major increases in coal mining, and especially in surface mining.

Mining coal involves disturbance of the environment to some degree, no matter what processes are employed, as does processing of coal as a primary energy source. Surface mining causes the most disturbance. Environmental concern requires utilization of mining and energy processing methods that will meet demand requirements with minimal environmental impact and disturbance.

Mining and processing of coal for energy utilization has frequent resulted in what is now perceived as unacceptable degradation of the environment in a residue of devastation, defilement, and pollution. Effects on the environment have varied, but mainly in degree rather than kind. Coal mining and use of coal as a primary energy source impact on four basic elements of the environment: air, water, land, and human populations and patterns. Through these elements, they impact on the quality of the environment for animal, plant, and human life.

Air

Mining coal has not been a major contributor in air pollution. However, dust from operations in densely populated areas could be a nuisance. Coal processing through combustion to produce energy, has been a major air pollutant through stack emissions of particulates and dangerous noxious gases. For humans engaged in mining, and especially subsurface mining, air pollution has been a major contributor to disease and death from breathing dust and gases.

The Clean Air Act of 1970 will limit stack emission of SO_2 (sulfur dioxide) into the air to 1.2 pounds per million BTUs of coal in 1975. Timing of implementation of this Act is a responsibility of the States before the deadline. Sulfur accounts for 50 percent of weight of total SO_2 by molecular ratios; and the allowable 1.2 pounds of SO_2 contains 0.6 pounds of sulfur. The usability of untreated coal becomes a function of not only the sulfur content, but also the thermal rating (BTU value) of the coal. For instance, 100 pounds of a 10,000-BTU coal containing 0.6 percent sulfur will emit 0.6 pounds of sulfur when burned (assuming no sulfur is retained in the ash in the form of sulfate).

100 pounds of coal at 10,000 BTU = 1,000,000 BTUs

0.6% sulfur X 100 lbs = 0.6 lbs sulfur (1.2 lbs SO_2) *

(maximum allowable amount)

Photo

Photo

* A certain amount of sulfur is retained in the particulate ash in the form of sulfate; a small amount is in the particulate matter emitted from the stack; a certain amount may be retained in the burning bed. The above figures show maximum emissions of SO_2.

On the other hand, only 76.9 pounds of a 13,000-BTU bituminous coal are required to generate a million BTU and sulfure percentages as high as 0.78 can be tolerated. Likewise, low BTU coals necessarily must be lower in sulfur content. Assuming the sub-bituminous coals of a particular region range from 7,220 to 9,720 in BTU values with an average of about 8,000 BTU. A 100 pounds of of 8,000 BTU coal generates only 800,000 BTUs and 125 pounds are required to generate a million BTUs. Again, assuming total sulfur as SO_2, coal of this thermal rating can contain no more than 0.48 percent sulfur to be acceptable.

Research to make higher sulfur coals usable is presently going on at three levels: (1) Washing or treatment at a beneficiation plant can remove some of the sulfur from coals and make some marginal coals usable. Some experimental methods of sulfur removal include magnetic separation, thermal treatment, chemical leaching, and bacterial oxidation; (2) Research with special burning processes such as the fluidized bed (Coal News 7/3/73) is being carried on by the Coal Research; (3) Investigations are also underway in the treatment and stacking gases so as to remove SO_2, but not seriously reduce plant efficiency.

<u>Land</u>

Surface mining has resulted in the most noticeable impact on land, but all mining results in some disturbance. Vegetation has been destroyed, soils turned upside down, and large areas left as bare, unsightly spoil banks. Natural topography and beauty were devastated. Some such areas have become useless for many productive purposes. Only a small percenta of strip-mined lands have been restored.

Water

Coal mining has resulted in major pollution of surface and ground water resources due to leaching of acids from spoil materials and the presence of sediment and toxic chemicals dissolved in mine run-off wate Such polluted mine water has often drained into watersheds supplying human, animal, and plant requirements.

Human Population and Patterns

Coal mining has seriously impacted the social, economic, and political environment of population living in coal mining areas. The impact of wide scale coal operations and mine-mouth powerplants on rural, thinly spread populations can be of major consequence; and measures mitigating such impacts -- and alternatives to them -- must be diligently researched and planned for.

Concern with the impacts of coal mining and energy uses on the environment have resulted in demands that damaged environmental resources be restored where possible and that future damages be prevented for the benefit of the American people.

F. Occurrence of Federal Coal

Coal is by far the most abundant and potentially the most valuable mineral deposited in the United States. Coal-bearing rocks containing an estimated 3,224 billion tons of coal (Averitt, 1973), underlie about 13 percent of the land area of the 50 states and are present in varying amounts in parts of 37 states (Trumbal, 1960; Barnes, 1961). Coal has been mined in the eastern part of the country since the days of early settlement (1787) and the Appalachian region still accounts for about 78 percent of the total bituminous coal production of the United States (1970). Because of air quality legislation, emphasis is changing and the vast coal deposits of the Rocky Mountain region are gaining importance primarily because of their low sulfur content, thick beds, and general availability by strip-mining methods.

1. Definition of Coal

Coal is defined as a readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume of carbonaceous materials including inherent moisture formed from compaction and induration of variously altered plant remains similar to those in peat.

Character and quality (as defined by rank and grade), are the factors that determine coal's relative value and usefulness.

These factors are controlled principally by conditions during formation and, also, the age and depth of burial of the coal.

Photo

2. Coal Formation

Coal is composed of ancient plants and plant fragments that accumulated in ancient fresh or brackish water marshes and swamps. As this plant material increased in quantity, year after year, in the swampy environment, the lower layers were compacted under the weight of the upper layers, and, in time, became peat, the initial stage in the formation of coal. Later, the swamps were covered by the sea or by meandering rivers that flooded, burying the layers of vegetation under vast accumulations of sand and silt washed in from nearby lands.

The accumulation of peat requires a humid climate to support a rich growth of vegetation and a high water table to permit prolonged accumulation of plant material in a reducing environment. Most of the large coal deposits of Pennsylvania age that are mined extensively in the eastern and central United States were developed from peat beds formed near sea level -- some in estuaries or coastal lagoons, others on large deltas or coalescing deltas, and others on broad, low lying coastal plains.

Many of the younger large coal deposits of Cretaceous and Tertiary age found in the West were not deposited near the sea. Instead, they formed in intercontinental basins characterized by broad interconnected swamps, lakes. and flood plains of large river systems. Some of these river systems may have formed on the nearly flat tidal plains exposed when the land was uplifted and ancient seas migrated out. Others were formed in non-marine environments millions of years after the land was last covered by the sea.

Development of thick coal beds of wide extent required a unique set of conditions: (1) Very large and wide coastal or flood plains, (2) a prolonged optimum rate of plant growth and accumulation, (3) nearly stable condition with a slow rate of subsidence, and (4) an equally slow encroachment of the sea or migrating of river valleys over periods measured in centuries or millenniums. Depositional environments capable of sustaining these several conditions for periods long enough to accumulate the nearly pure vegetal piles necessary to form thick beds of coal are indeed unique.

The transgressing seas or migrating river channels ultimately covered the peat-forming swamps and terminated plant growth. The eroding landmasses continued to supply sand, silt, and mud and this material was deposited in layers over the submerged peat swamps. In time, depending in length on the rate of sedimentation, the depth of the transgressive area in marginal marine areas, and the rate of subsidence or sinking of the basins, this sedimentary material built-up new flood plains, swamps, deltas, lagoons, and coastal plains conducive to the development of new younger peat-forming swamps.

Weight of the overlying sedimentary cover, heat produced by depth of burial, pressures and heat accompanying structural deformation, and long periods of time all contribute to the progressive compaction and devolatization of peat to form the various ranks of coal.

3. Classification of Coal

Coal is classified according to a particular property such as degree of metamorphism or "coalification" (rank), constituent plant materials (type), or degree of impurity (grade). The rank of a particular coal is established according to the percentage of fixed carbon and the heat content, calculated on a mineral-matter-free basis (Figure 3). As shown in Figure 3 , the percentage of fixed carbon and the heat (BTU) content increases from low rank lignite to higher rank bituminous coal as the percentages of volatile matter and moisture decreases. These changes are primarily the result of depth and accompanying heat of burial, compaction due to weight of overlying deposits, time, and structural deformation. Rank is thus a way of expressing the progressive metamorphism of coal. It is quite independent of grade which is a way of expressing quality; however, a few local observed differences in rank are attributed to difference in the nature of the coal-forming material (differences in coal type).

On a regional scale, the required amount of heat to form coal is produced by the normal geothermal gradient accompanying depth of burial (approximately 25° C. per kilometer). This, in turn, is clearly related to the geological age of the beds, because the older beds are likely to have been more deeply buried than the younger beds and they have been subjected to more heat and pressure over a longer period of time. In most of the Rocky Mountain states, this relation is demonstrated by the fact that older coal beds of Cretaceous age

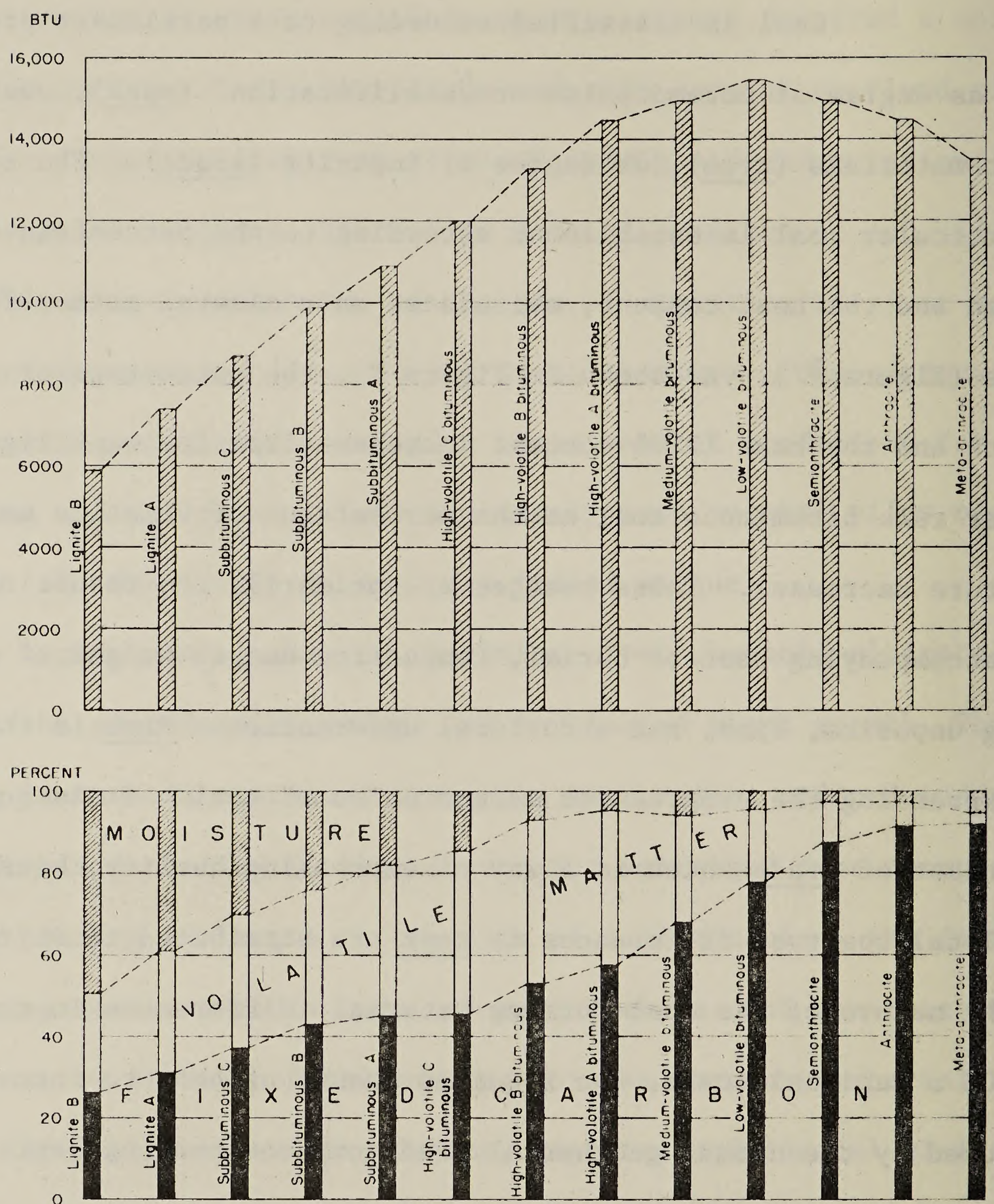

BTU
16,000
14,000
12,000
10,000
8000
6000
4000
2000
0
Lignite B
Lignite A
Subbituminous C
Subbituminous B
Subbituminous A
High-volatile C bituminous
High-volatile B bituminous
High-volatile A bituminous
Medium-volatile bituminous
Low-volatile bituminous
Semianthracite
Metaanthracite
PERCENT
100
80
60
40
20
0
MOISTURE
VOLATILE MATTER
FIXED CARBON

Figure 3

are generally of high-volatile bituminous rank, whereas the overlying beds of Tertiary age are generally sub-bituminous or lignite in rank. The terms "lignite", "sub-bituminous coal", "bituminous coal", and "anthracite" thus describe stages in the coal forming process.

Coal is classified by grade largely according to the content of ash, sulfur, and other deleterious constituents. Thus far in work on coal resources, a preliminary classification on the basis of sulfur content has been made, but classification on the basis of ash content has not been made because ash is a more highly variable component than sulfur. Coal contains widely varying amounts of sand, silt, and mud that were washed into the coal swamps; and this admixed sediment forms the bulk of the ash of burned coal.

In recent years, information on minor or on trace elements in coal has increased somewhat, but classification according to trace element content is not yet possible.

Sulfur is an undesirable element in coal. It lowers the quality of coke and the resulting iron and steel products. It contributes to corrosion, to the formation of boiler deposits, and to air pollution. Its presence in spoil banks inhibits the growth of vegetation. As sulfuric acid, it is the main deleterious compound in acid mine waters, which contribute to stream pollution. The sulfur content of coal in the United States ranges from 0.2 to about 7.0 percent, but the average in coal is between 0.1 and 2.0 percent. Most of the sulfur, perhaps 40-80 percent, occurs as a constituent of pyrite and marcasite

(FeS_2). The remainder occurs as hydrous ferrous sulfate ($FeS_4.7H_2O$) derived by weathering of pyrite, as gypsum ($CaSO_4.2H_2O$), and as organic sulfur in combination with the coal-forming vegetal material (Walker and Hartner, 1966).

The percentage of sulfur and of pyritic sulfur is highest in bituminous coals of Pennsylvania age in the Eastern and Interior Coal Provinces. The percentage is relatively low, generally less than 1 percent, in sub-bituminous coal and lignite of the Rocky Mountain and Northern Great Plains Coal Provinces. This relation is shown in Table 6 .

The conspicuously large percentage of low-sulfur coal in the United States, shown on the last line of Table 6 , is primarily due to the fact that the resources of low-sulfur sub-bituminous coal and lignite concentrated in the Rocky Mountain and Northern Great Plains Coal Provinces represent about 54 percent of total identified resources.

Coal contains small quantities of virtually all metallic and non-metallic elements, that were introduced into the coal bed in one or all of four different ways:

1. As inert material washed into the coal swamp at the time of plant accumulation.
2. As a biochemical precipitate from the swamp water.
3. As a minor constituent of the original plant cells.
4. As a later addition, introduced after coal formation,

Table 6 - Distribution, in percent, of identified 1/ United States coal resources according to rank and sulfur content 2/

Rank	Sulfur Content (in percent) Low 0-1.0	Medium 1.1-3.0	High 3+
Anthracite	97.1	2.9	---
Bituminous coal	29.8	26.8	43.4
Sub-bituminous coal	99.6	.4	---
Lignite	90.7	9.3	---
All ranks	65.0	15.0	20.00

1/ Identified resources: Specific, identified mineral deposits that may or may not be evaluated as to extent and grade, and whose contained minerals may or may not be profitably recoverable with existing technology and economic conditions.

2/ From DeCarlo, Sheridan, and Murphy (1966).

primarily by ground water moving downward and laterally.

When coal is burned, most of these elements are concentrated in the coal ash, but a few of the more volatile elements are emitted into the atmosphere. Coal ash is composed largely of the oxides of Si, Al, Fe, Ca, Mg, K, Na, and S, which typically make up 93-98 percent of the total weight of the ash, (Abernethy and others, 1969a). The remaining few percent of coal ash is made up of small individual amounts of many other elements, which differ in variety and quantity in different areas and beds. These elements are generally measured in parts per million or billion, and for this reason are termed minor elements, although they may not be minor elements in other contexts.

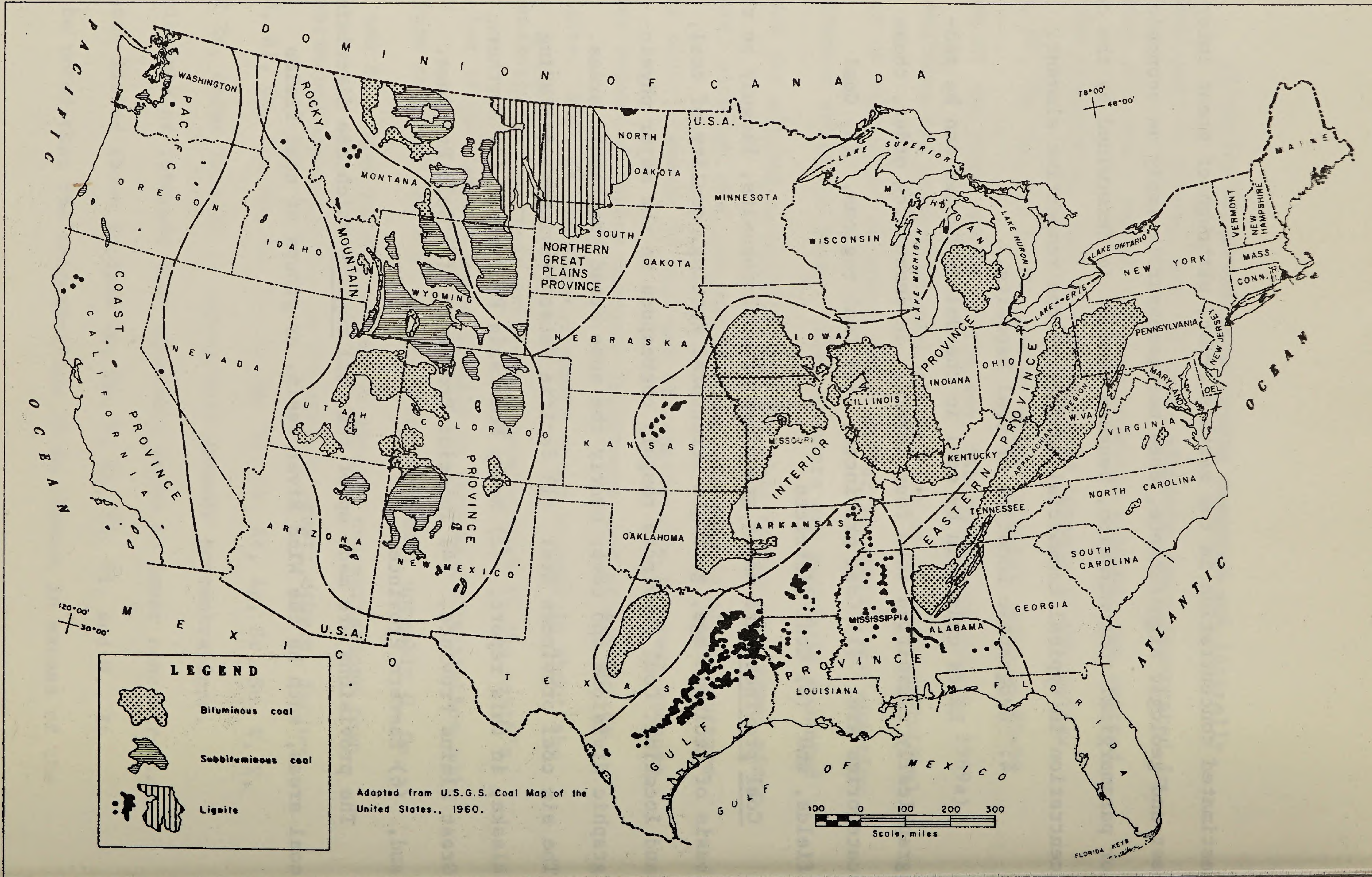
The minor elements in coal are of considerable interest because some may become of future resource importance, and others may be pollutants. Most of the minor elements occur in coal in about the same concentration as their estimated concentration in the earth's crust, but 25-30 elements occur locally in greater concentration and these have received the most study. A few elements, noteably U, Ge, As, B, and Be, occur locally in vastly greater concentrations than their estimated concentration in the earth's crust; others, including BA, Bi, Co, Cu, Ga, La, Pb, L, Hg, Mo, Ni, Sc, Ag, Sr, Sn, V, Y, Zn, and Zr, occur locally in appreciably greater concentrations. Other elements of interest that generally occur in lower concentrations than those listed above include Cr, Mn, P, Te, Tl, Ti, and W. It should be noted that the concentration of an element in excess of the estimated concentration in the earth's crust, although of great interest and geologic significance, does not necessarily imply an economic or paramarginal concentration, because that it is determined by the concentration in typical commercial sources of the respective element.

4. Geographic Location of Coal Deposits

Lands underlain by coal in the United States can be geographically classified into four levels. In descending order, these categories are: (1) Coal provinces, (2) Coal regions, (3) Coal fields, and (4) Coal districts.

Coal provinces are major groupings of coal deposits, largely on the basis of geologic age, geologic structural setting, quality of coal, and location. Coal provinces roughly correspond to the major physiographic divisions and cover nearly the same broad geographic areas. The six coal provinces are: (1) Pacific Coast Provinces, including Alaska, in this report, (2) Rocky Mountsain Province, (3) Northern Great Plains Province, (4) Interior Province, (5) Gulf Province, and, (6) Eastern Province.

The provisions are made up of the coal regions which are discriminate coal areas, such as the Wind River Basin, or groups of coal fields



DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
U.S.A.
PACIFIC COAST PROVINCE
CALIFORNIA PROVINCE
ROCKY MOUNTAIN PROVINCE
NORTHERN GREAT PLAINS PROVINCE
INTERIOR PROVINCE
EASTERN PROVINCE
GULF PROVINCE
APPALACHIAN REGION
WASHINGTON
OREGON
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
FLORIDA KEYS
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
W. VA.
MARYLAND
DEL
NEW JERSEY
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMPSHIRE
MAINE
MASS.
CONN.
R.I.
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
78°00'
48°00'
120°00'
30°00'
LEGEND
Bituminous coal
Subbituminous coal
Lignite
Adapted from U.S.G.S. Coal Map of the United States., 1960.
100 0 100 200 300
Scale, miles

geologically related or having some geomorphic or geographic feature or features in common.

Coal fields, the next smaller subdivision, are generally separate from one another, but also have some special geographic identity or characteristic coal quality.

Coal districts represent the smallest subdivision and are areas where mining has been developed around a fairly definite geographic center or on a given coal bed or group of beds.

a. Pacific Coast Coal Province

The Pacific Coast Coal Province includes coal fields in California, Oregon, Washington, and Alaska.

Several fields occur in the south-central part of Alaska. The Arctic Slope region, the largest of the Alaskan coal deposits also is known as the northern Alaska fields. The coal fields in California and Oregon are small and generally contain coal of low rank and poor quality. Only limited mining in these states has been attempted. Washington, on the other hand, produces coal ranging from lignite to anthracite, including some coking coal, from several fields concentrated in the western part of the state. The coal-bearing rocks of those states range from Eocene to Miocene in age.

Alaskan coal fields contain extensive coal resources chiefly of

Cretaceous and Tertiary age that range in rank from lignite to coking low-volatile bituminous. Long distance to ready markets discourage large scale development of Alaskan coal deposits.

b. Rocky Mountain Province

The coal lands of the Rocky Mountain and Northern Great Plains Coal Provinces total about 193,345 square miles and contain most of the Federally-owned coal in the United States. The Rocky Mountain Coal Province includes eight coal regions as well as several, small isolated fields and basins.

The regions are as follows: The Big Horn Basin region in northern Wyoming and south-central Montana, the Yellowstone region in southwestern Montana, the Hams Fork region that lies mainly in Wyoming, but includes fields in Idaho, and northeastern Utah, the Wind River region in central Wyoming, the Green River region in Wyoming and northwestern Colorado, the Uinta region of eastern Utah and west-central Colorado, the San Juan River region in Colorado and New Mexico, and the Southwestern Utah region.

The Rocky Mountain Coal Province contains a greater variety of coal than any other province in the United States. The coal ranges from lignite to anthracite and includes all of the coal ranks.

The coal-bearing rocks range in age from Cretaceous to Miocene and are contained mostly in large structural basins throughout the province. The depth of burial ranges from surface outcrop to as deep as 20,000 feet.

Extensive deposits of high-quality coking coal are contained in the Uinta region and the Southeastern Utah and San Juan River regions are of immediate importance for their large reserves of bituminous to sub-bituminous coal suitable for large scale power generation.

c. The Northern Great Plains Coal Province

This province includes coal regions and fields which lie in the Great Plains east of and adjacent to the Rocky Mountains. The province includes the Black Hills region in Wyoming, the Bighorn, Bull Mountain and Judith River regions in Montana, the Fort Union region of eastern Montana, and North and South Dakota, the Powder River region of northeastern Wyoming and southeastern Montana, and also the Denver region of Colorado and the Raton Mesa region of southeastern Colorado and northeastern New Mexico.

The coal-bearing rocks throughout the Great Plains east of the Rocky Mountains are little disturbed, and largely flat-lying, and coal is mostly accessible by surface or underground mining methods. The coals are mostly either lignite or sub-bituminous except in regions adjacent to the mountains where they are generally higher rank. The Raton Mesa region in New Mexico, for instance, produces high-volatile A bituminous coal with excellent coking properties.

Rapidly increasing demands for low-sulfur coal suitable for burning in modern large thermal powerplants have precipitated extensive exploration and development of the huge coal reserves of the Powder River region. The concentration of coal reserves in this area is the largest

Extensive deposits of high-quality coking coal are contained in the Uinta region and the Southwestern Utah and San Juan River regions are of immediate importance for their large reserves of bituminous to sub-bituminous coal suitable for large scale power generation.

c. The Northern Great Plains Coal Province

This province includes coal regions and fields which lie in the Great Plains east of and adjacent to the Rocky Mountains. The province includes the Black Hills region in Wyoming, the Assinniboine and Judith River regions in Montana, the huge Fort Union region of eastern Montana, and North and South Dakota, the Powder River region of northeastern Wyoming and southwestern Montana, and also the Denver region of Colorado and the Raton Mesa region of southeastern Colorado and northeastern New Mexico.

The coal-bearing rocks throughout the Great Plains east of the Rocky Mountains are little disturbed, and largely flat-lying, and commonly accessible by surface or underground mining methods. The coals are mostly either lignite or sub-bituminous except in regions adjacent to the mountains where they are generally higher rank. The Raton Mesa region in New Mexico, for instance, produces high-volatile, a bituminous coal with excellent coking properties.

Rapidly increasing demands for low-sulfur coal suitable for burning in modern large thermal powerplants have precipitated extensive exploration and development of the huge coal reserves of the Powder River region. The concentration of coal reserves in this area is the largest of any area of comparable size in the United States. The coal occurs in beds as thick as 220 feet and commonly lies under 150 feet or less or cover. The coal is largely Federally-owned and will play a dominnant role in future leasing operations.

d. The Gulf Coal Province

The Gulf Coal Province extends northeasterly from southeast Texas into Louisiana, Arkansas, and Tennessee and then southeasterly across Mississippi into southern Alabama. The area includes only two coal regions, the Texas region and the Mississippi region. Ranging in age from Upper Cretaceous to Eocene, the coals of this province are mostly lignite and have been mined only a few localities in the state of Texas.

e. The Interior Coal Province

The Interior Coal Province covers parts of eleven states and is divided into four regions as follows: the Northern region which lies completely within the state of Michigan; the Eastern region which covers most of Illinois and parts of western Indiana and Kentucky; the Western region which extends from Oklahoma to Iowa and includes parts of Kansas, Nebraska, Missouri, and Arkansas; and the Southwestern region which lies mostly in north-central Texas.

The coal-bearing rocks of the various regions in the Interior Coal Province are Pennsylvanian in age, older geologically than those of the provinces to the west, and the coals are mostly higher in rank on the average (high volatile bituminous), but also generally higher in sulfur content. The coal has been used extensively for power generation, but future pollution controls will greatly restrict its continued use unless acceptable sulfur removal techniques are developed.

f. The Eastern Coal Province

The Eastern Coal Province parallels the East Coast and extends along the Appalachian Mountains from Pennsylvania to Alabama. It is made up of the Anthracite region of Pennsylvania, the Atlantic Coast region of Virginia and North Carolina, and the Appalachian region which covers parts of Ohio, Pennsylvania, Virginia, West Virginia, eastern Kentucky, Tennessee, and northern Alabama. Though about half the size of the Interior Coal Province, the Eastern Coal Province contains more coal and remains the most important coal province in the United States on the basis of production and rank of coal produced.

The coal beds of the Eastern Coal Province are mostly about the same age as those in the Interior Coal Province, but they lie in rocks in and near the structurally disturbed Appalachian fold belt. From west to east they progress in rank from high volatile bituminous to anthracite. As is the case, in the Interior Coal Province, most of the coal is relatively high in sulfur content, except in West Virginia, Virginia, and Kentucky, where good-sized reserves of low and medium sulfur coal are reported.

5. Geologic Age of the Coal Beds of the United States

Coal beds in the United States range in age from Lower Carboniferous (Mississippi) to Miocene (10 to 340 million years). The

Carboniferous Age is called the "Age of Coal" and is considered as a single period in Europe. In this country, it includes both the Mississippian and Pennsylvanian periods. The Eastern and Interior Provinces contain nearly all the Carboniferous coals in the United States including some limited coal deposits of Permian and Traissic age. The Gulf province and the provinces of the west include within their borders nearly all of the Cretaceous and Tertiary age coal beds. In a broad sense, the period designation or age of the coal also denotes the quality.

Though some of the coal deposits found in the western provinces are of higher rank, most of the large deposits found there are mainly sub-bituminous and lignitic. Whereas, in the Eastern and Interior provinces, the coal is mostly bituminous to anthracite. Age does not necessarily determine quality, but, all other things being equal, the older the coal, the longer it has been subjected to coal forming or rank-increasing factors such as heat and pressure. The young higher rank coal beds in the west have been subjected to sufficient heat and pressure to cause devolatization, thus improving the quality.

6. Ownership of Coal Lands

Coal in the United States is held by several broad classes of owners, including the Federal and State Government, mining and manufacturing corporations, railroads, Indian tribes, and private individuals. Information about the ownership of the surface, coal, and other mineral rights for any individual tract of land can be ascertained from the records of appropriate County, State, or Federal agencies.

Most of the coal lands in the Eastern and Interior Coal Provinces are privately owned. In the Appalachian basin, many large tracts of coal land are held by mining, manufacturing, or landholding corporations. In this area also, the three or four main eastern coal-hauling railroads own some coal lands along their rights-of-way. In areas remote from transportation facilities, some coal acreage is owned by individual counties, having been acquired during the depression of the 1930's through failure of the owners to keep up real estate tax payments. Federal coal constitutes a very small part of the total in the East.

Most of the coal lands in the Rocky Mountain and Northern Great Plains Coal Provinces are owned by the Federal Government. In disposing of public domain land prior to 1906, coal rights went with the land as it was transferred to private ownership. Between 1906 and 1920, the Federal Government appraised each tract of land for its coal value and fixed the sale price accordingly. Following passage of the Mineral Leasing Act of 1920, the Federal Government reserved coal rights on all lands classified as valuable for coal when such lands were patented. Although thousands of acres of coal lands, including coal rights, were acquired automatically or sold to private owners prior to 1920, the Federal Government is still the largest single owner of coal rights in the West.

The Bureau of Land Management maintains records showing disposition and retention of lands and rights by the Federal Government.

Early transcontinental railroad companies received grants of considerable land, including coal rights, adjoining the rights-of-ways. (See U.S. Department of the Interior, 1931, p. 405-431.) The Northern Pacific Railroad, for example, received odd-numbered sections in a checkerboard pattern for a distance of 40 miles on both sides of the right-of-way. The Union Pacific and Santa Fe Railroads received odd-numbered sections for a distance of 20 miles on both sides of their rights-of-way. At the time of these grants, the extent and potential value of the coal lands could only be surmised.

Subsequently. the railroads made many exchanges of land to accomodate homesteaders, States, and the Federal Government. The grant to the Santa Fe, for example, resulted in ownership of coal lands in the southern part of the San Juan basin of New Mexico, south of the Navajo Indian Reservation. At a later date, when it became desirable to enlarge the reservation southward, the Santa Fe lands in the path of the expansion were, by request, exchanged for a relatively solid block of coal land of comparable acreage east of the reservation. The railroads sold some land, including coal rights, to early settlers; and they sold much larger amounts, exclusive of coal rights, to later settlers. As a result of exchanges and sales, the current pattern of coal ownership by the western railroads differs considerably from that of the original grants, but the western railroads as a group still hold the second largest acreage of coal land in the Rocky Mountain and Northern Great Plains Coal Provinces.

In Oklahoma, New Mexico, and Arizona, fairly large acreages of coal land are owned by the various Indian tribes, who are assisted by the Bureau of Indian Affairs in coal lease administration.

In Washington and Oregon, the percentage of coal land owned privately is somewhat higher than it is in the Rocky Mountain region, but even in these States the Federal Government manages substantial areas of coal land.

Table 7 - Analyses of Coal From Principal Regions Where Federal Coal Occurs

Coal Province and Region	Proximate Analysis (as received)					
	Moisture Percent	Volatile Matter Percent	Fixed Carbon Percent	Ash Percent	Sulphur Percent	BTU per lb.
Northern Great Plains						
Fort Union	30.5 - 42.8	24.5 - 27.7	25.1 - 35.9	4.1 - 9.6	0.2 - 1.2	5675-7660
Powder River	21.4 - 33.5	27.8 - 39.0	32.5 - 41.5	3.9 - 9.14	0.2 - 1.1	7220-9720
North-Central	6.6 - 22.6	28.2 - 30.2	36.6 - 46.4	8.8 - 18.2	0.6 - 2.7	8580-10210
Denver	15.5 - 35.0	37.3 - 41.8	51.5 - 56.2	2.3 - 18.2	0.1 - 1.1	5510-10660
Raton	1.0 - 10.2	22.9 - 40.0	50.0 - 54.5	5.3 - 21.8	0.4 - 1.3	10310-13970
Interior Province						
Western (E. Oklahoma area)	2.2 - 3.5	17.3 - 37.2	68.1 - 72.7	5.5 - 8.5	0.5 - 1.1	13010-14310
Rocky Mountain Province						
Big Horn	9.5 - 17.2	33.6 - 34.2	38.1 - 47.4	2.8 - 12.0	0.4 - 1.1	9740-11650
Hams Fork	5.6 - 22.7	33.5 - 38.4	40.5 - 49.8	1.7 - 6.2	0.6 - 0.8	9720-12650
Wind River	22.3 - 24.6	27.7 - 32.5	39.9 - 40.0	5.2 - 7.8	0.5 - 1.1	8610-9530
Green River	6.5 - 25.0	28.0 - 45.6	27.0 - 54.6	3.5 - 25.0	0.4 - 5.0	5000-12572
Hanna Field *	11.1 - 14.1	33.3 - 39.4	41.6 - 50.1	3.8 - 7.8	0.5 - 1.1	10290-11450
Uinta (Utah)	4.1 - 16.3	35.9 - 41.9	42.4 - 51.7	5.4 - 11.0	0.5 - 1.3	10400-13220
Uinta (Colorado)	2.2 - 14.6	8.4 - 37.6	45.4 - 80.2	3.2 - 13.6	0.4 - 1.1	10830-14120
San Juan River	3.3 - 16.2	35.4 - 40.9	38.0 - 50.8	3.1 - 11.8	0.4 - 0.9	10150-13120
Southwestern Utah	12.0 - 17.4	36.0 - 42.2	30.0 - 46.0	4.0 - 15.8	0.7 - 6.1	10390-11020

Data from Fieldner, A.C., Rice, W.E., and Moran, H.E., 1942, Typical analyses of coals of the United States : U.S. Bureau of Mines Bulletin 446, p. 45 modified by date from Keystone Coal Industry Manual, 1972; Glass, 1972; Hombaker and Holt, 1973; and Pillmore. C.L., 1970.

* Smith, J.B., et al, 1972, Strippable Coal Resources of Wyoming: U.S. Bureau of Mines Information Circular 8538, p. 47.

G. Past and Present Coal Production

The first bituminous coal mining in America began in Virginia in 1787. The earliest record of production was in 1820 when 3,000 tons of coal were produced. Production of a million tons of anthracite was reached in 1837 and the same tonnage for bituminous coal in 1850 (E.S. Moore, 1922), coal production reached the 100 million ton level in 1880. It exceeded the 200 million ton rate by the turn of the century, (Bureau of Mines, 1920). The gradual growth of coal production increased to 579 million tons in 1918 during the peak production years during and following World War I. Production remained somewhat steady until the depression years when it dropped to a low of 310 million tons in 1932. The industry operated at a deficit during the 1930's. As the economic demands of the country grew, coal production grew to a sustained production of over 460 million tons in 1940. The all time peak production year was 1947 when 631 million tons of coal were produced. This peak was achieved just three years after the railroads switched from coal to diesel fuel in 1944. Trains at that time were using 132 million tons of coal annually.

Coal production was sporadic from 1947 to 1961. It dropped to a low of 392 million tons in 1954, up to 501 million tons in 1956 and back down to 403 million tons in 1961. From 1961 to 1973, there was a steady growth with the exception of a minor drop in 1968, caused by strikes.

A major effect upon coal production from 1947 to 1961 was the steadily increasing availability of oil and gas. The convenience of use, competitive price, and new technology of the oil and gas indust resulted in its increasing role in meeting the energy requirements of the country. Coal's contribution to the total U.S. energy demand dropped from 43.5% in 1947 to 21% in 1961, (Bureau of Mines, 1970).

The transporation market for coal has virtually disappeared. Hou hold and commercial space heating have drastically declined. But the has been a tremendous growth in coal consumption for the electric utilities.

Table 8 - Production of Bituminous Coal, by type of mine, relat the production of coal from 1900 to 1970. It also breaks down the mining methods which include strip, auger and underground mining, (Keystone Coal Industry Manual, 1972).

The first production figures for strip mining were in 1915 when less than one percent of the nation's total was mined by stripping. By 1930, stripping accounted for 5 percent of coal mined. This figu rose to 10 percent in 1940; 20 percent in 1950; 30 percent in 196 35 percent in 1969; and 40 percent in 1970, (Keystone Coal Industry Manual, 1972).

In 1969, the Federal Government passed the Federal Coal Mine Health and Safety Act. The requirements of this act increased the co of underground operations and virtually closed out the small indepen dent underground coal miner. Stripping operations are rapidly growi in the Appalachian area. Nearly all of the coal mines in New Mexico

Table 8 - Production of Bituminous Coal, by Type of Mines
Thousands of Short Tons

Year	Strip Mining	Auger Mining	Underground Mining	Total Production
1900	---	---	212,316	212,316
1905	---	---	315,063	315,063
1910	---	---	417,111	417,111
1915	2,832	---	439,792	442,624
1920	8,860	---	559,807	568,667
1925	16,871	---	503,182	520,053
1926	16,923	---	556,444	573,367
1927	18,378	---	499,385	517,763
1928	19,789	---	480,956	500,745
1929	20,268	---	514,721	534,989
1930	19,842	---	447,684	467,526
1931	18,932	---	363,157	382,089
1932	19,641	---	290,069	309,710
1933	18,270	---	315,360	333,630
1934	20,790	---	338,578	359,368
1935	23,647	---	348,726	372,373
1936	28,126	---	410,962	439,088
1937	31,751	---	413,780	445,531
1938	30,407	---	318,138	348,545
1939	37,722	---	357,133	394,855
1940	43,167	---	417,604	460,772
1941	55,071	---	459,078	514,149
1942	67,203	---	515,490	582,693
1943	79,685	---	510,492	590,177
1944	100,893	---	518,678	619,576

Source: U.S. Bureau of Mines

Tables prepared by the National Coal Association

Table 8 (Continued)

Year	Strip Mining	Auger Mining	Underground Mining	Total Production
1945	109,987	---	467,630	577,617
1946	112,964	---	420,958	533,922
1947	139,395	---	491,229	630,624
1948	139,506	---	460,012	599,518
1949	106,045	---	331,823	437,868
1950	123,467	---	392,844	516,311
1951	117,618	205	415,842	533,665
1952	108,910	1,506	356,425	466,841
1953	105,448	2,291	349,551	457,290
1954	98,134	4,460	289,112	391,706
1955	115,093	6,075	343,465	464,633
1956	127,055	8,045	365,774	500,874
1957	124,109	7,946	360,649	492,704
1958	116,242	7,320	286,884	410,446
1959	120,953	7,641	283,434	412,028
1960	122,630	7,994	284,888	415,512
1961	121,979	8,232	272,766	402,977
1962	130,300	10,583	281,266	422,149
1963	144,141	12,531	302,256	458,928
1964	151,859	13,331	321,808	486,998
1965	165,241	14,186	332,661	512,088
1966	180,058	15,299	338,524	533,881
1967	187,134	16,360	349,133	552,626
1969	197,023	16,350	347,132	560,505
1970	244,117	20,027	338,788	602,932

Source: U.S. Bureau of Mines
Tables prepared by the National Coal Association

Arizona, North Dakota, Montana, and Wyoming are surface strip mines. However, much of the high quality, high BTU coal from Colorado and Utah will continue to be mined by underground methods. There was no auger mining in the west prior to 1973.

In order to see where Federal coal production is coming from, a table of state production for total tons, production value and royalty value was prepared. This table is only for public land and does not include Indian lands, (Geological Survey, 1972).

Table 9 - Federal Coal Production Through 1971

State	Total Tons	Total Production Value	Royalty Value
Alaska	16,982,283	$118,111,604	$ 1,874,585
California	1,257	3,190	299
Colorado	35,383,196	183,794,137	4,717,376
Idaho	31,574	88,984	7,228
Illinois (ACQ)	24,170	92,128	3,138
Kentucky (ACQ)	1,011,795	4,278,280	166,641
Montana	22,939,102	35,084,777	2,371,357
Nevada	141	207	133
New Mexico	3,432,964	10,843,992	642,614
North Dakota	23,288,393	41,723,187	1,995,846
North Dakota (ACQ)	116	334	7
Ohio (ACQ)	489,461	2,066,465	89,459
Oklahoma	5,876,324	40,884,344	932,462
Oregon	18,900	240,719	23,891
South Dakota	41,435	69,381	7,119
Tennessee (ACQ)	974	81,340	4,452
Utah	90,390,240	374,031,424	11,153,937
Virginia (ACQ)	798	4,589	119
Washington	838,669	2,163,110	114,643
Wyoming	66,976,008	219,729,389	7,386,867

(ACQ) Acquired Lands

The production value represents the value of coal produced. The royalty value is the amount of money returned to the Federal Government for the right to mine the coal. The coal was mined from acquired lands in Illinois , Kentucky, Ohio, Tennessee, Virginia, and a small portion of North Dakota. There has been no Federal coal mined in California since 1951. The last production in Idaho was in 1955. The Federal coal mined from acquired land in Illinois was during the years 1959 to 1965. The production figures only go back to 1955 in Kentucky. The production figures start in 1947 in Ohio and 1949 in Oklahoma. The Federal coal in Tennessee was mined from 1956 to 1960 and in Virginia it was mined during 1956 and 1957.

The combined total of coal produced from Federal leases and from Indian land varied between 1.2 and 2.0 percent of the total U.S. production from 1950 through 1970. This combined total percentage rose to 3.1 percent in 1971, (Geological Survey, 1972). The total percentage of Federal coal production will tend to rise as more Federal leases come into production in the western states.

H. Coal Reserves and Resources

In discussions of most mineral commodities, it is customary to present data in at least two categories -- one termed reserves, and the other termed total resources. The term "reserves" generally means quantities determined by detailed mapping and closely spaced exploratory drilling, and suitable for extraction by current mining methods and economics. Total resources, on the other hand, represents all known material within certain broad limits of thickness, grade, or overburden, and thus includes material of marginal or of long-term economic interest. Data on total coal resources are presented in terms of thickness of coal beds and thickness of overburden.

Coal resources are classified in most Geological Survey coal reports as being "measured," "indicated," or "inferred." "Measured" resources are those judged to be accurate within 20 percent of true tonnage as calculated on the basis of observations at outcrops, trenches, drill holes, and mine workings spaced within one-half mile apart. "Indicated" resources are based on observations spaced one to one-half miles apart and are based partly on specific measurements and observations and partly on geological projection. "Inferred" resources are based on broad knowledge of the geology and extent and continuity of the coal beds, and may be supported by only limited outcrop and subsurface data. In general, coal classed as inferred lies more than two miles from the outcrop.

In reporting tonnages of coal resources, the term "original resources" refers to resources in the ground before mining began. "Remaining resources" are as yet unmined resources in the ground as of the date the appraisal. Where the term "remaining resources" is used, past production and mining losses have been subtracted from the estimated original resources, but no allowance has been made for future losses. Where allowance has been made for mining losses, future losses, and production as well, the term "recoverable reserves" or "recoverable resources" is used.

1. Distribution of Identified Resources by State

Identified coal resources are specific, identified coal deposits that may or may not be evaluated as to extent or grade and that may or may not be profitably recoverable with existing technology and economic conditions. The identified coal resources lying under 0-3,000 feet of overburden are listed in the following table by State and rank of coal.

Table 10 - Total Estimated Remaining Coal Resources in the United States, January 1, 1972

Figures are for resourcss in the ground, about half of which may be considered recoverable. They include beds of bituminous coal and anthracite fourteen inches or more thick and beds of sub-bituminous coal and lignite 2-1/2 feet or more thick, (After Averitt, 1973).

Table 10 - (Continued)

Estimated Identified Resources Remaining in the Ground

Millions of Short Tons

State	Bituminous Coal	Sub-Bituminous Coal	Lignite	Anthracite and semi-anthracite	Total
Alabama	13,342	0	2,000	0	15,342
Alaska	19,413	110,668	1/	0	130,081
Arizona	21,246	0	0	0	21,246
Arkansas	1,638	0	350	430	2,418
Colorado	62,339	18,242	0	78	80,659
Georgia	24	0	0	0	24
Illinois	139,124	0	0	0	139,124
Indiana	34,573	0	0	0	34,573
Iowa	6,509	0	0	0	6,509
Kansas	18,674	0	0	0	18,674
Kentucky	64,842	0	0	0	64,842
Maryland	1,158	0	0	0	1,158
Michigan	205	0	0	0	205
Missouri	31,014	0	0	0	31,014
Montana	2,299	181,855	87,521	0	221,675
New Mexico	10,752	50,671	0	4	61,427
North Carolina	110	0	0	0	110
North Dakota	0	0	350,630	0	350,630
Ohio	41,358	0	0	0	41,358
Oklahoma	3,281	0	0	0	3,281
Oregon	50	284	0	0	334
Pennsylvania	56,759	0	0	20,510	77,269
Rhode Island	0	0	0	0	0

Table 10 - (Continued)

State	Bituminous Coal	Sub-Bituminous Coal	Lignite	Anthracite and semi-anthracite	Total
South Dakota	0	0	2,031	0	2,031
Tennessee	2,572	0	0	0	2,572
Texas	6,048	0	6,824	0	12,872
Utah	23,541 2/	180 2/	0	0	23,721 1/
Virginia	9,352	0	0	335	9,687
Washington	1,867	4,190	117	5	6,179
West Virginia	100,628	0	0	0	100,628
Wyoming	12,705	107,951	0	0	120,656
Other States	610	32	46	0	688
Total	686,033	424,073	449,519	21,362	1,580,987

1/ Small resources of lignite included under sub-bituminous coal.

2/ Excludes coal in beds less than four feet thick.

2. Distribution According to Coal Province

The distribution of resources in the coal provinces is given in Table 11. Reserves are "measured and indicated resources in thick and intermediate beds; includes bituminous coal and anthracite in beds 28 inches or more thick, and sub-bituminous coal and lignite in beds five feet or more thick."

The amount of coal that can be classified as reserves in the ground

Table 11 - Remaining Coal Reserves and Total Remaining Identified Coal Resources in the United States, January 1, 1973

Province	Remaining reserves in the ground 0-1,000 feet overburden	Inferred Resources in thin beds, 0-1,000 feet overburden; and identified resources in all beds, 1,000-3,000 feet overburden	Total remaining identified resources 0-3,000 feet of overburden
	Billions of Short Tons		
Eastern Province			
(Pa., Ohio, W.Va., Md., eastern Ky., Tenn., N.C., Ga., & Ala.)	122	154	276
Interior & Gulf Province			
(Ill., Ind., western Ky., Iowa, Kansas, Mo., Okla., Ark., & Texas)	109	176	285
Northern Great Plains Province 1/			
(N. Dak., S. Dak., Mont., Wyo., & Idaho)	106	589	695
Rocky Mountain Province 2/			
(Colo., Utah, Ariz., & N. Mexico)	37	150	187
Pacific Province			
(Alaska, Wash., Oreg., & Calif.)	8	129	137
Total	382	1,198	1,580

1/ Includes coal in the western parts of Montana and Wyoming that normally would be considered in the Rocky Mountain Province.

2/ Includes coal in the Denver and Raton Mesa regions of Colorado and New Mexico that normally would be considered in the Northern Great Plains Province.

in the 0-1,000 feet overburden category is much larger in some provinces than in others because of differences in the thickness and number of coal beds, and differences in the structure and topography of the major coal-bearing basins. About half of the coal resources in the ground can be recovered.

The very large reserve tonnage in the Northern Great Plains Coal Province reflects the fact that coal beds are very thick, numerous, and closely spaced; the coal-bearing rocks are nearly flat-lying; and the topography is relatively flat over thousands of square miles in North Dakota, eastern Montana and northeastern Wyoming.

The modest reserve tonnage in Rocky Mountains Coal Province reflects the fact that in most of the provinces, the coal-bearing rocks are on the edges of moderately to steeply-dipping structural basins. In parts of the province, particularly in the Wasatch Plateau and Book Cliffs of central Utah, the moderately dipping coal crops out at the bases or nearly vertical cliffs, and thus passes below 1,000 feet of overburden a short distance from the outcrops. All the coal occurring in this topographic setting can be reached by drift mines, and even larger tonnages with overburden more than 1,000 feet thick can be reached conveniently through the same openings.

The small reserve tonnage in the Pacific Coal Province reflects the fact that in Washington most of the coal lies on the flanks of steeply-dipping basins, and thus passes below 1,000 feet of overburden a short distance from the outcrops, and also the fact that in Alaska, most of the coal is classified as inferred.

I. Coal Uses

Coal is used almost exclusively as a source of heat and power, the major exception being use for the production of metallurgical coke.

Coal's largest and fastest growing market is the electric utility industry, which accounted for 66 percent of total bituminous coal and lignite consumption in 1971. In turn, coal at present accounts for more than 50 percent of total power generation, and 54 percent of total generation by fossil fuels. This is a result, primarily, of high efficiency in the use of coal for power generation and of the relatively low cost of coal.

How long coal will maintain dominant position is subject to the interplay of many variables, including reserves, availabilities, and prices of competitive energy sources, plus relative efficiencies in utilization and environmental qualifications. Coal's position in these several respects generally is favorable.

Next to importance to power generation by utilities is the use of coal in the primary metal industries, principally for the production of coke for use in blast furnaces of the steel industry, and for the self-generation of power at steel and rolling mills. These uses accounted for approximately 18 percent of coal consumption in 1971. The amount of coal used for such purposes in the future will be determined by the demand for iron and steel, together with the results of new technological experimentation in reducing iron ores whereby coke requirements would be lessened.

Major future users of coal are expected to be those same industries now consuming it, but increases in consumption are projected for generating electric power and manufacturing steel. In addition, coal will be used to manufacture synthetic gas and liquid fuels. Its use for these products should equal or exceed that used for electric power generation by the year 2000. The Bureau of Mines has projected that 36 coal-gasification plants will be in operation by 1985. Each plant will be manufacturing at least 250 million cubic feet of pipeline gas per day and, depending upon the type of coal, each will be consuming 6 to 10 million tons annually. Such consumption will utilize about 300 million tons of coal each year, an increase of about 50 percent over the total produced in the United States in 1972. Additional coal will be required for liquefaction. It has been projected that requirements in the year 2000 for liquefaction and gasification combined will be as high as 1,274 million tons.

De-ashed coal is considered to be a coal product of the future. However, whatever quantity of coal is de-ashed, the product will be used by one of the coal consuming industries. Therefore, total consumption will be increased only by the amount required for heat and power for the de-ashing process.

The utilization of coal in the household and commercial market has declined drastically since the early 1940's, when consumption ranged around 120 million tons per year, as compared to 11.4 million tons in 1971. Direct consumption in this market is expected to continue downward on an overall basis, largely in response to shifts to other energy sources. A significant consideration in the switch to oil and natural gas in this market has been greater convenience in using these fuels. More recently, some of the direct loss for coal can be attributed to the substitution of electricity in space heating. Indirectly, however, this is not a complete loss because the decline is compensated to the extent that coal is consumed in generating electricity used for space heating.

Since 1950, the use of coal in food, paper,chemical, and allied industries has been decreasing, as has its use in transportation. For many years, railroads and sea and lake vessels collectively were the largest consumers of coal (132 million tons in 1944). The railroad market virtually has disappeared and that for vessel bunkering has declined drastically.

Coal consumption in the stone, clay, and glass products industries, other than cement production, has been declining steadily. This decline has been offset, however, by increasing coal requirements at cement plants, which, in 1970 accounted for about 70 percent of the coal used by the group, a percentage that is increasing.

J. Coal Mining

Four operations -- exploration, development, production, and restoration -- are executed during the life of a coal mine. Although often overlapping, each operation must be done in a manner that will cause little or no adverse affects on the environment. A secondary operation, beneficiation, is required for coals containing an excess of impurities.

1. Exploration

Exploration aims at locating the presence of economic deposits and establishing their nature, shape, and grade. The investigation may be divided into two parts -- (1) preliminary or prospecting, and (2) final exploration -- which often overlap. In general, locating the presence of a coal deposit is considered as preliminary exploration. Then establishing whether or not it is an economic deposit by its nature, shape (size), and grade is considered as final exploration.

An accepted method of exploration is to first search the literature to determine the geology, previous discoveries, surface and mineral ownership, and access routes in the general area. This is followed by a geologic reconnaissance to select the logical location(s) for detailed geologic study and exploratory holes. Such reconnaissance may require the use of an airplane or helicopter. After establishing the location(s) for detailed exploration, it becomes necessary to obtain permissions and permits. The procedure for obtaining a prospecting permit on Federal land and minerals is described elsewhere in this

report. From detailed geology and drill-hole data, the nature of the overlying strata, depth and thickness of the coal deposit, and the quantity of ground water is determined. Analysis of samples taken from the drill hole will ascertain the grade of coal and quality of ground water. A number of exploratory holes are required to delineate the shape of the deposit for determining its quantity and boundaries.

Exploratory drilling is generally done with truck-mounted rotary rigs, and the samples taken with such rigs can be either cuttings or core, or both. Additional equipment used by an exploration crew may include water trucks, personnel carriers, a hole-logging equipment truck, and a dozer or blade to assist in obtaining access to the exploration area and drill site. The latter is used only when terrain or vegetation will not otherwise allow travel.

Although state regulations vary, Federal regulations require all aquifers and workable coalbeds be cemented off and a concrete plug placed in the collar of the hole. Disposal of cuttings and reclamation of the drill-site is also required.

Occasionally, during exploration, pits or trenches are dug with a backhoe or dozer near the coal outcrop. On Federal owned land and/or coal deposit, regardless of how they were excavated, requirements are that they be backfilled and the surface graded and seeded.

When exploration terminates, all dozed or bladed trails or any other disturbed surface must be graded and seeded.

2. Development

Development, the preparatory operation to production, begins after an economic coal deposit has been found. However, it continues throughout the life of the mine. Except for planning the mine, which includes plans for mined-land reclamation and prevention of air and water pollution, actual on-the-ground development cannot begin until all necessary arrangements have been made with Federal, State, and local governments as well as the surface and mineral owners if privately owned. Such arrangements include the obtaining of a lease; required permits and licenses; access to the mine property for roadways, railroad, and utilities; and bonding. The procedure for obtaining a Federal coal lease is described elsewhere in this section. Permits and licenses are requirements of State and local authorities. A usual requirement, in addition to a fee, is for an approved mining and reclamation plan before a permit is granted. Obtaining access to the mine property is usually the responsibility of the lessee. Bond is posted to insure payment of rents and royalties and restoration of the land as mining progresses. When a coal deposit has been mined by underground methods, restoration is the removal of all equipment and structures, grading waste piles to acceptable standards, sealing all accesses to the mine, and revegetation. For a coal deposit mined by a surface method, bonding is to assure removal of all equipment and structures, and reasonable grading of the spoil followed by revegetation. Exposed strata containing toxic material are covered.

Almost all states where coal is mined by surface methods require bonding of the operator to assure reclamation of the mined land. Where such bonding is required the amount is based upon the number of acres that will be disturbed in one year. The bond remains in force until the disturbed land is reclaimed. The amount of such State bonds is commonly greater than the amount required for mined-land restoration under a Federal lease. Therefore, the bond for land reclamation can be a common bond for both the State and the Federal Government.

Planning is the first stage of development, and for a successful operation it must include all details of how the development work is to be accomplished, the method and equipment to be used for mining, provisions for restoration of the land and prevention of air and water pollution, and a map depicting the progress of proposed mining and land reclamation. Development drilling is often done at this stage to define mine limits and mine problems.

After planning, the development of a mine includes construction of a road for access to the mine property, utility lines, a mine plant, and access to the coal deposit. Depending upon the amount of coal produced annually and where the coal is to be used, construction of a railroad spur may be required. For coal that contains excessive impurities, a washing plant would be constructed as part of the mine plant. This is usually the rule for large mines with impure coal, but for small mines, impure coal is generally hauled to a central washing plant.

If the coal is to be mined from underground, the mine plant is

commonly constructed near the portal of the main drift, slope, or shaft. For coal mined by a surface method, the mine plant should be off the coal outcrop, if possible.

A mine plant will include a tipple; coal storage; office; maintenance shops; change house with showers and toilets; power substation; laboratory; parking lot; storage building for equipment, supplies and materials; and a waste disposal area.

Mine ventilation fans are part of the surface plant at underground operations.

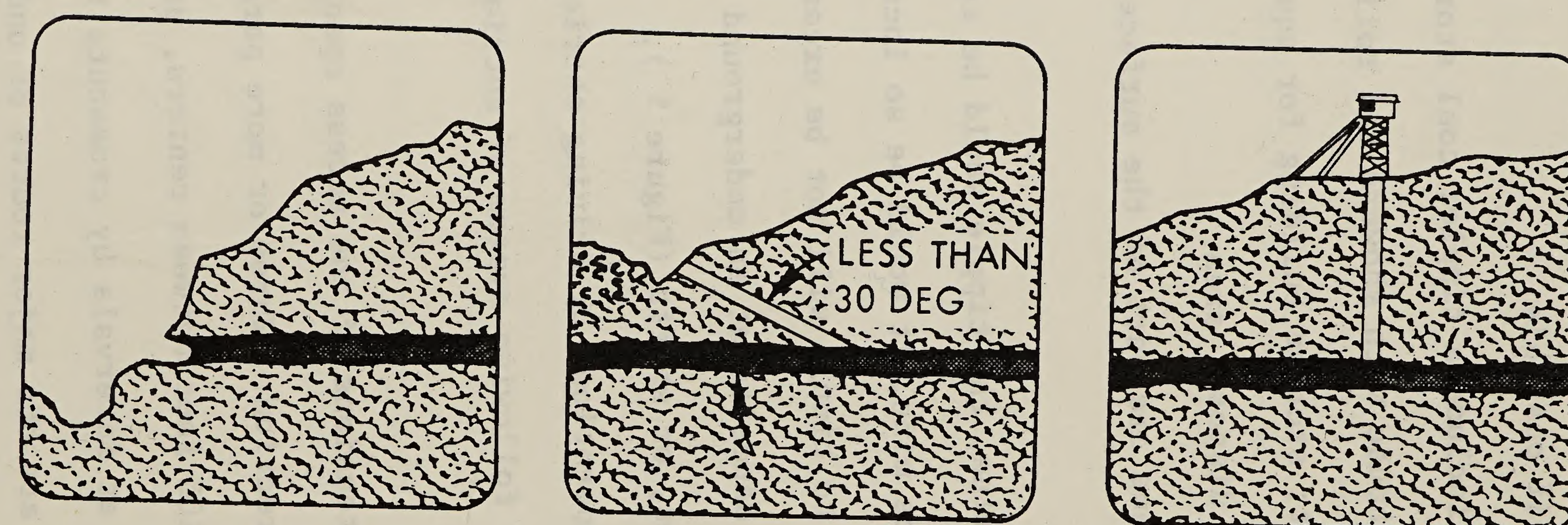
At an underground mine, the tipple would be constructed at the main portal, and at a surface mine, it would be so located that the maximum haul from working face to tipple will not be excessive.

Access to the coal deposits at an underground operation is provided by either drifts, slopes, or shafts (Figure 5). The coal seam is developed for further operations by driving entries. Although the terminology varies, the following system of entries is universal in the industry.

Main entries are extensions of the access openings and often run several miles in one direction. Three or more parallel entries, 12 to 22 feet wide and 40 to 100 feet between centers, are driven in a given direction and connected at intervals by crosscuts to provide proper air circulation. These are the major routes of underground transport and access and serve for the life of the mine.

Panel entries are driven from the main entries, resulting in a sub-

Figure 5



division of the coal seam into blocks or panels having dimensions that may be as much as 1 by 1/2 mile. Panel entries serve as routes from main entries to the working places and for air circulation. Although coal is removed during the driving of both the main and panel entries, it is with completion of the panel entries that the production cycle begins.

Main entries must remain open for the life of the mine, and panel entries must remain open until the adjacent panels are mined. To insure their remaining open, they must be supported. Supports can be roof bolts, roof trusses, yieldable arches, reinforced concrete liners, and wood or steel sets. The frequency, type, and size of the supports depend upon the nature and condition of the overlying strata.

To comply with the Federal Coal Mine Health and Safety Act of 1969 (PL 91-173), a minimum of three entries must be driven. One for air intake, one for removal of coal, and the third for exhausting air from the mine. A roadway for men and equipment may be located in the intake air entry or coal removal entry. Although the entry used for transporting coal from the mine must be ventilated, it cannot be used as an air course.

The installation of the transportation system (railroad or conveyor belt), water and compressed air lines, and electric power and telephone lines is part of mine development. It is also considered development when these facilities are carried forward.

Gaining access to the coal seam(s) where mining is to be accomplished by a surface method is part of the development phase. It includes construction of haul roads from the tipple to the mining area, roads from the haul roads to the working face, electric power lines from the substation to the mining area, gasoline and diesel fuel storage, and installation of portable chemical toilets near working places. It also includes assembly of large equipment such as bucket-wheel excavators, draglines, and shovels; and removal of the initial overburden from the coal so mining may begin. Closer spaced drilling to define mining limits or mining problems is often part of development. As mining progresses, development mainly consists of extending the haul roads and power lines, and constructing new roads to provide access to the working face.

3. Production Methods

Production is defined as the yield or output of a mine. However, this phase or cycle depends on many factors, For a mine to succeed it must operate at a profit, and a profit cannot be made without production. But production cannot be gained at the expense of the health and safety of the miners or the health and well being of the public. The Federal Coal Mine Health and Safety Act of 1969 (PL 91-173) was passed to protect miners, while air and water pollution and land reclamation laws are for protection of the public. In addition, esthetic values must be considered, and coal should be mined with the least possible waste of the resource. The mining methods must be such that cemeteries, highways, and structures will not be damaged while the mine is operational or thereafter.

Since 1910, some improvement has been made in coal mine safety in the United States, but coal mining is still the most hazardous of all major industries, as shown for a nine-year period in Figure 6 .

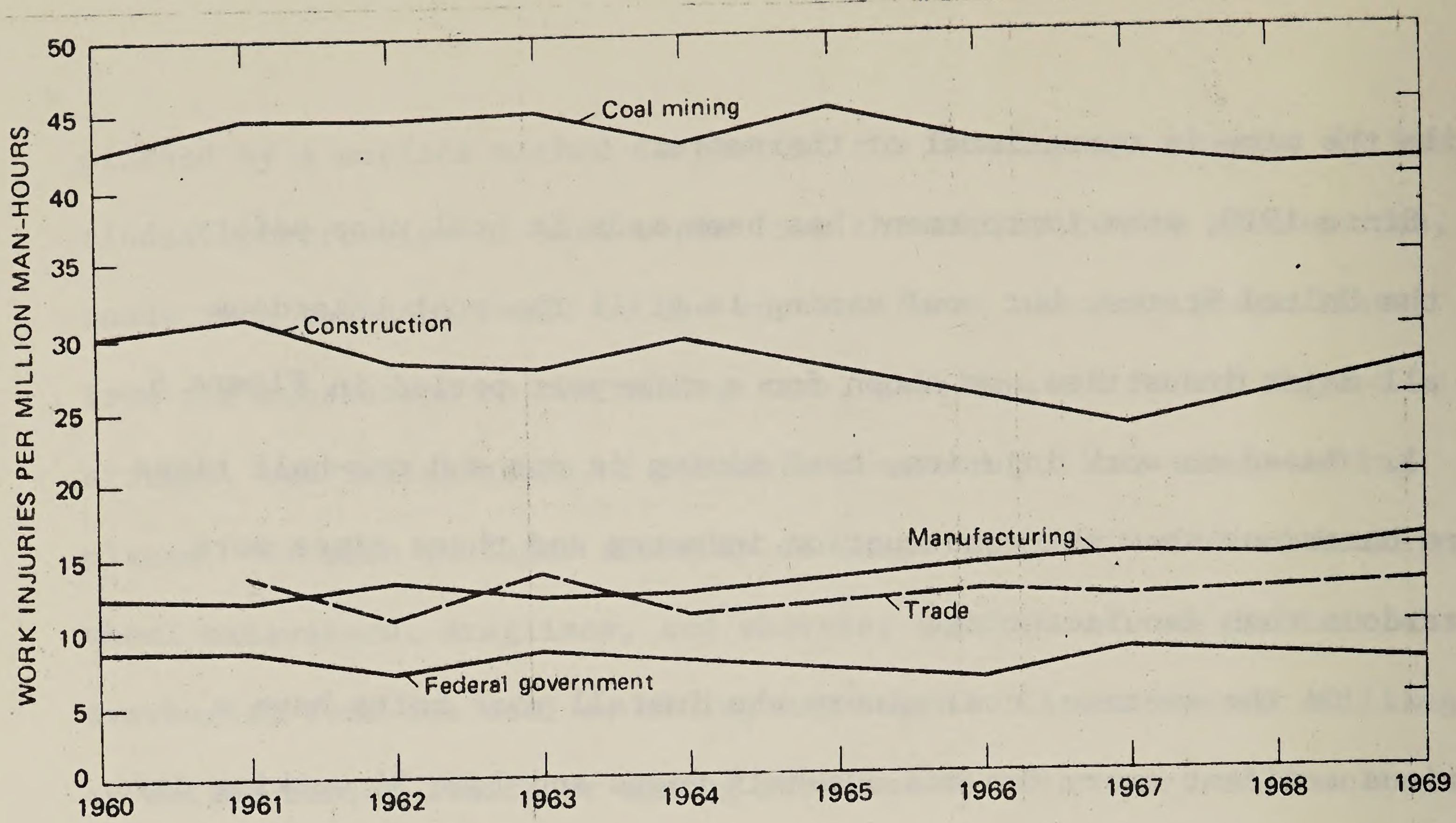
1. Based on work injuries, coal mining is one and one-half times more hazardous than the construction industry and three times more hazardous than manufacturing.

2. On the average, coal miners who install roof bolts have a serious accident every two and one-half years and lose 54 working days per lost-time accident.

3. In coal mining, the death rate from respiratory diseases is five times the industrial average.

4. Coal mining has eight times the average incidence of occupational respiratory diseases.

Information on all injuries incurred in coal mining has been collected and compiled by the Bureau of Mines since 1910. The statistics developed from these data were originally published in Bulletins, later in Technical Papers, and now annually in Information Circulars. Figures 7, 8, 9, and 10 were developed from data published in the Information Circulars for the period 1960 to 1970. It may be noted that the number of injuries, fatal and nonfatal, per million manhours worked shows little if any, improvement. While the injuries per million short tons of coal produced have decreased because of improved production technology, Figures 7, 8, 9, and 10 also show that when injuries per mil-



WORK INJURIES PER MILLION MAN-HOURS
50
45
40
35
30
25
20
15
10
5
0
Coal mining
Construction
Manufacturing
Trade
Federal government
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969

Figure 6

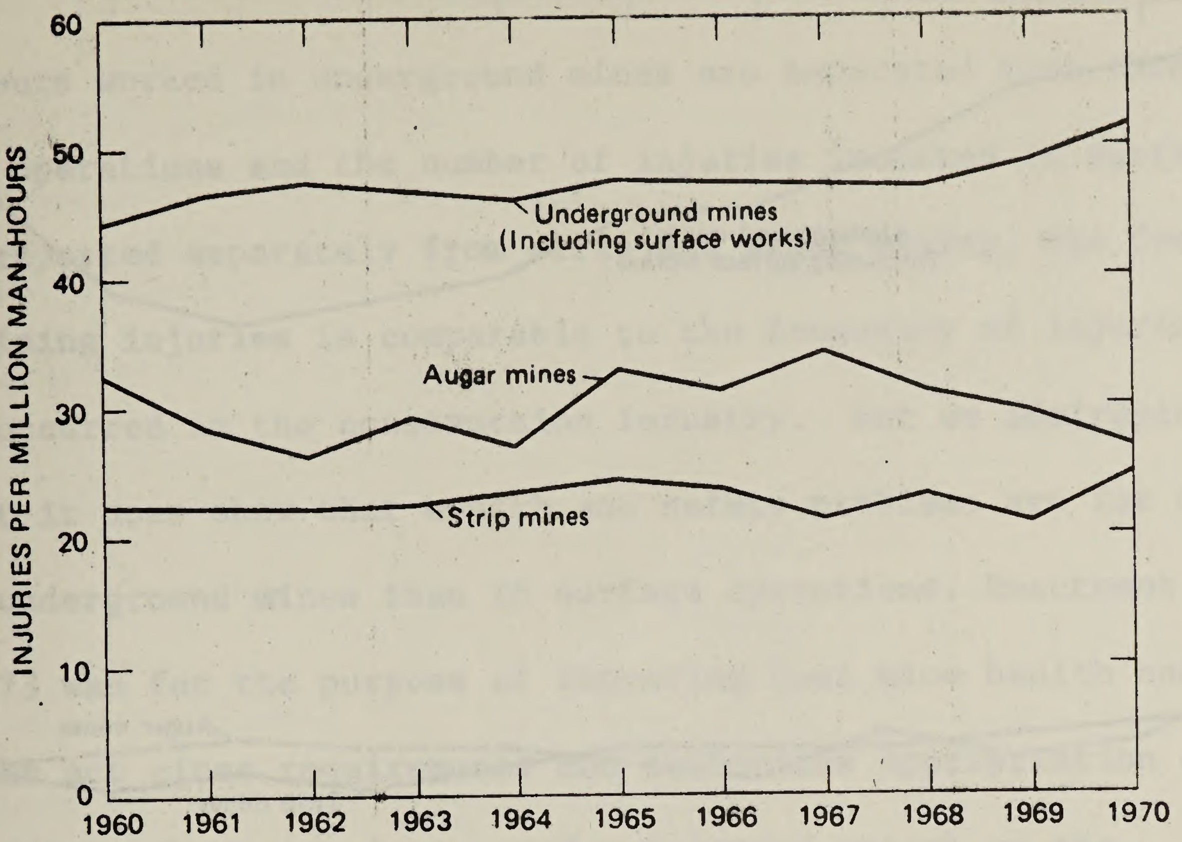


Figure 7

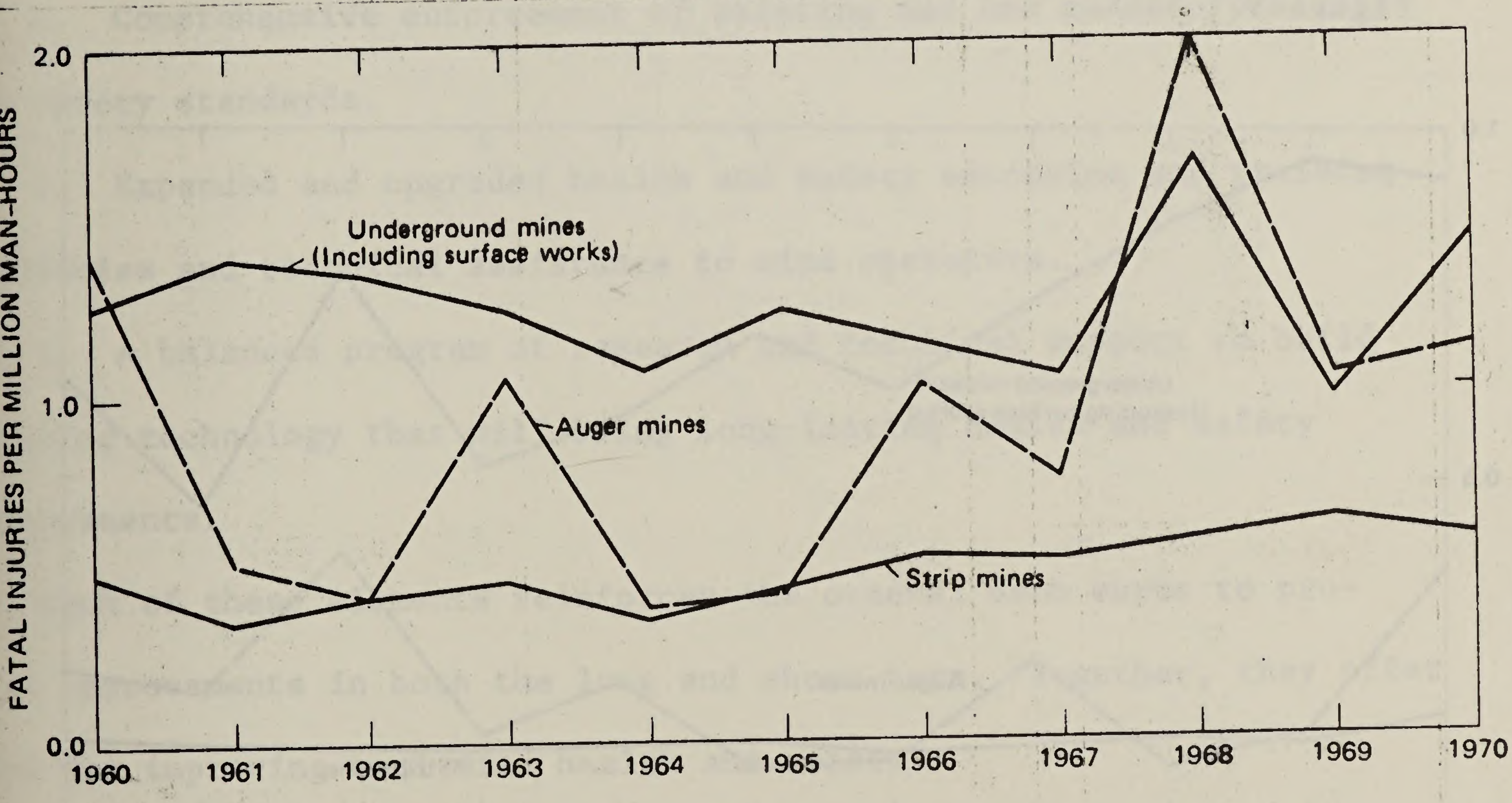


Figure 8

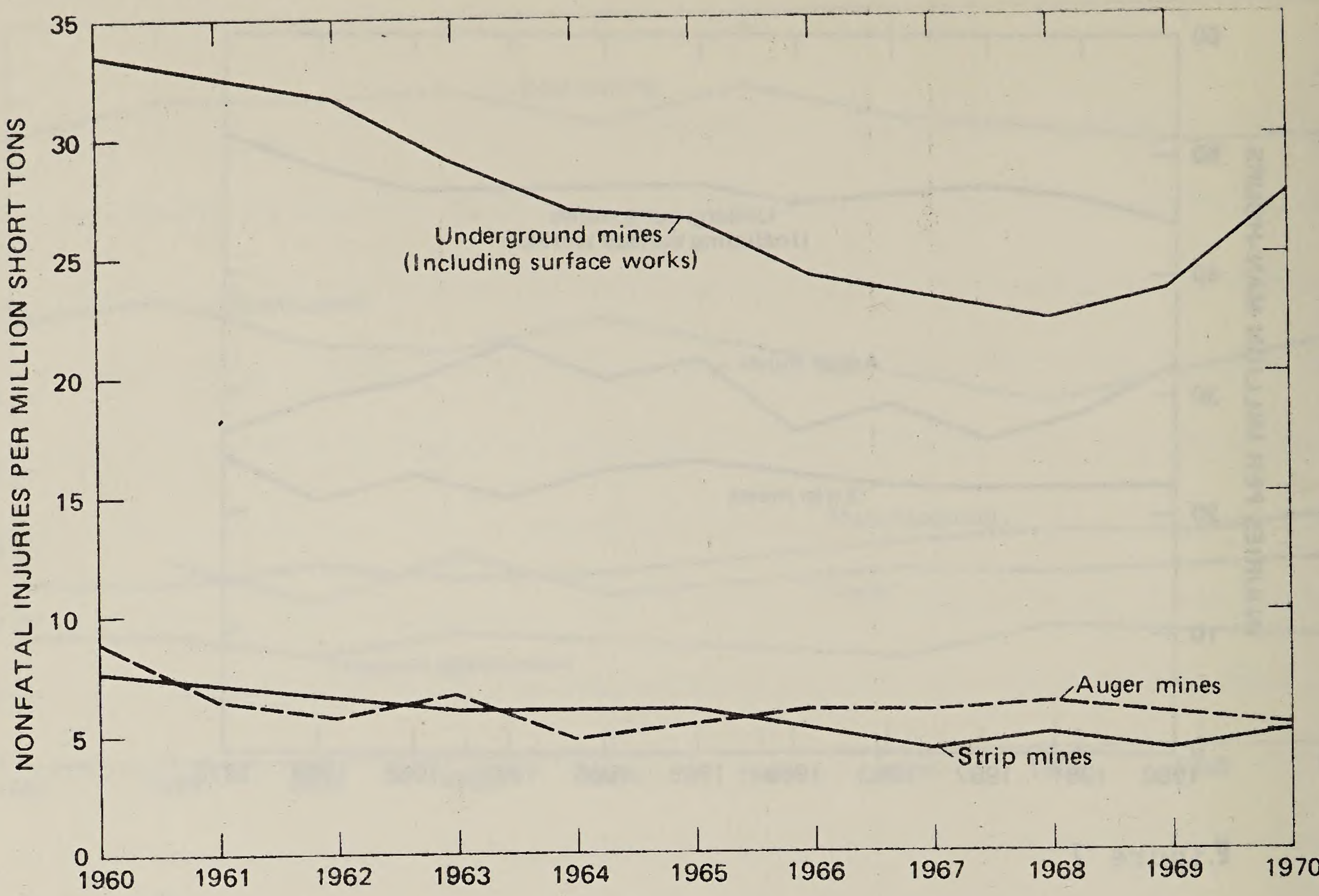


Figure 9

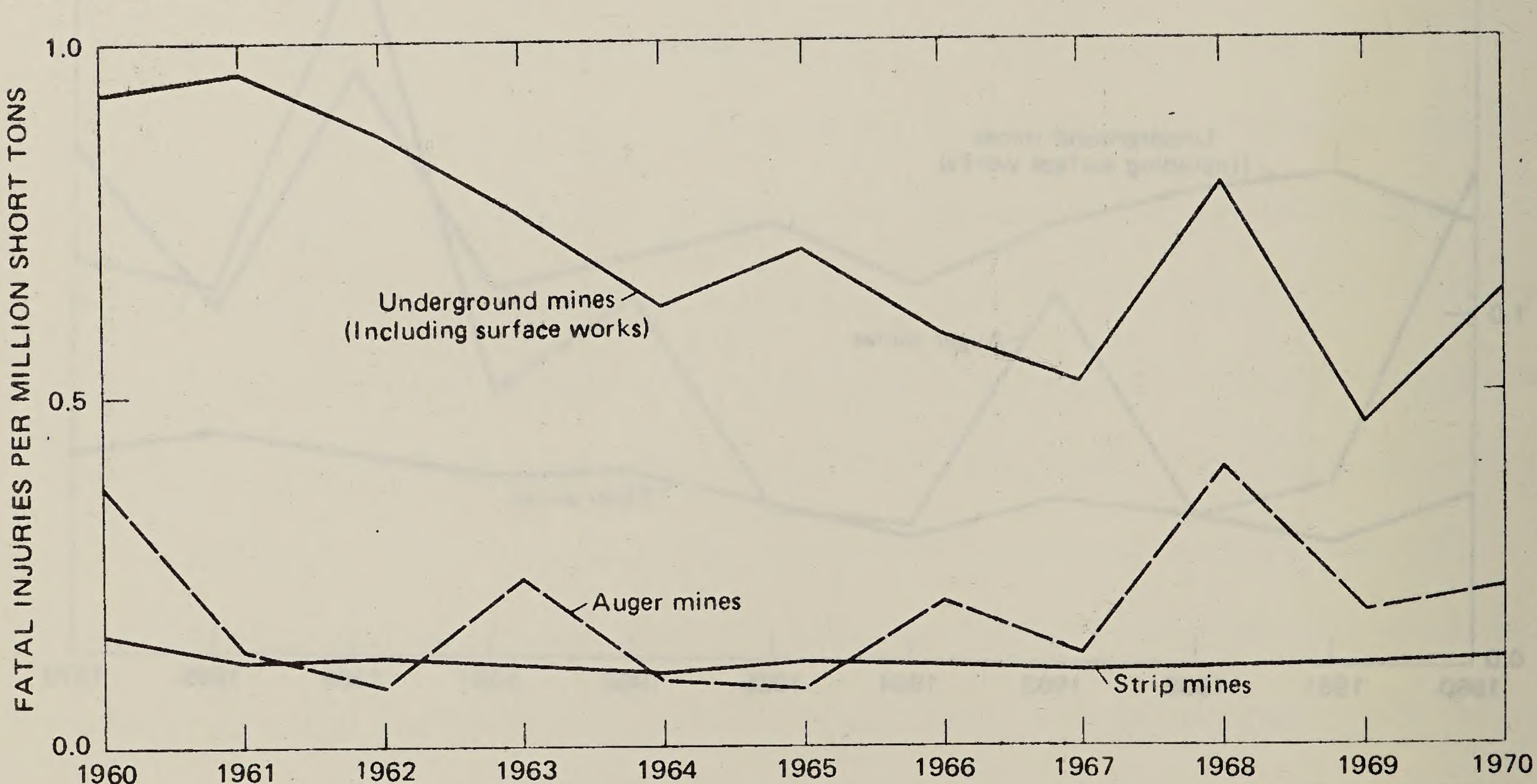


Figure 10

lion man-hours worked in underground mines are separated from those of surface operations and the number of injuries incurred in surface mining is reported separately from strip and auger mining, the frequency of strip-mining injuries is comparable to the frequency of injuries that have occurred in the construction industry. Not an admirable record, but it does show that health and safety problems are far more severe in underground mines than in surface operations. Enactment of PL 91-173 was for the purpose of improving coal mine health and safety. The act cites requirements and authorizes appropriation of funds for three necessary elements of a balanced attack on the problem:

1. Comprehensive enforcement of existing and new mandatory health and safety standards.

2. Expanded and upgraded health and safety education and training activities and technical assistance to mine operators.

3. A balanced program of research and technical support to build a mining technology that will bring long-lasting health and safety improvements.

Each of these elements reinforces the others; each works to produce improvements in both the long and short term. Together, they offer hope for improving coal mine health and safety.

a. Underground Mining

In underground mining after the initial development has gained access to the coal seam, one of three methods -- room-and-

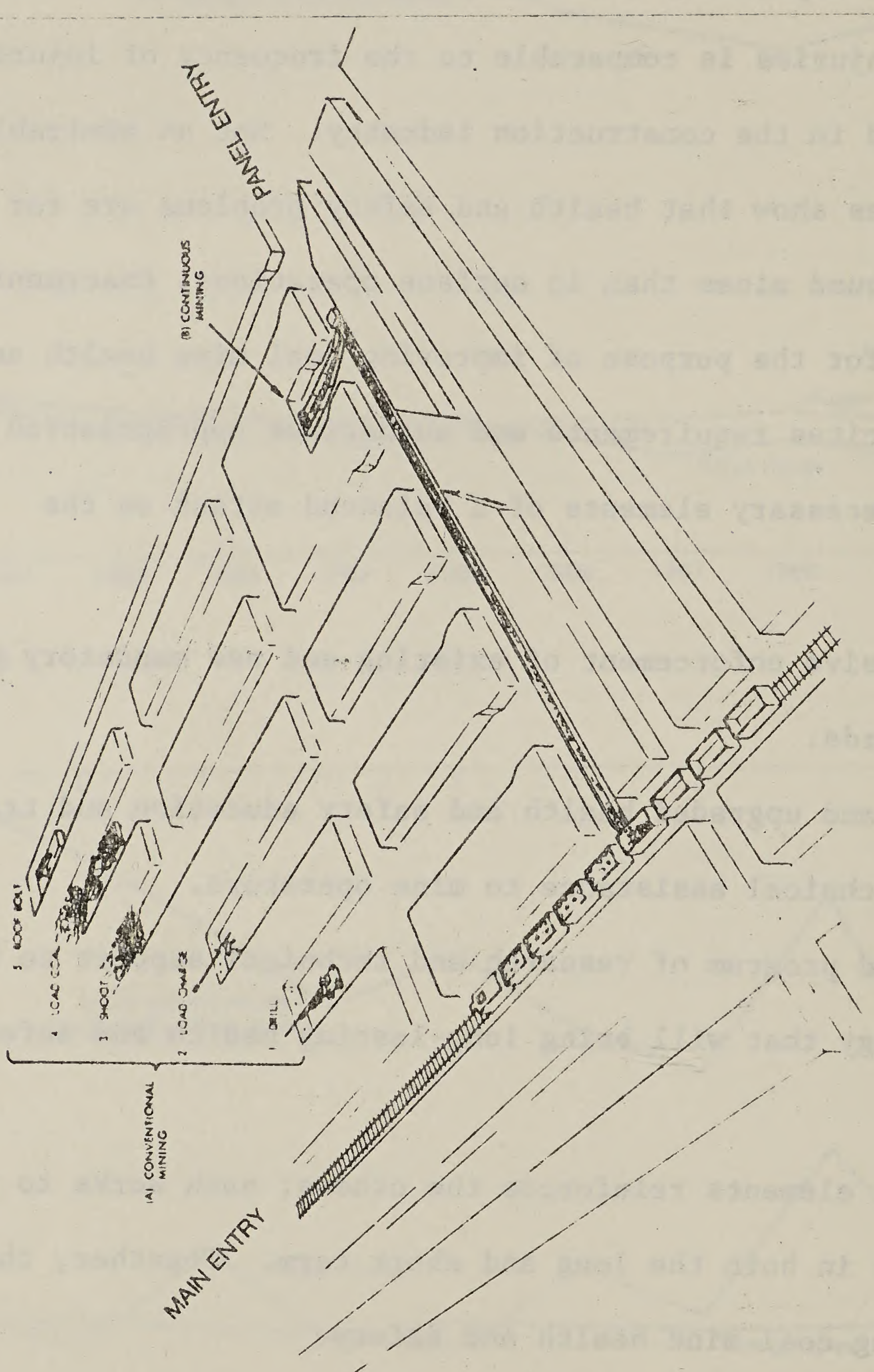

PANEL ENTRY
(B) CONTINUOUS MINING
MAIN ENTRY
(A) CONVENTIONAL MINING
5 ROOF BOLT
4 LOAD COAL
3 SHOOT COAL
2 LOAD CHARGE
DRILL

Figure 11

pillar, longwall, and shortwall -- are commmonly used to extract the coal. Regardless of the underground mining method used, surface subsidence generally will result. It can occur immediately after the coal is removed or at any time thereafter. It has been known to occur as long as 50 years after coal was mined.

(1) Room-and-Pillar Mining

Room-and-pillar mining had been used in the United States longer than any other underground methods. Mining is accomplished by driving entries off the panel entries. As mining advances, rooms are excavated in the coal seam, and the strata above are supported by pillars of coal left in place. Then, after a block, panel, or section has been mined, part of the coal in the pillars can be recovered as a retreat is made toward a main entry. Mechanization of room-and-pillar mining has created a new technique called continuous mining. The older technique is referred to as conventional or blasting mining. Until about 1950 most of the coal produced from underground mines was by the conventional technique. Since then, conventional mining gradually has been replaced by more mechanized, continuous mining. Figure 11 illustrates the basics of both techniques.

Conventional mining requires driving a number of entries so that each operational phase--undercutting, drilling, placing explosives, blasting, loading the shot coal, and roof-bolting--can be done simultaneously without one phase of the operation interfering with another.

Continuous mining is performed by electric-powered machines that either bore, dig, or rip the coal from the working face. Such machines are usually crawler-type vehicles operated by one man. They either load the coal into a shuttle car or pile it behind the machine. When coal is piled behind the machine, a mechanical loader is used to load the shuttle cars. Continuous operation of a mining machine cannot be achieved, however, because stops are required to support the roof, await haulage equipment, advance power and water supply, change cutting bits, etc. Hence, the effective duty cycle is reduced to approximately 20 percent. A mining machine, on an average, can cut 500 to 600 tons of coal per shift. All machines are equipped with detectors that automatically stop the machine when a concentration of gas becomes excessive, and with water sprays to suppress the dust.

The room-and-pillar method, whether performed by the conventional or continuous technique, is called "advance" mining. Where the entire thickness of the coal seam is mined, up to 50 percent of the coal in the seam is recovered. However, it is not always possible to take the entire coal seam thickness, because it often is necessary to leave part of it for roof support. Coal is left as roof support where the overlying strata is too weak to stand alone or to reduce pillar failure, which increases with increases in the height of the pillars. The latter is a common practice in seams greater than ten feet in thickness. Roof bolts and timber are used for additional support. None of the foregoing will prevent subsidence which will eventually reach the surface. Where coal is mined by advance mining alone, the surface at sometime in the future will depress into the rooms. This type of subsidence can be dangerous to man and animals alike. There have been instances where they have fallen in as the surface subsided, and were killed or injured. An additional hazard is the loss of a potential resource by fire. The caving will allow air to reach the coal seam which then activates the coal to the point of combustion. Once a fire has started, it continues to burn until additional caving, induced by man or nature, prevents air from entering, or until the fire reaches the limit of coal or a fault in the coal seam. Displacement of the seam at the fault must exceed the coal seam thickness to prevent the fire from continuing. Severity of both surface subsidence and coal fire hazard decrease as depth of mining increases.

Where subsidence of the ground above is permissible, the coal pillars can be removed by "retreat" mining, which allows the roof to collapse after the mining operation. Retreat mining can only be done in an area where the surface is free of cemeteries, structures, roadways, etc. Drainage of the area is also a consideration, because if surface water is allowed to enter the mine, it can create a potential for flooding the mine or polluting the water below. Where all of the pillars in the panel area can be recovered, the surface over the panel should subside uniformly. Manually, or mechanically operated props are used to support the roof adjacent to the pillars. Then as the pillars are recovered, the props are moved in the direction of retreat. Retreat mining allows for greater recovery of the resource, lessens the

potential of fire in the remaining coal, and generally provides a greater area of uniformity in the subsided surface.

(2) Longwall

Contemporary longwall mining, first introduced to the United States in the 1950's, has long been practiced extensively in European mines. To support the roof at the face, longwall mining originally used manually-operated props, then gradually evolved to the presently-used powered, self-advancing supports. Longwall mining is used most efficiently in uniform coal seams of medium height (42 to 60 inches). The lower limitation is attributable to the minimum height of currently available self-advancing roof supports. However, 30-inch seams are mined by the longwall method in Wales.

As in the room-and-pillar method, longwall mining starts with sets of entries cut into the panel areas. The difference in the technique lies in the seam (i.e., panel) length between these sets of entries and the method used to extract intervening coal. Longwall blocks range from 300 to 600 feet wide and are sometimes one and one-half miles long (Figure 12). The longwall machine, (Figure 13) laterally shears or plows coal from the entire face, transports the fallen coal by an advancing conveyor to a secondary haulage conveyor, reverses direction at the end of a cut, and supports the roof in the area of the face by a self-advancing system of hydraulic jacks. The roof is allowed to cave behind the advancing working area; the roof is occasionally blasted to insure a controlled cave-in rate and to reduce overburden

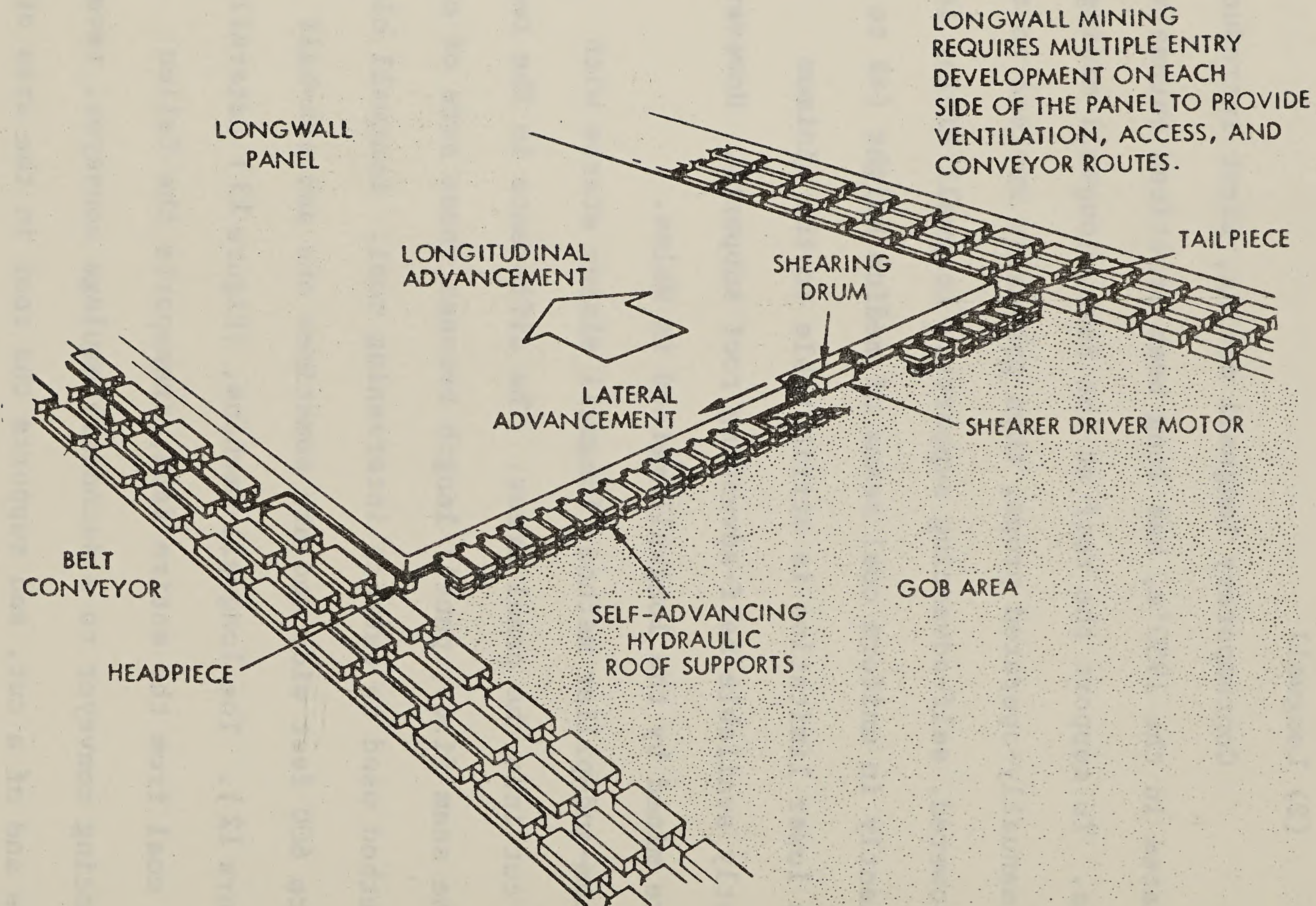

LONGWALL MINING
REQUIRES MULTIPLE ENTRY
DEVELOPMENT ON EACH
SIDE OF THE PANEL TO PROVIDE
VENTILATION, ACCESS, AND
CONVEYOR ROUTES.
LONGWALL
PANEL
LONGITUDINAL
ADVANCEMENT
SHEARING
DRUM
TAILPIECE
LATERAL
ADVANCEMENT
SHEARER DRIVER MOTOR
BELT
CONVEYOR
HEADPIECE
SELF-ADVANCING
HYDRAULIC
ROOF SUPPORTS
GOB AREA

Figure 12

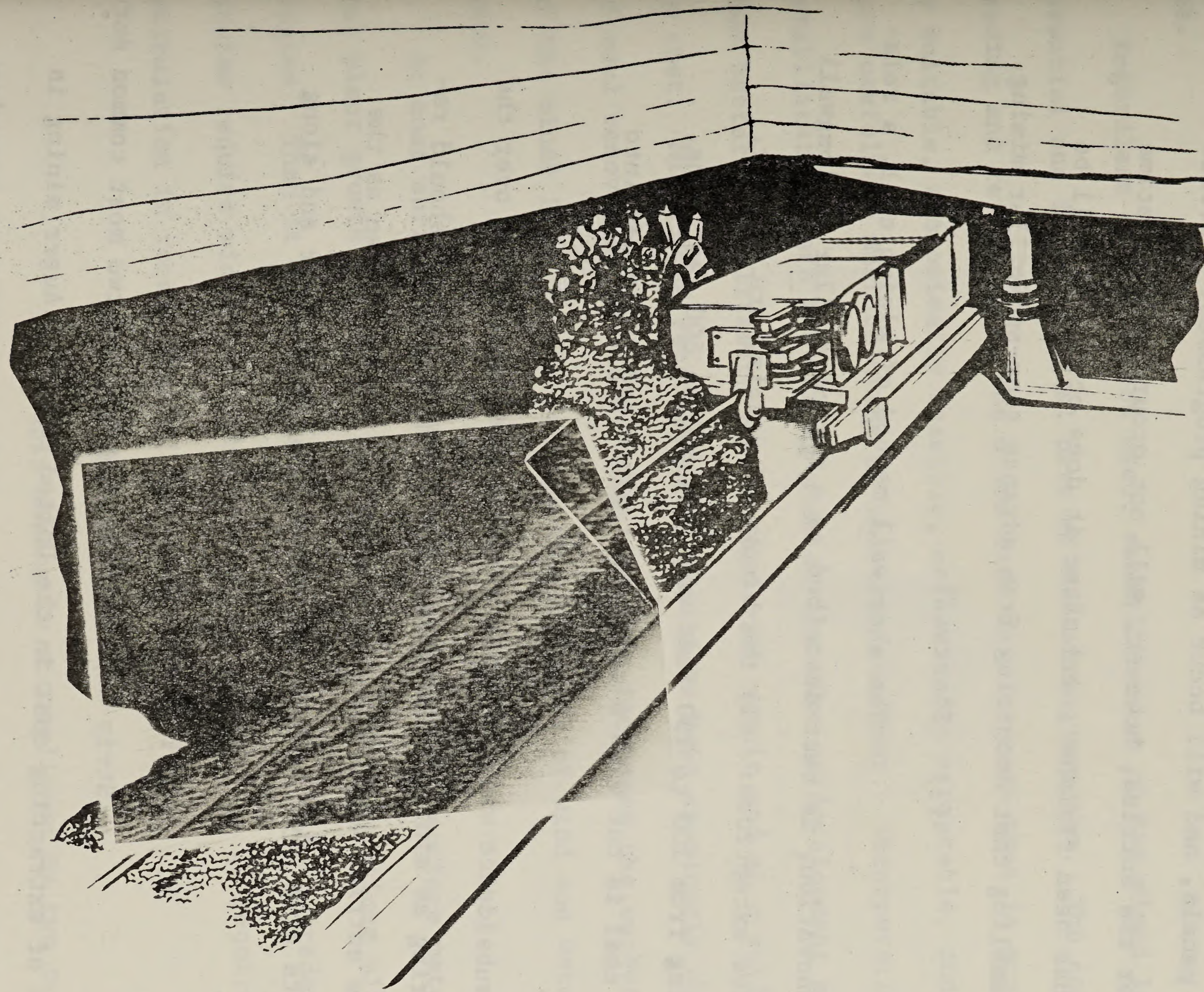


Figure 13

pressure on the coal seam being mined.

Surface subsidence from longwall mining should be generally uniform over the panels, and will occur as mining progresses. Surface subsidence over the entries, however, will not occur until sometime after mining has been finished, and after it does occur, it will be irregular resembling that occurring from advance room-and-pillar mining.

(3) Shortwall

The shortwall method of mining coal, a relatively new innovation, is best described as a method similar to longwall mining with two exceptions: (1) the blocks of panels, are smaller, usually ranging from 100 to 150 feet wide and 300 to 500 feet long, and (2) the coal is cut with a continuous miner and is loaded into shuttle cars.

Surface subsidence will be irregular with the depressions over the panels occurring as mining progresses. The natural surface should remain over the entries until after completion of mining. Then as the entry supports give way, surface subsidence will begin over and along the entries.

b. Surface Mining

Strip and auger mining are the two most common surface methods of extracting coal in the United States. Auger mining is placed in this category even though the coal is mined without removing overlying strata. It does, however, require a surface cut (removal of overburden and coal seam), to allow the auger access to the seam. Two other methods, open pit and quarry type mining, are being tried in Wyoming, and may become accepted methods where conditions warrant their use.

Regardless of the method used, rehabilitation of the mined land is essential and is an integral part of the mining process. The cost for grading and revegetating the mined land to a terrain that is ecologically suitable, economically feasible, esthetically acceptable, and has future usefulness must be borne by the coal consumer. Incorporating rehabilitation into the mining plan at the time of development means that better rehabilitation of the land will result and at a savings in cost. Mined-land rehabilitation should be kept as closely abreast of coal removal as possible. This not only increases the esthetic value of the mined land, but it reduces the potential of wind and water erosion.

At most surface mines, topsoil affords the best surface material for plant growth. It should be removed and stockpiled before mining begins. Then it can be replaced after the spoil has been graded. (Most States require mined-land rehabilitation, and it also is required by stipulation in recent Federal leases.)

(1) Strip-Mining

Strip-mining is accomplished by two techniques, area stripping and contour stripping. Stripping is done where coal seams are relatively flat and near the surface.

In area strip-mining, the most frequent technique, overlying

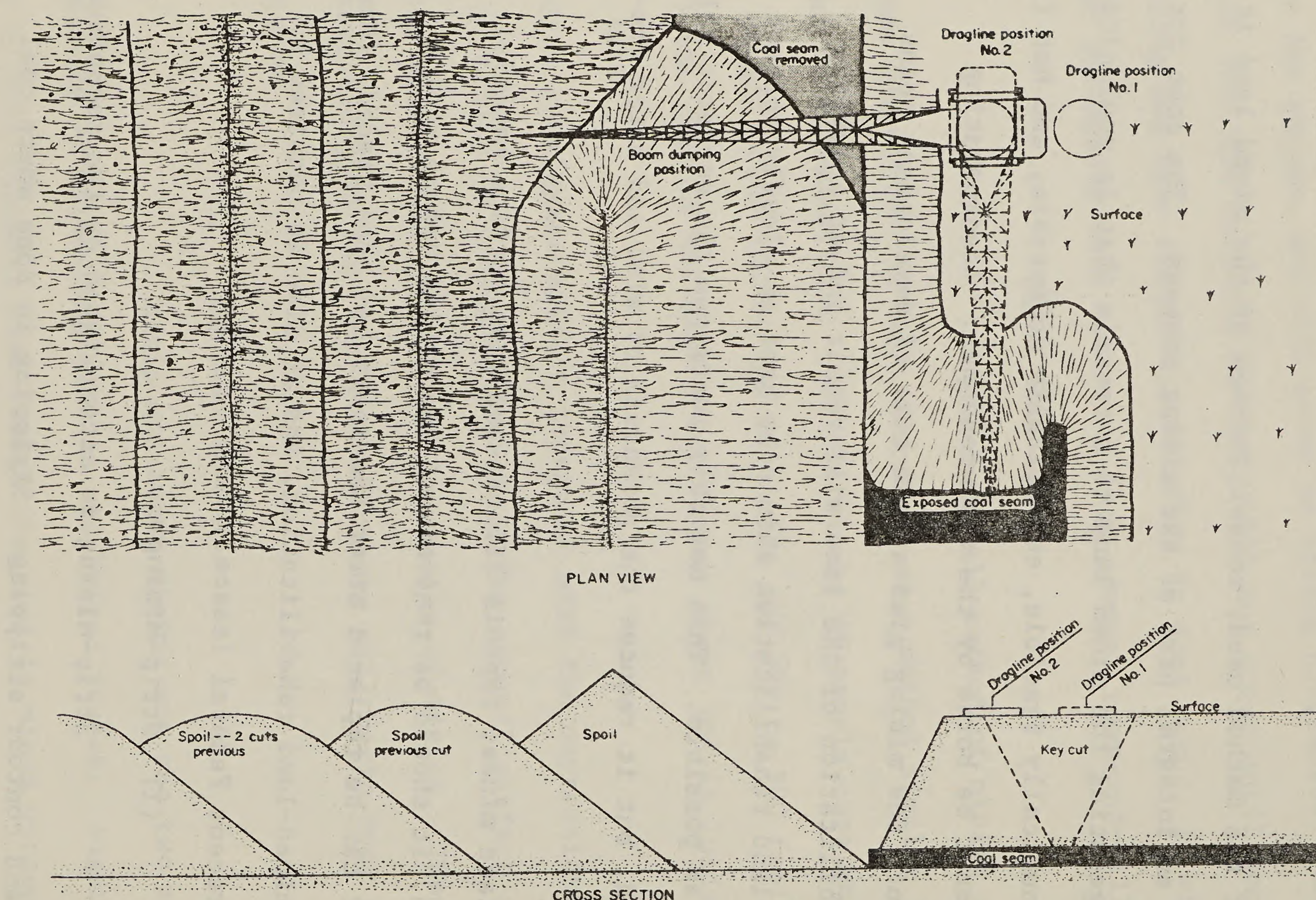

Coal seam removed
Dragline position No. 2
Dragline position No. 1
Boom dumping position
Surface
Exposed coal seam
PLAN VIEW
Dragline position No. 2
Dragline position No. 1
Surface
Spoil -- 2 cuts previous
Spoil previous cut
Spoil
Key cut
Coal seam
CROSS SECTION

Figure 14

material (overburden) is removed from a seam of coal in long narrow parallel bands, or strips, followed by removal of the exposed coal. With the exception of the first cut (box cut), overburden from each cut is discarded in the previous cut from which the coal has been removed. These parallel cuts continue across the coal seam until the thickness of the overburden becomes too great to be removed economically or until the end of the coal seam or property is reached. Figure 14 depicts a cross-section and plan view of a portion of a strip coal mine. Both single and multiple seams, near the surface, can be mined in this manner.

Overburden removal could be accomplished with almost any kind of earth-moving equipment, but bucket-wheel excavators, draglines, and shovels are the three kinds of equipment used at the large area-stripping operations. Bucket-wheel excavators are used extensively in Europe, but in the United States, the predominate machines for overburden removal are draglines and shovels. This is not strictly a matter of preference, but results from the nature of the overburden material. A bucket-wheel excavation will not work efficiently in rock even after it has been drilled and blasted. In the United States much of the overburden contains layers of shale, limestone, or sandstone that must be drilled and blasted before it can be removed. Draglines and shovels are more efficient in these materials than a bucket-wheel excavator.

One difference between removing overburden with a dragline or a shovel is the place from which it operates. A dragline operates from

atop the cut while a shovel removes the overburden with the crawlers resting atop the coal seam. In the large mines operating in the United States, bucket capacities of both draglines and shovels will average about 35 cubic yards, but the largest is a dragline with a bucket capacity of 220 cubic yards.

Coal is drilled and blasted after the overburden is removed. Then it is loaded into coal haulers with either a shovel or a front-end loader to be hauled to the tipple. Bucket capacities of coal loading shovels and front-end loaders commonly range from 10 to 20 tons, and coal haulers range in capacity from 40 to 200 tons.

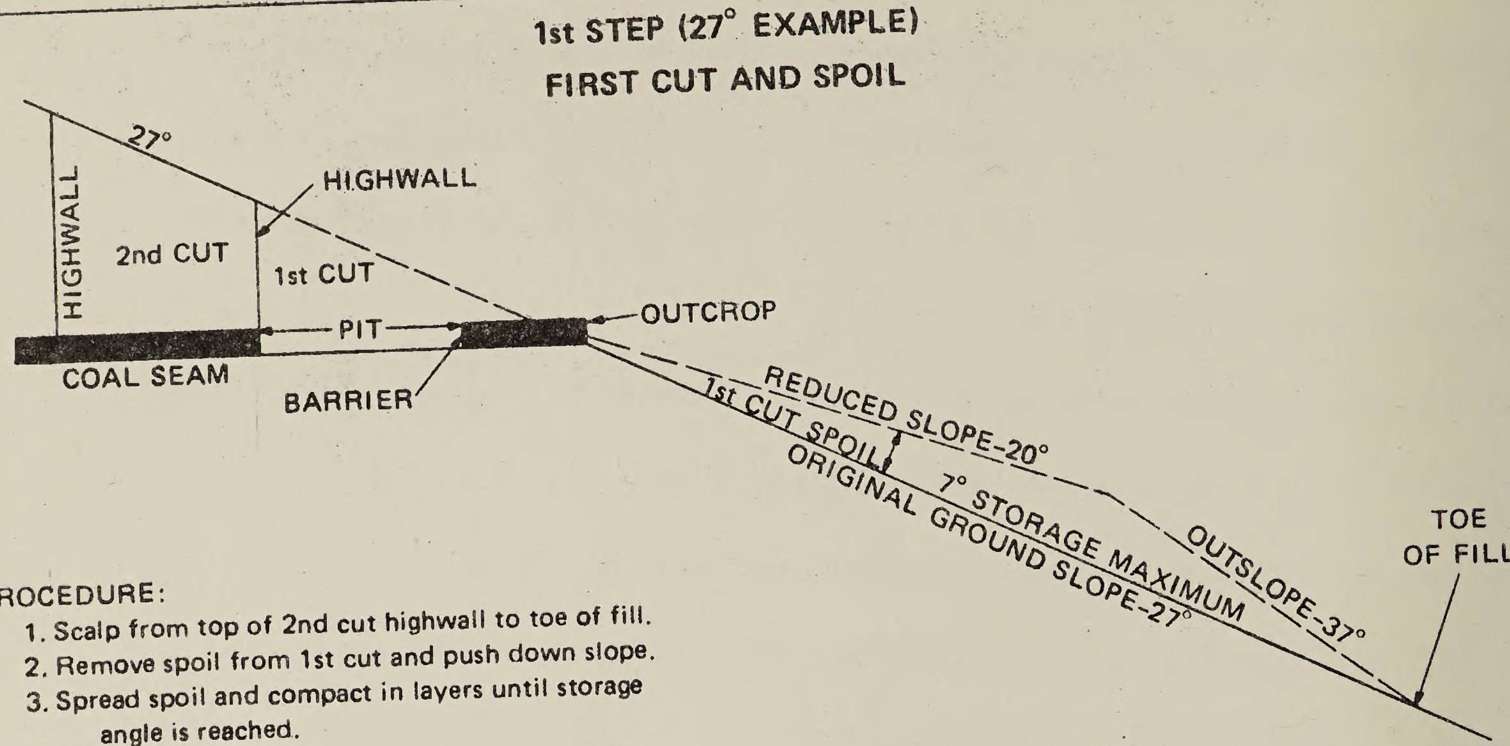
Contour stripping is practiced on steep terrains. The method consists of removing overburden from the coal seam with the first cut at or near the outcrop and proceeding around the hillside. The cut appears as a contour line, thus the name. Overburden is cast down the hillside and stacked along the outer edge of the bench. After the uncovered seam is removed, successive cuts, usually only two or three, are made until the depth of the overburden exceeds the economical recovery of the coal. Contour mining creates a shelf or bench on the side of the hill. On the inside it is bordered by the highwall ranging in height from a few feet to more than 100 feet and on the outer side by a high ridge of spoil with a precipitous downslope which is subject to erosion and landslides.

In the late 1960's, modifications to eliminate or reduce erosion and landslides began. Although refinements are still being made the

riparian woodlands primarily in the Green River and Ham's Fork Coal Regions. Canada lynx occur in forest areas of these same regions. Some species are considered characteristic of both the montane and boreal coniferous forests. These include the snowshoe rabbit, red squirrel, porcupine, deer, mouse, water shrew, black bear, ruffed grouse, goshawk, great horned owl, and others.

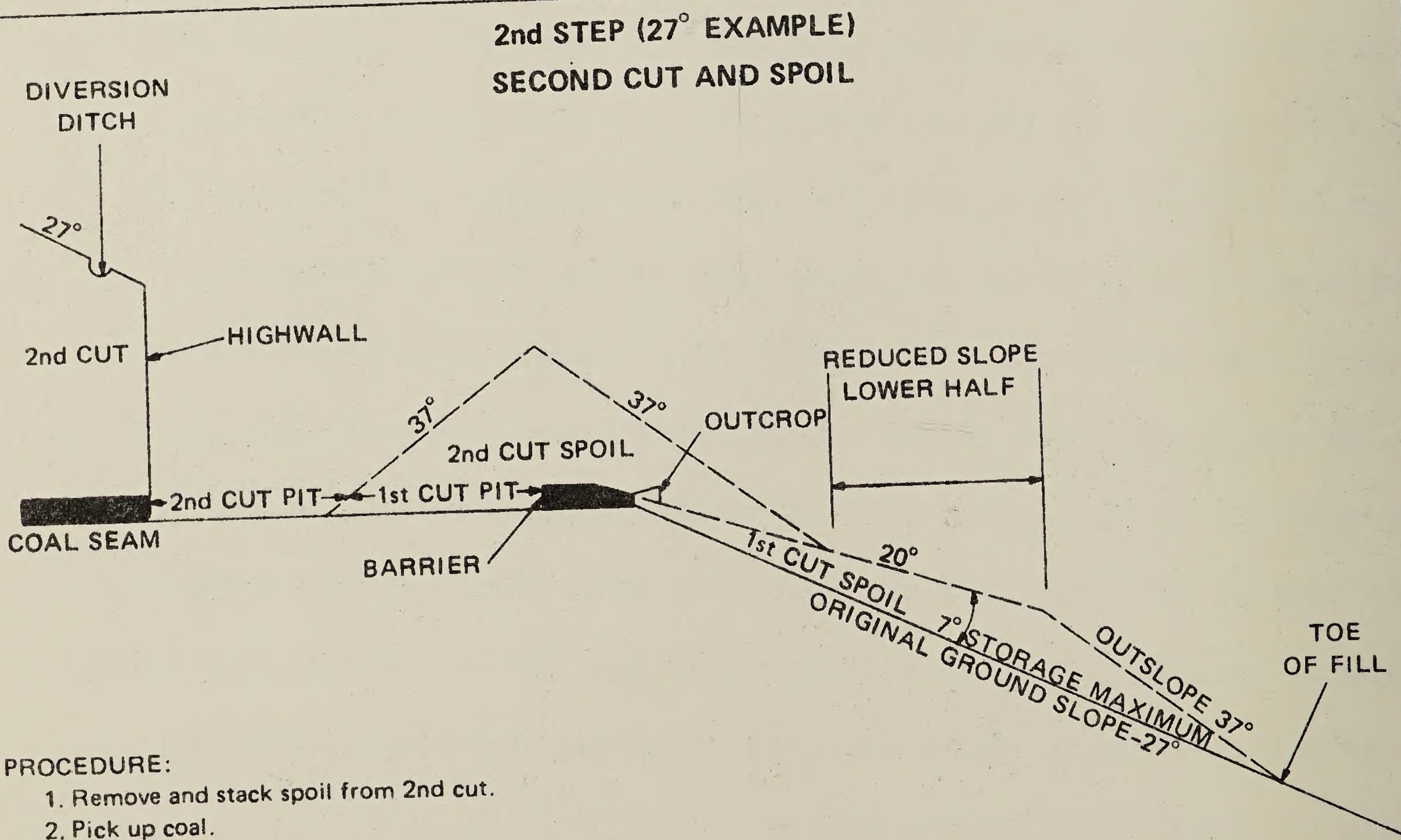
The woodland-bushland communities, i.e., juniper, pinon-juniper, mountain mahogany-oak, attract species from the adjacent montane coniferous forest. Since the trees are sometimes scattered and interspersed with grass or shrubs, grassland or desert species may penetrate into the community. The mule deer, mountain lion, and coyote commonly occur in the woodlands during the fall, winter, and spring, although most of these species spend summers in the higher mountains. The bobcat, rock squirrel, cliff chipmunks, desert and bushy-tailed woodrats, and pinon mouse show preference for rough country, rocky hillsides, and cliffs within the woodland-bushland communities. Birds such as the pinon jay, band-tailed pigeon, and scrub jay are characteristic. Invertebrate populations are low and consist largely of spiders, ants, termites, and jumping plant lice, (Kendeigh, 1961). Rattlesnakes, lizards, and horned toads invade from the desert, but are not particularly characteristic.

The cold desert communities of the Green River, Big Horn River and Wind River Coal Regions are largely sagebrush-grasslands. Saltbrush-greasewood associations are present in most regions, but become most prominent in the Uinta Coal Region. The pronghorn antelope and the sage grouse are abundant only in the sagebrush-grass ranges of the province, (Sundstrum, 1973, Scott et al, 1971). This is not surprising since both species are



PROCEDURE:

1. Scalp from top of 2nd cut highwall to toe of fill.
2. Remove spoil from 1st cut and push down slope.
3. Spread spoil and compact in layers until storage angle is reached.
4. Leave at least 15′ barrier.
5. Pick up coal.

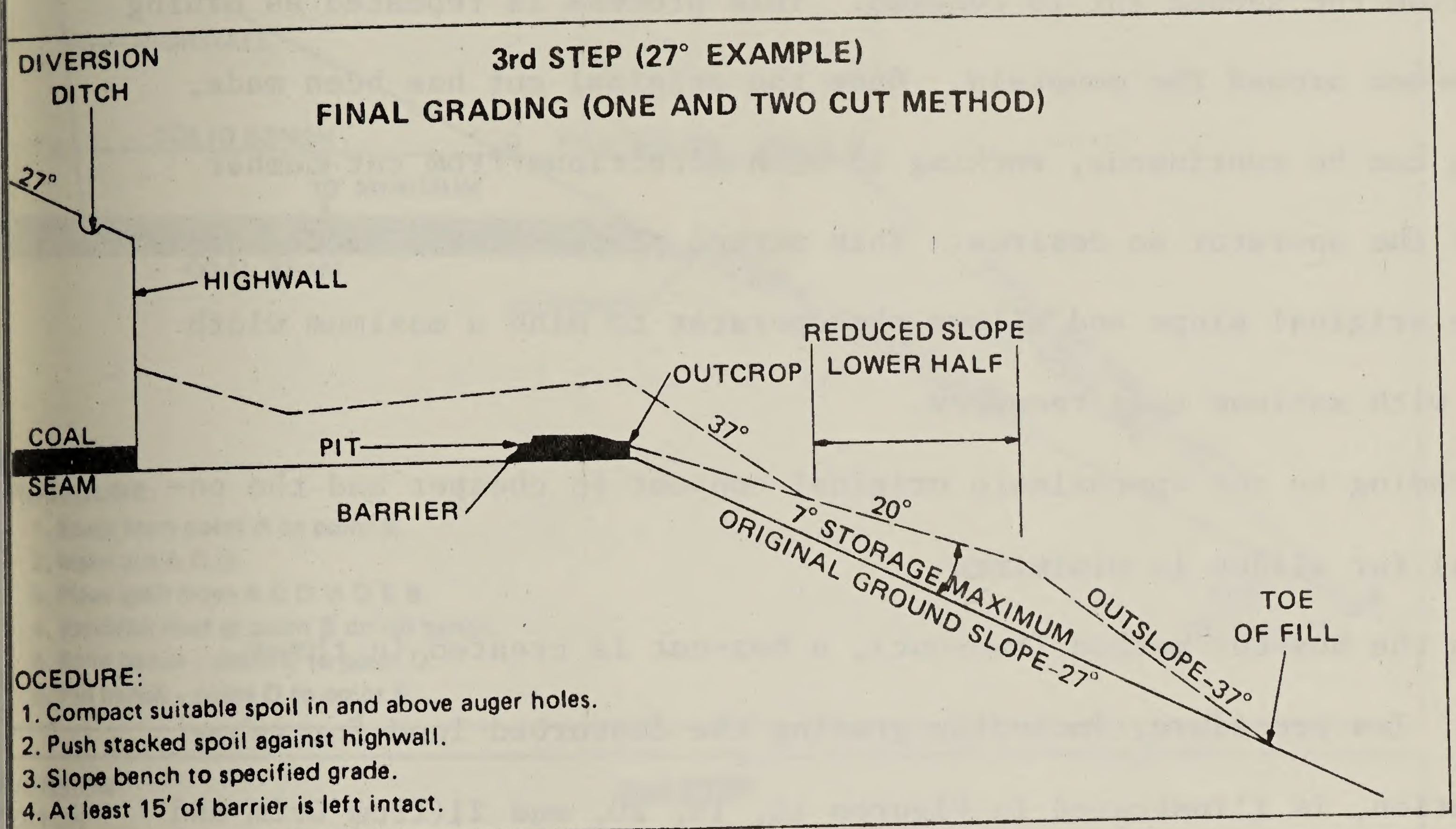


PROCEDURE:

1. Remove and stack spoil from 2nd cut.
2. Pick up coal.
3. Auger if permitted.

Figure 15

Figure 16



DIVERSION DITCH
3rd STEP (27° EXAMPLE)
FINAL GRADING (ONE AND TWO CUT METHOD)
27°
HIGHWALL
REDUCED SLOPE LOWER HALF
OUTCROP
37°
COAL SEAM
PIT
BARRIER
20°
7° STORAGE MAXIMUM
ORIGINAL GROUND SLOPE-27°
OUTSLOPE-37°
TOE OF FILL
OCEDURE:
1. Compact suitable spoil in and above auger holes.
2. Push stacked spoil against highwall.
3. Slope bench to specified grade.
4. At least 15' of barrier is left intact.

'igure 17

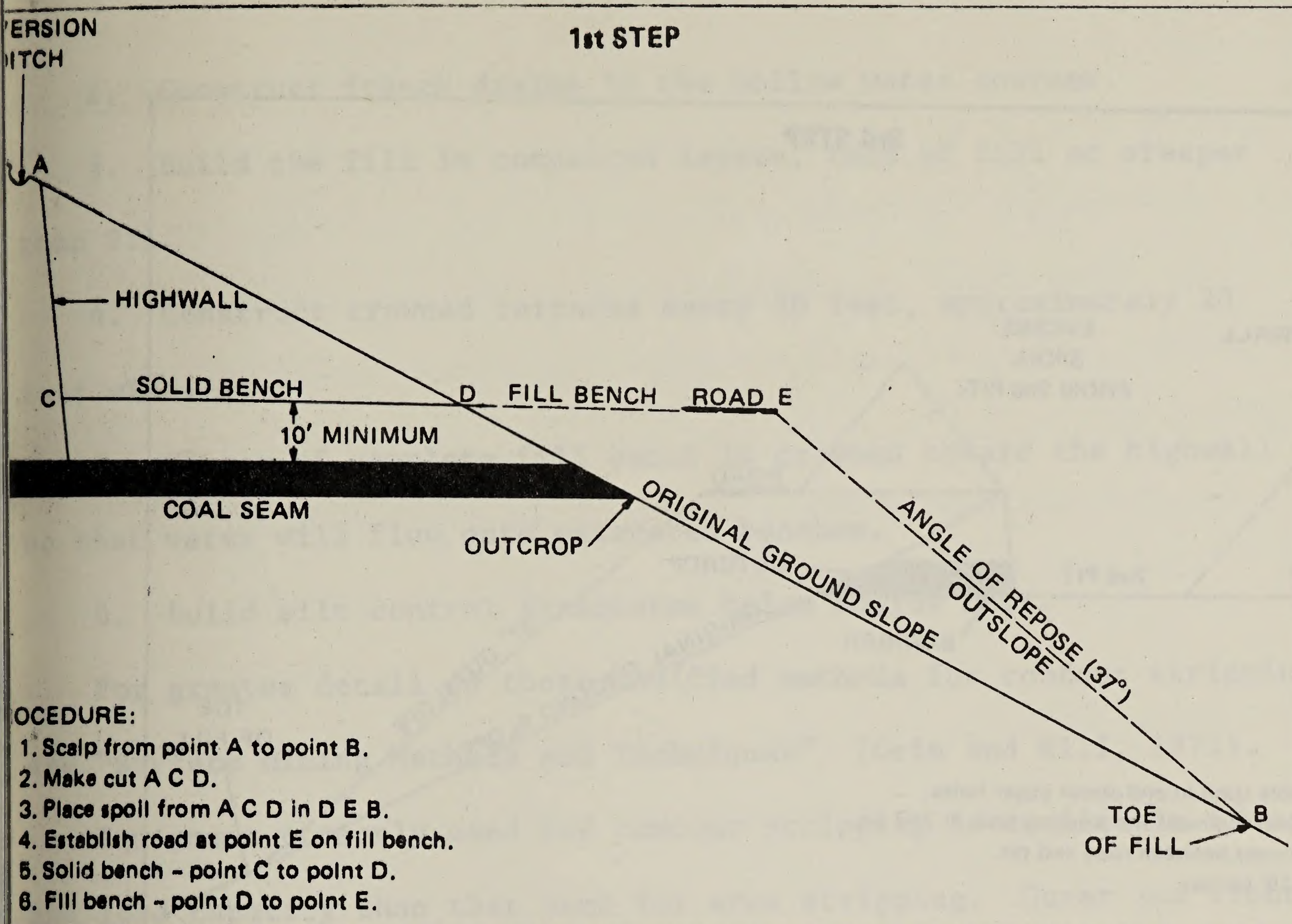
as long as that of the following cuts. After the coal is removed, the overburden from the second cut is placed in the first pit and the coal from the second cut is removed. This process is repeated as mining progresses around the mountain. Once the original cut has been made, mining can be continuous, working in both directions from cut number one if the operator so desires. This method places little overburden on the original slope and allows the operator to mine a maximum width bench with maximum coal recovery.

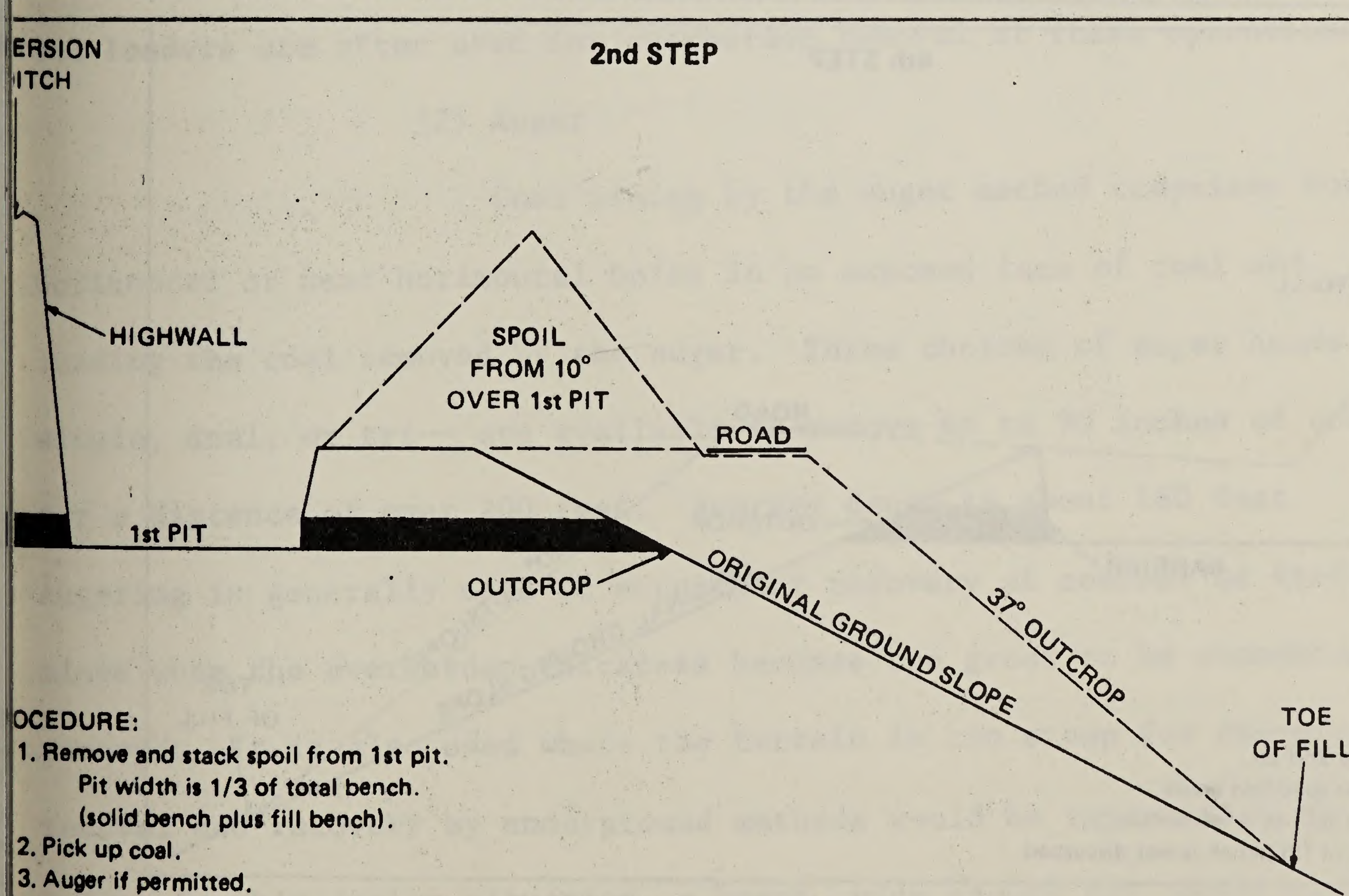
Grading to the approximate original contour is cheaper and the potential for slides is minimized.

In the box-cut method (two-cut), a box-cut is created in three steps. Its procedure, including grading the disturbed land for rehabilitation, is illustrated in Figures 18, 19, 20, and 21(from Grim and Hill, 1972).

The head-of-the-hollow fill method was developed to improve esthetics and reduce landslides. It can be used for full recovery of one or more coal seams, and to produce rolling mountain top land that is suitable for multiple use. Spoil storage space is provided for in narrow "V" shaped steep-sided hollows, near the ridge top, that are free of underground mine openings or wet weather springs. The size of the selected hollow must be such that the overburden generated by the mining operation will completely fill it. The procedure for placing the spoil in the hollow is:

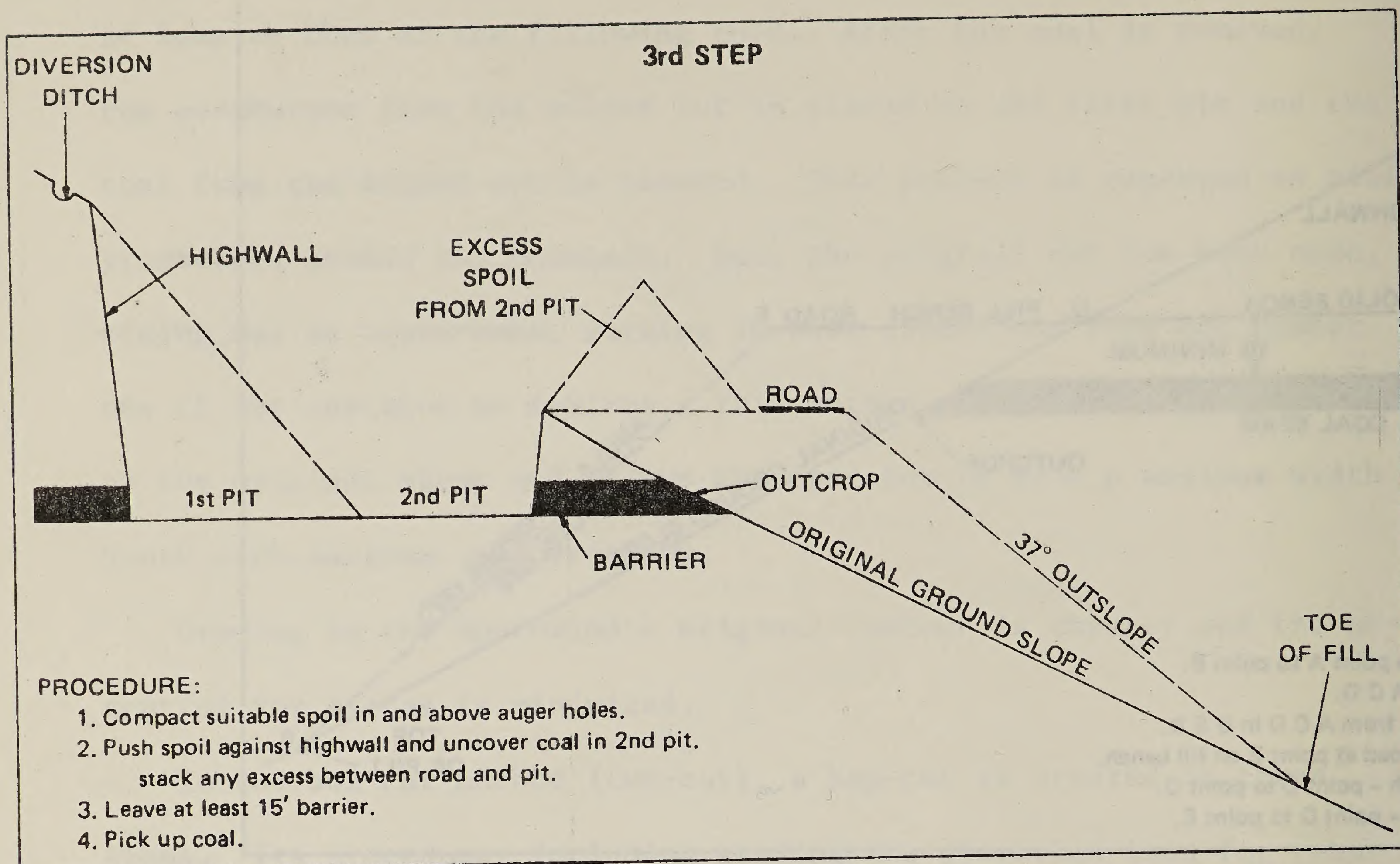
1. Scalp entire area that will be covered with fill.





'igure 18

'igure 19



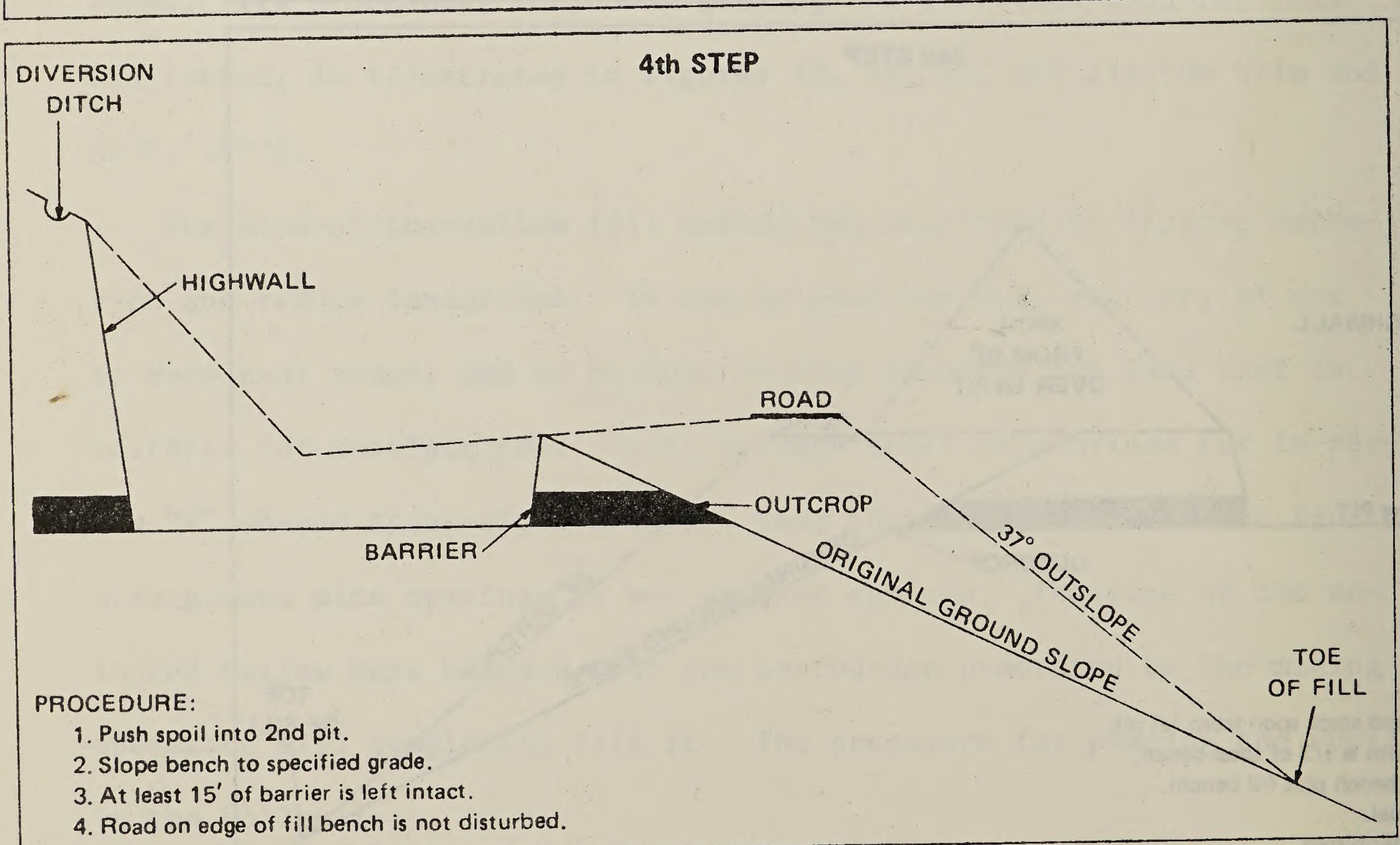


Figure 20
Figure 21

2. Construct french drains in the hollow water courses.

3. Build the fill in compacted layers; face of fill no steeper than 2:1.

4. Construct crowned terraces every 20 feet, approximately 20 feet wide.

5. Center of complete fill bench is crowned toward the highwall so that water will flow onto excavated benches.

6. Build silt control structures below hollow fill.

For greater detail on these modified methods for contour stripping, see "Surface Mining Methods and Techniques" (Grim and Hill, 1972).

Equipment commonly used for contour stripping is smaller in size and load capacity than that used for area stripping. Dozer and front-end loaders are often used for overburden removal at these operations.

(2) Auger

Coal mining by the auger method comprises boring horizontal or near horizontal holes in an exposed face of coal and loading the coal removed by the auger. Three choices of auger heads -- single, dual, or tri-- are available to remove up to 90 inches of coal for a distance of over 200 feet. Average depth is about 160 feet. Augering is generally used to supplement recovery at contour or strip mines when the overburden thickness becomes too great to be economically removed. It is also used where the terrain is too steep for overburden removal and recovery by underground methods would be impractical or unsafe. In this latter situation, a bench, wide enough for operating the

er and transporting mined coal, is cut around the hillside at the crop. Augering is considered by some to be a method of recovering t of a coal seam that, once left in place, otherwise may never be covered. From this standpoint, auger mining also can be used (1) recover coal between abandoned underground mines and adjacent strip nes, (2) in areas where a weak roof would prevent underground mining, d (3) where a thick overlying sandstone would necessitate difficult d expensive drilling and blasting if strip or contour mining were sed.

Rehabilitation of auger-mined land should be accomplished be sealing he auger holes with an impervious material; then covering the coal seam nd any toxic material in the highway with the spoil generated in gain-ng access to the coal seam. Grading the spoil for drainage and re-vegetation should be done in the same manner as it is for contour stripping, or if the augering was into a highwall at an area stripping operation, grading should follow that plan.

In open pit mining, overburden is removed and placed outside the mining area. The pit increases in size and depth as mining progresses, and it is unusual that the overburden, once removed, is ever returned to the pit. It is used extensively for mining ores of copper and iron, and sand and gravel. It is used also, but not as extensively, to re-cover other metallic ores and nonmetals. Its use in coal mining has just begun, and it is being tried where numerous pitching seams lie parallel to each other and outcrop on a relatively flat terrain. The

overburden -- the non-combustible material over and between the coal seams -- can be removed with either scrapers or shovels loading into trucks. Coal is loaded into coal haulers and taken to the tipple.

Spoil from open pit mining can be rehabilitated the same as that from strip-mining. Within the pit however, land rehabilitation cannot begin until mining has been completed. Then, methods similar to those used for quarry rehabilitation will be required. Although most soil organisms are destroyed when topsoil is stockpiled over a long period of time, it should be removed from the proposed pit area and that area where spoil will be deposited. It can then be spread upon the graded spoil, and the remainder can be used to assist revegetation of the pit after mining has been completed.

(3) Quarry Type Mining

Quarry type mining -- so named by Amax Coal Company because the coal is benched to facilitate its removal -- is being used to recover coal that averages over 60 feet in thickness. It first requires dividing the mine area into tracts (for example, 40-acre tracts). In preparation for the initial or box-cut, overburden is removed from two tracts, away from the outcrop, with shovel and trucks and spoiled on land toward the outcrop that will be mined later. Eighty acres of spoil will have to be handled twice, but when mining is completed, land that did not produce coal will not have been disturbed. When overburden is removed from a third tract, enough of the thick coal seams will have been mined from the first tract to allow spoiling in the first tract. Overburden spoiled in the mined-out pit is graded to the approximate relief of the land before it was mined so when mining terminates, the mined area will have an appearance similar to that before mining started, but lower in elevation.

Where this quarry type mining is being done, plans call for spoil to be graded so a lake will form in the lower part of the mined area. However, should the formation of a lake be undesirable, grading can be planned so the entire mined area will drain. Revegetation of the graded plots would be the same as revegetating graded spoil at a stripping operation.

Typical equipment used for both overburden and coal removal is a shovel with an 18 cubic yard bucket loading into 65-ton end-dump trucks.

c. Potential Extractive Techniques

Experimentation is proceeding on several new techniques for coal removal or deriving energy from coal. Although none of the techniques has advanced sufficiently to be used for producing coal or its energy, they should be considered as potential means for future production.

These techniques may be categorized according to the form in which the energy in the coal is brought to the surface: i.e., solid, liquid, gas, or other.

Potential techniques for coal or energy extractions

Solid	Liquid	Gas	Other Energy Form
Completely automated underground	Distillation of coal underground	Hydrogenate carbon to methane	Complete Gasification to produce high-pressure steam
Thorough fracture of coal seam and flushing broken coal to surface	Dissolution of coal in solvent and bringing solution to surface	Partial oxidation of coal to combustible gases (CO + H)	
Production of fine ashless carbon			

Should any of these techniques become commercial, a plant site would be required that would necessitate site rehabilitation after the coal deposit had been exhausted. The surface above the coal deposit would subside over a wide area. Because of the many factors involved -- such as the thickness of coal seam(s), depth of coal seam(s), nature and condition of overlying strata, etc., it is difficult to predict what land rehabilitation methods will be used. Also, how aquifers, if any, overlying the coal seams would be affected by subsidence is uncertain.

(1) Solid

One way to bring coal energy to the surface in the form of a solid would be to automate conventional underground coal mining practices so that the coal could be mined by remotely controlled mining equipment. Industry and government have developed technologies for coal mining and for other industries that would seem to be adaptable to a completely automated underground mining system. Another way would be to hydraulically fracture the coal seams very thoroughly and flush the solid coal to the surface. With both of these techniques, the coal would be brought to the surface in its natural form, that is, with its ash and sulfur content intact.

A theoretically possible alternative is the production of a fine ash-free and sulfur-free carbon powder that could easily be transported to markets and would burn without emitting any pollutants. This technique involves underground gasification, using a mixture of oxygen and carbon dioxide as the gasifying agent. At the surface, after particulate and sulfur removal, the high carbon monoxide content of the product gases would be reverted to carbon dioxide and carbon. Part of the carbon dioxide would be recycled to the gasifying agent, and the remainder vented to compensate for the oxygen input to the system.

(2) Liquid

One possible technique of recovering coal in liquid form would be to heat it underground in the absence of air to liberate its volatile combustible liquids and gases. Then pyrolysis could be achieved by driving boreholes into the coal seam, linking them electrically, and passing an electric current through the seam. The passage of the current causes heat, which in turn causes distillation. Although patents have been issued (and operations proposed) for the in situ distillation of carbonaceous materials in general, he methods involve the construction below ground of processing acilities adjacent to the coal seam. The distillation equipment can nvolve personnel working below ground.

Another technique would be to dissolve the coal in certain organic olvents, a technique that is well-known and has been widely invesigated. Using organic solvents, essentially anthracene-rich coalar fractions, one could recover the coal in a liquid form by using a rocess analogous to the Frasch process for the recovery of sulfur. The solvents could be injected into the coal seam through boreholes, which then could be used as passages through which the liquified coal could be brought to the surface. The temperatures of operation would be high. In the order of 800° F., a hydrogen atmosphere would be required. Some means would therefore have to be provided to maintain the high temperatures without degrading the reducing atmosphere required for the solution process.

(3) Gasification

One technique for in-situ extraction of the coal's energy in the form of a gas would be to force hydrogen into the coal seam under conditions suitable for transforming the carbon content of the coal directly (by hydrogenation), into methane, the basic component of pipeline gas. The reaction is highly exothermic. To achieve reasonable yields it must be carried out at high pressure, while to achieve reasonable reaction rates it must be carried out at temperature levels above 1700° F.

The alternative route to the production of a gaseous fuel from coal is through oxidation of the carbon content to carbon monoxide associated with elemental hydrogen. This partial oxidation approach, being perhaps the simplest way to achieve gasification, has been the basis of essentially the entire world experience in the technology. It is commonly referred to as in-situ combustion or underground gasification of coal. Experimental work on this alternative was done in Belgium, England, France, Italy, and the United States during a period from about 1945 to about 1960. In the USSR, experimentation started about 1933 and the work reached the stage where the extracted gas was used for generation of electricity, but in the late 1960's, it was apparently stopped, because since then nothing has been published, and requests for information have been ignored.

In late 1972, the Bureau of Mines, again began experimenting with underground gasification in Carbon County, Wyoming. Insufficient time has elapsed to determine its success, but the following brief description of the experiment shows the principle involved in underground gasification of coal.

To start the experiment, a circle 400 feet in diameter was laid out on the surface. Initially four vertical holes were drilled; one in the center of the circle, and three on the perimeter of the northeast quadrant. The holes penetrated 400 feet of overburden and a 30-foot coal seam. Two of the holes were fitted with deep water pumps to dewater the area. Then air was injected into the center hole to determine if there was a flow path to the other holes. A slight flow path was detected toward two of the holes. Hydrofracing followed with no breakdown of the formation, but four fractures were determined; one on the southwest quadrant -- the major fracture, two in the northwest quadrant, and one on the southeast quadrant. After hydrofracing, three additional holes were drilled in the southwest quadrant; one 75 feet from the center hole and the other two 25 feet to its right and left. The center hole was then fired and air was injected. This is called forward firing. If air were injected into the perimeter holes it would be reverse firing. In earlier experiments oxygen was injected and will probably be tried here. Some gas has been recovered from the perimeter holes, but the results are inconclusive.

(4) Other Energy Forms

The coal could be completely oxidized by a synthetic geothermal steam approach to produce combustion gases and steam at high pressures. These high pressure gases, could be utilized at the surface to run the turbines of electric powerplants.

4. Beneficiation

Crushing and cleaning of mine-run coal is commonly referred to as beneficiation or preparation. Often crushing and sizing is all that is required, but many coal seams, especially those in eastern and midwestern States, contain enough impurities to necessitate further cleaning. Impurities in coal are innumerable, but those occurring in quantity, such as clay, rock, shale, and pyrite, require removal. Processes vary from simple to complex. The simplest are crushing and screening, which remove large pieces of foreign material, and usually are done with a breaker. Beyond this, whether the process is wet or dry, it is commonly referred to as washing.

a. Air Washing

Air as a separating medium dates back to the winnowing of chaff from grain in Biblical times. Modern coal washing with air has advanced from merely blowing the dust from coal to using pulsating air to separate the coal and largely eliminating the need for close screen sizing. A survey revealed that all air cleaning machines used in 1966 depended on pulsating air as a medium of concentration, and pneumatic jigs using such a pulsating air current have proven the most effective. Such machines have an inherent advantage in that they do not contribute to stream pollution and to thermal or chemical pollution of the air. Air pollution is virtually nil because the modern plants are completely enclosed, confining all dust to the plant. In addition, coal washing plants must comply with PL 91-173, which requires suppression of dust within the plant.

Although not all coals can be beneficiated by air washing, it can be advantageous for those coals that are easy to clean. Of all the preparation methods, pneumatic cleaning is the most acceptable from the standpoint of delivered BTU cost. This conclusion is based on the premise that a percent of moisture as detrimental as a percent of ash.

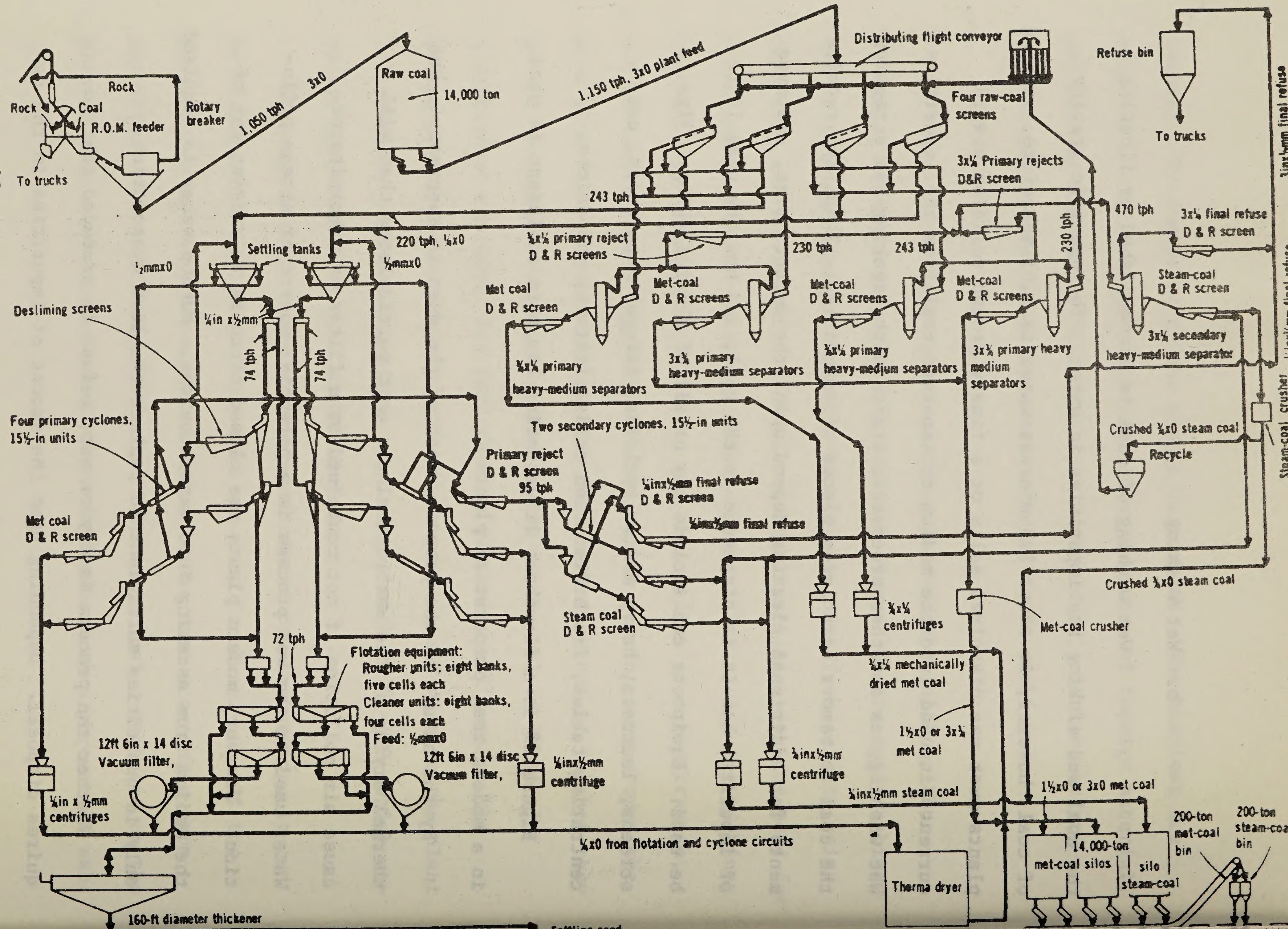
b. Wet Washing

Wet washing of coal is accomplished by floating the coal and sinking the impurities in water. The specific gravity of coal, however, is about 1.3 whereas water is 1.0; therefore, washing plants must use dissolved salts or a finely ground solid/or upward currents induced into the medium to separate coal from the impurities. Wet washing, as do other processes, starts with breaking and screening the coal to remove hard large pieces of impurities. Then, the requirements for additional cleaning depend upon the amount, size, and type of impurity, how it is dispersed in the coal, and how the coal is to be used. Equipment can include any or all of the following: jigs, screens, launders, heavy medium cycloids, tricone separators, concentrating tables, froth flotation cells, filters, and driers.

Figure 22 is a flowsheet illustrating how this equipment is used in a modern coal preparation plant.

By the nature of the process, most of the dust is suppressed, but thermal drying of the washed coal can emit particulates that will cause air pollution if not contained by a filter or precipitator. Water used in the wet process is a potential source of stream pollution. However, modern plants use closed circuits to prevent any of the medium from escaping into water courses. Makeup water is required only in quantities sufficient to replace the lost evaporation.

Whether the process is dry or wet, refuse is produced that requires disposal. Depending upon the amount of impurities in the raw



Rock
Rock
Coal
R.O.M. feeder
Rotary breaker
To trucks
1,050 tph
3x0
Raw coal
14,000 ton
1,150 tph, 3x0 plant feed
Distributing flight conveyor
Four raw-coal screens
Refuse bin
To trucks
3inx½mm final refuse
3x¼ Primary rejects D&R screen
243 tph
470 tph
3x¼ final refuse D & R screen
220 tph, ¼x0
¾x¼ primary reject D & R screens
230 tph
243 tph
230 tph
Settling tanks
½mmx0
½mmx0
Met coal D & R screen
Met-coal D & R screens
Met-coal D & R screens
Met-coal D & R screens
Steam-coal D & R screen
Desliming screens
¼in x½mm
74 tph
74 tph
¾x¼ primary heavy-medium separators
3x¾ primary heavy-medium separators
¾x¼ primary heavy-medium separators
3x¾ primary heavy medium separators
3x¾ secondary heavy-medium separator
¼inx½mm final refuse
Steam-coal crusher
Four primary cyclones, 15½-in units
Two secondary cyclones, 15½-in units
Crushed ¾x0 steam coal
Recycle
Primary reject D & R screen
95 tph
¼inx½mm final refuse D & R screen
¼inx½mm final refuse
Met coal D & R screen
Crushed ¾x0 steam coal
Steam coal D & R screen
¾x¼ centrifuges
Met-coal crusher
72 tph
Flotation equipment:
Rougher units; eight banks, five cells each
Cleaner units: eight banks, four cells each
Feed: ½mmx0
¾x¼ mechanically dried met coal
12ft 6in x 14 disc Vacuum filter,
12ft 6in x 14 disc Vacuum filter,
¼inx½mm centrifuge
¼inx½mm centrifuge
1½x0 or 3x¾ met coal
¼in x ½mm centrituges
¼inx½mm steam coal
1½x0 or 3x0 met coal
200-ton met-coal bin
200-ton steam-coal bin
14,000-ton met-coal silos
silo steam-coal
¼x0 from flotation and cyclone circuits
Therma dryer
160-ft diameter thickener
Settling pond

Figure 22

coal, refuse quantities will range from almost zero to 25 percent of the total raw coal processed. Coarse waste commonly is hauled to a disposal area by truck, and fine waste is slurried to a settling pond. Several methods of refuse disposal are acceptable, but waste containing toxic material must be disposed of in a manner to prevent contamination of surface and ground water.

One acceptable method of preventing toxic refuse from contaminating water is to return the coarse-dry waste to the mine. (However, for coal produced by underground methods returning refuse to old workings can be costly, and sometimes impossible.) If the coarse refuse cannot be returned to the mine, it should be buried to prevent its oxidation, hence prevent it from polluting any water, or catching on fire. Settling ponds for fine-wet refuse that contains toxic material should be lined with an impervious material, such as an impervious clay. Settling pond sites sometimes may be found that are naturally impervious, but no site for a settling pond should be selected where it would be subject to flooding. When a settling pond becomes filled, surface water should be removed, and the surface of the waste covered with non-toxic material. Topsoil, when available, should be used for the top layer of cover if its future use requires revegetation.

5. Site Rehabilitation

Three types of sites -- underground, surface, and preparation plants -- must be considered when describing site restora-

tion. No industrial operation can restore a site to exactly the condition that existed before the operation began. Therefore, rehabilitation of the site consists of making it safe, acceptable in appearance, and available for other uses.

In the past, when a coal operation ceased, equipment of value was removed and the site was virtually abandoned. That practice is no longer acceptable. Federal coal leases require rehabilitation of mines and plant sites. Several states have mined-land reclamation laws which require rehabilitation of private lands where coal has been mined.

Section 5 of the Federal coal lease and 43 CFR 23 gives the mining supervisor or his agent the authority to approve or disapprove a lessee's surface protection plans, and the mining supervisor is responsible to see that the plans are carried out. This, in effect, gives the mining supervisor the authority to see that air and water pollution and land erosion are prevented; other natural resources are protected; surface mined land rehabilitated according to the plan and maintained and protected until rehabilitation is complete; all surface openings and subsidence holes are filled in, closed, or barriers installed; all underground openings are permanently sealed; all surface structures are removed; and the plant site cleaned up, including rehabilitation of refuse piles, prior to termination of the lease.

Coal preparation plants, if covered by Federal coal leases, would be subject to the same regulations as mine plants covered by Federal leases.

With the exception of Alaska and Utah, all states that have appreciable amounts of strippable Federal-owned coal have strip-mined land reclamation laws which require rehabilitation of areas mined.

Plugging surface openings that result from subsidence caused by underground coal mining does not assure that the site will remain safe, or suitable for other uses. Subsidence can continue over a period of many years. Unless the entire area is caved at the time of mining it is difficult to ascertain when the land will become stable.

K. Federal Coal Leasing

1. Authorities

a. Laws

The statutory authority for leasing all Federal coal deposits and Federal coal lands (other than acquired lands, including national resource lands and national forest lands), is contained in the Act of February 25, 1920, referred to as the "Mineral Leasing Act" (41 Stat. 437, as amended; 30 U.S.C. 181 *et seq.*). General mineral leasing provisions are found in Sections 181-194 of 30 U.S.C. Provisions dealing specifically with coal are coded under Sections 201-209 of 30 U.S.C.

Lands exluded from operation of the Mineral Lands Leasing Act include those acquired under the Appalachian Forest Act, and those in incorporated cities, towns and villages and in national parks and monuments, those acquired under other Acts subsequent to February 25, 1920, and lands within the naval petroleum and oil shale reserves, (30 U.S.C. 181).

Lands disposed of with reservations of the coal deposits to the United States are subject to the provisions of the Mineral Leasing Act (30 U.S.C. 182).

Coal is subject to disposition by leasing only, (30 U.S.C. 181, 193), with the exception of permits to take coal for local domestic needs, (30 U.S.C. 208).

The Secretary of the Interior is directed to reserve authority to cancel any prospecting permit upon failure of the permittee to exercise due diligence in the prosecution of the prospecting work in accordance with the terms and conditions of the permit, (30 U.S.C. 183).

Total acreage in leases held by persons, associations, or corporations may not exceed 46,080 acres, (30 U.S.C. 184 (a) (1)), except that an application for forty acres or multiples thereof, up to 5,120 additional acres in any one State, may be approved by the Secretary, if determined to be necessary to enable an applicant to carry on business economically and approval of the increased acreage is believed in the public interest, (30 U.S.C. 184 (a) (2)). The Secretary may reserve to the United States, the right to dispose of the surface not necessary to lessee's operations, (30 U.S.C. 186). Lands or deposits may not be subleased without the permission of the Secretary. Each lease shall contain provisions for the purpose of insuring the exercise of reasonable diligence, skill, and care in the operation of said property, (30 U.S.C. 187).

A lease may be cancelled in a proceeding in the United States District Court for noncompliance with the Act, the lease or the regulations, (30 U.S.C. 188).

The law gives the Secretary broad authority to make rules and regulations necessary to carry out the mineral leasing program under the Mineral Leasing Act of 1920, (30 U.S.C. 189). The Secretary is authorized to divide any of the coal lands or the deposits of coal owned by the United States, into leasing tracts of forty acres each, or multiples thereof, in a form which in his opinion will permit the most economical mining of coal.

The coal lands or deposits may be offered for leasing upon application or Secretarial motion by competitive or other procedures as the Secretary may set forth in regulations, (30 U.S.C. 201). When prospecting is necessary to determine existence or workability of coal deposits in unclaimed or undeveloped areas, applicants may be issued prospecting permits for two year terms, for not to exceed 5,120 acres. If the prospector discovers commercial quantities of coal, he is entitled to a lease under the Act. Prospecting permits may be extended for 2 years for good reason, (30 U.S.C. 201). To more properly conserve resources of a coalfield or prospective coal area, lessees and permittees may enter into agreements for prospecting, development or operation of such areas if it is determined by the Secretary to be in the public interest. Contracts operating under such agreements may be exempted from the maximum lease acreage limitations, (30 U.S.C. 201-1).

Coal leases may be modified by including additional coal lands or deposits contiguous to the existing lease, to the extent that the total lease does not exceed 2,560 acres, (30 U.S.C. 203). Upon showing that all workable coal deposits within a lease area will be exhausted within 3 years, the Secretary may, within his discretion, lease to such lessee additional tracts which, including the remaining deposit acreage, do not exceed 2,560 acres. The new lease would be issued under the same conditions as in the case of an original lease, (30 U.S.C. 204).

Coal leases or deposits may be consolidated, (30 U.S.C. 205). Noncontiguous coal lands may be leased, (30 U.S.C. 206).

Lessees will pay the United States royalties, fixed in advance of issuance of the lease, and in the amount of at least 5 cents per ton. Rental of the lands or deposits will be at least 25 cents per acre for the first year, 50 cents for the ensuing four years and $1 per acre thereafter. Leases are for indeterminate periods contingent upon diligent development. At the end of each twenty-year period of the lease, the terms and conditions of the lease may be adjusted (30 U.S.C. 207).

In order to provide for the supply of strictly local domestic needs, the Secretary may issue limited licenses or permits to individual or municipalities free of charge, (30 U.S.C. 208). The Secretary is authorized to waive or reduce rents or royalties to encourage the greatest ultimate recovery of coal, (30 U.S.C. 209).

The statutory authority for leasing coal on Federally acquired lands is contained in the Act of August 7, 1947, referred to as the "Mineral Leasing Act for Acquired Lands", (61 Stat. 913; 30 U.S.C. 351-359). Lands excepted from the Act include those acquired specifically for development of mineral deposits or within incorporated cities, towns, villages, or national parks or monuments. For the most part, the basic leasing provisions and conditions under the Mineral Leasing Act for

Acquired Lands are the same as the provisions and conditions contained in the leasing program pursuant to the Mineral Leasing Act of 1920. There are, however, several exceptions. Unlike the 1920 law, the Mineral Leasing Act for Acquired Lands require the consent of the head of the Federal agency, department, etc., having administrative jurisdiction over the lands, before a deposit is leased. In addition, the agency head may subject the lessee to certain conditions to insure use of the land for the purposes for which it was acquired, (30 U.S.C. 352). The agency which has such administrative jurisdiction may sell or convey the land, subject to existing mineral leases, (30 U.S.C. 353).

The Secretary is also authorized to lease partial or future interests of the United States in acquired lands, (30 U.S.C. 354). The Secretary may make rules and regulations necessary to carry out the provisions of the Mineral Leasing Act for Acquired Land, (30 U.S.C. 359). However, the rules must be the same as those prescribed under the general Mineral Leasing Act of 1920 insofar as they are applicable.

The Secretary has delegated his authority to issue leases to the Director, Bureau of Land Management. The Director has redelegated his authority to the State Directors. Officials in BLM State Offices are authorized to issue coal leases.

The Secretary has delegated his authority to administer operations conducted under leases to the Director, Geological Survey.

Following is a list of statutes directly or indirectly affecting the issuance of Federal coal prospecting permits and coal leases and operations thereunder, including environmental statutes, as of June, 1973:

30 U.S.C. S71-77	Coal Land Entries in General
30 U.S.C. S81-90	Coal Land Entries Under Non-Mineral Land Laws with Reservation of Coal to United States

Mineral Leasing Act of February 25, 1920, 41 Stat. 437, 30 U.S.C.

S181-184	Leasing and prospecting permits
S186	Reservation of easements or rights-of-way for working purposes; reservation of right to dispose of surface of lands; determination before offering of lease; easement periods
S187	Assignment or subletting of leases; relinquishment of rights under leases; conditions in leases for protection of diverse interests in operation of mines, wells, and so forth; State laws not impaired
S188	Forfeiture, cancellation or reinstatement of leases
S188a	Surrender of leases
S193	Disposition of deposits of coal, and so forth
S193a	Preference-right of United States to purchase coal for Army and Navy; price for coal; civil actions; jurisdictions
S201-209	Coal

Mineral Leasing Act for Acquired Lands, 61 Stat. 913, 30 U.S.C.

S351-359 (1947) (S358 not applicable to coal)

Chapter 12A. Entry and Location on Coal Lands on Discovery of Source Material

S541-541i

Chapter 13 Control of Coal-mined Fires

S551-558

Chapter 14 Anthracite Mine Drainage and Fire Control

S571-576

Chapter 18 Coal Research and Development

S661-668

Chapter 22 Coal Mine Health and Safety

S801-960

River and Harbor Act of 1899, 30 Stat. 1182; 33 U.S.C. 407

National Environmental Policy Act of 1969, 83 Stat. 852; 42 U.S.C. 4321 et seq.

Federal Water Pollution Control Act, 62 Stat. 1155; 33 U.S.C. 466, 467

Water Quality Improvement Act of 1970, 84 Stat. 91; 33 U.S.C. 1151 et seq.

Clean Air Act of 1970; 42 U.S.C. 1857 et seq., as amended by P.L. 91-604 (12-20-70) 84 Stat. 1676

b. Regulations

Regulations governing the prospecting for and leasing or contracting for coal are found in Title 43, CFR 23, 43, CFR 3500, and 30 CFR 211.

Title 43, CFR 3500 primarily restates provisions of the "Mineral Leasing Act" and the "Mineral Leasing Act for Acquired Lands" which were summarized in II A 2 a(1) of this report. This group sets out the administrative requirements for issuing prospecting permits and leases. Subpart 3509, Surface Management, refers to 43, CFR 23 which is discussed below.

Title 43, CFR 3823 sets forth regulations for the protection of the environment during the exploration for, and surface mining of coal. Part 23 applies only to those permits issued after January 18, 1969. Part 23 requires that a permit, lease, or contract be approved before any surface disturbance in conjunction with prospecting or mining is initiated. The regulations set forth the requirements for technical examinations of proposed operation sites and approval of prospecting or mining plans. Performance bonds or other guarantee of satisfactory execution of terms of a permit, lease, or contract are required.

Title 30, CFR 211 deals with requirements for supervision of coal prospecting and mining operations by Geological Survey. This part concentrates on insuring the orderly development of the publicly owned coal lands safety of workmen, accounting of coal produced and rent and royalty payments.

Following is a list of regulations of the Department of the Interior concerning Federal coal leasing, from Titles 30 and 43 of the Code of Federal Regulations:

43 CFR 23 — Surface exploration, mining and reclamation of lands.

43 CFR 3000 — Mineral Management

- Group 3000
  - Part 3000 -- Mineral Management; General

43 CFR 3500 — Leasing of Minerals Other than Oil and Gas

- Subpart 3510 -- Prospecting permits
- Subpart 3520 -- Preference-right and competitive leases
- Subpart 3530 -- License to mine coal
- Subpart 3550 -- Fractional and future interest leases and permits

Part 3560 -- Special Leasing Acts

- Subpart 3565 -- National Forest Lands in Minnesota
- Subpart 3566 -- Lake Mead Recreation Area
- Subpart 3567 -- National Forest Wilderness

30 CFR Subchapter C -- Explosives and Related Articles; Tests for Permissibility and Suitability

- Part 15 -- Explosives and Related Articles
- Part 16 -- Stemming Devices
- Part 17 -- Blasting Devices

Subchapter D -- Electrical Equipment, Lamps, Methane Detectors; Tests for Permissibility; Fees

Part 18 -- Electrical Motor-Driven Mine Equipment and Accessories

Part 19 -- Electric Cap Lamp

Subchapter L -- Interpretations

Part 45 -- Interpretations; Title II, Federal Code Mine Safety Act of 1952

Subchapter O -- Coal Mine Health and Safety

Part 70 -- Mandatory Health Standards - Underground Coal Mines

Part 74 -- Coal Mine Dust Personal Sampler Units

Part 75 -- Mandatory Safety Standards - Underground Coal Mines

Part 77 -- Mandatory Safety Standards, Surface Coal Mines and Surface Work Areas of Underground Coal Mines

Part 80 -- Notification, Investigation, Reports and Records of Accidents

Part 81 -- Procedure for identification of Representatives of Miners at Mines

Part 90 -- Procedure for Transfer of Miners with Evidence of Pneumoconiosis

Part 100 -- Civil Penalties for Violation of the Federal Coal Mine Health and Safety Act of 1969

30 CFR Chapter II -- Geological Survey

Part 200 -- (a) Forms and Reports - Coal
Part 211 -- Coal-mining Operating and Safety Regulations
Part 216 -- Operating and Safety Regulations

30 CFR Chapter III -- Board of Mine Operation Appeals

Part 301 -- Procedures Under Federal Coal Mine Health and Safety Act of 1969

30 CFR Part V -- Interim Compliance Panel (Coal Mine Health and Safety)

Subchapter A -- Coal Mine Health

Part 501 -- Permits for Noncompliance

Subchapter B -- Coal Mine Safety

Part 503 -- Permits for Noncompliance With the Electric Face Equipment Standard

Subchapter C -- General Administration

Part 505 -- Practice and Procedure for Hearings

c. Policies Pertaining to Coal Leasing

(1) Natural Resources and Environmental Quality

"The Department of the Interior is the Federal agency primarily responsible for management of much of the Nation's renewable and nonrenewable living and nonliving resources. This requires protection of the environment in all development activities. In meeting this responsibility, the Department must strive for a balance between resource utilization and environmental quality. Both of these objectives must receive increased emphasis if an acceptable quality of life is to be maintained in the face of increasing resource needs.

"It is, therefore, the policy of the Department of the Interior that, except where it would be legally impermissible:

"All natural resource development and management programs and plans formulated or implemented within the Department of the Interior shall conform to applicable Federal and State environmental quality standards and shall include special stipulations to mitigate potential environmental damages not adequately covered by State and Federal standards.

"All leases, contracts, agreements, or other arrangements concerning living and nonliving resource management of development on all lands administered by the Department will be structured to assure that all operations on such lands conform to applicable State and Federal environmental quality standards and that they include special stipulations to mitigate potential environmental damage not adequately covered by existing State and Federal standards.

"All leases, contracts, agreements, and other arrangements indirectly related to living and nonliving resource development on public or private lands, such as those for Federal water services, rights-of-way across Interior-administered lands and other Federal involvements, will contain stipulations to insure that development operations conform to applicable State and Federal environmental quality standards and comply with any special conditions deemed necessary by the Department of the Interior for protection of the environment.

"All leases, contracts, agreements, and other arrangements that predate current environmental quality standards, and do not require compliance with such standards, shall be administered or revised where possible, and appropriate, to require an upgrading of technology in an orderly, practical schedule to achieve compliance with applicable Federal and State standards and special stipulations considered necessary by the Department for proper environmental protection.

"Resource developers seeking leases, contracts, agreements, or other arrangements with the Department of the Interior shall submit advance plans of proposed operations for Departmental approval, unless this would be manifestly impractical in a given set of circumstances, and shall establish a reporting system on performance to regularly demonstrate compliance with applicable environmental quality standards and special stipulations. The Department will establish guidelines to facilitate submission and review of such plans."

The above policy was established by the Secretary of the Interior in June 30, 1972.

(2) Leasing Policy

With full awareness that there is a growing need for low-sulfur coal to supply the Nation's need for clean energy, the new coal leasing policy announced by Secretary Morton, February 17, 1973, will operate in conformity with the Department's three overriding goals:

1. Assure maximum environmental protection.
2. Provide for orderly and timely resource development.
3. Assure a fair market value return for resources sold.

Further, the policy is divided into short-term and long-term aspects. The short-term leasing policy is intended to insure that coal production can continue and will prevent deficiencies in supplies of coal which are necessary to meet continuing energy needs. In summary, coal leases will be issued under the following conditions:

When coal is needed now to maintain an existing mining operation; or

when coal is needed as a reserve for production in the near future; and

when coal land to be mined will in all cases be reclaimed in accordance with lease stipulations that will provide for environmental protection and land reclamation; and

when an environmental impact statememt covering the proposed lease has been prepared when required under the National Environmental Policy Act.

Long range aspects of the Secretary's leasing policy provide for:

1. Development of an environmental impact statement on the Department's entire coal leasing program, supplementing this as necessary for appropriate impact reporting on a regional basis or for individual leases.

2. Development of a planning system to determine the size, timing, and location of future coal leases in order to meet energy needs most effectively.

The long range aspects of the new leasing policy will combine a sound approach to development with an environmental ethic that will become the core of philosophy of Interior as a Department of Natural Resources.

Basically, this policy will be implemented through the Bureau's Energy Minerals Allocation Recommendation System (EMARS). A brief description of this system follows:

The EMARS system accepts, from various sources, economic analysis and projections which identify commodity allocation needs. Regional commodity allocation targets are inserted into BLM's budget systems as inputs to preparation of the Annual Work Plan (AWP). Starting at the lowest field level, BLM field managers make allocation recommendations (AR's) in response to the identified regional targets. AR's are based on resource data received from all sources and available within the unit resource analysis-management framework plan (URA-MFP) components of the BLM planning system. These recommendations are documented locally and show specifically the trade-off aspects of multiple use considerations and public comments, which are integral components of the URA-MFP process.

Local allocation recommendations are aggregate by BLM State offices during formal action of the BLM Annual Work Plan. This detailed budget system provides adequate review capability for checking effectiveness of field response to over-all program objectives which the budget system has quantified. The State allocation recommendations are aggregated into regional and national totals sufficient to meet commodity needs previously identified. Approvals by BLM and Secretarial levels are announced as proposed leasing schedules for which we will prepare selected environmental impact statements, taking advantage of previously prepared programmatic statements and the thorough analysis and public review afforded during formulation of local allocation recommendations.

Coal lease sales have not been held under the new system, but will probably follow procedures utilized for Outer Continental Shelf sales as to pre-sale and post-sale evaluation.

Future production from leases issued will yield statistical information upon which judgements can be made as to how closely the allocations have met identified commodity needs. Such analysis will also serve to improve econometric modeling from which the original allocation targets were derived. Continuing analysis will also be made of how well environmental impacts have been mitigated, and how completely other land-use factors have been considered in the planning and allocation process.

(3) Prospecting Permits

On February 13, 1973, Secretary of the Interior, Rogers C. B. Morton, issued Order No. 2952 regarding issuance of prospecting permits for coal, as follows:

> "In the exercise of my discretionary authority under Section 2(b) of the Mineral Leasing Act, as amended (30 U.S.C. 201(b)), I have decided not to issue prospecting permits for coal under that section until further notice and to reject pending applications for such permits in order to allow the preparation of a program for the more orderly development of coal resources upon the public lands of the United States under the Mineral Leasing Act, with proper regard for the protection of the environment.

"Accordingly, no prospecting permits for coal under Section 2(b) of the Mineral Leasing Act, supra, shall be issued until further notice. All pending applications for such permits shall be rejected, and any applications submitted in the future shall be promptly rejected.

"Nothing in this memorandum shall be deemed to restrict the rights of holders of prospecting permits, issued prior to this directive, to obtain preference right coal leases under Section 2(b), supra, or to prevent the issuance of competitive coal leases under Section 2(b) of the Mineral Leasing Act, as amended (30 U.S.C. 201(a)).

"I have determined that the issuance of this order is not such a major Federal action significantly affecting the quality of the human environment as to require the preparation of an environmental impact statement under Section 102(2) (C) of the National Environmental Policy Act of 1969 (42 U.S.C. 4332 (2) (C)).

2. Administration

a. Roles of Federal Agencies

The roles of Federal agencies, such as the Bureau of Land Management, Geological Survey, Bureau of Mines, Mining Enforcement and Safety Administration, Bureau of Sport Fisheries and Wildlife, and the Bureau of Reclamation in the United States Department of the Interior; the Forest Service, U.S. Department of Agriculture; and the Corps of Engineers, Department of the Army, in coal lease administration have been modified by passage of the National Environmental Policy Act (NEPA), in 1970. Prior to the passage of NEPA, the land management agencies were guided by specific legislation pertaining to the management of lands under their jurisdiction. NEPA, while it did not change the basic concepts of the enabling and directional acts, it did broaden the management philosophy of these agencies and created a more definitive approach to their management and administration with respect to environmental protection.

Statutory limitations are found in several laws which constrain management of the coal resource. These constraints affect not only the leasing of coal, but also operating methods and rehabilitation practices. These laws include the National Wilderness Preservation Act, various national recreation area acts, the Wild and Scenic Rivers Act, and others which pertain to national recreation and heritage programs.

Bureau of Land Management

The Bureau of Land Management (BLM) classifies and manages national resource lands and their related resources according to principles of multiple use, sustained yields, and environmental quality.

Resources managed by BLM include timber, minerals, land, wildlife habitat, livestock forage, water, public recreation values, and open space. Bureau programs provide for the protection and orderly use of these resources.

The Bureau administers laws relating to mineral resources of all Federal lands, including lands under its primary jurisdiction, submerged lands of the Outer Continental Shelf, lands withdrawn by other Federal agencies, acquired lands, and Federal mineral reserves in private lands.

In the Federal coal leasing program, the Bureau of Land Management exercises the Secretary of the Interior's discretionary authority under the mineral leasing acts to determine whether or not leases, permits, or licenses are to be issued. It is responsible for issuing leases, permits and licenses, and for formulating the surface, nonmineral resource, and rehabilitation requirements to be incorporated in them. With respect to Federal coal deposits where BLM has surface management responsibilities, BLM determines the adequacy of environmental protection and rehabilitation aspects of all mining operation plans. BLM also, is responsible for compliance examinations on lease areas, as well as on prospecting permit or license lands beyond operating areas.

In addition to managing the national resource lands, administering mining laws applicable to all Federal lands, and conducting official cadastral surveys of all Federal lands, the Bureau of Land Management also maintains the official land status records for all Federal lands. Such records are maintained for areas within their jurisdictions by BLM State Offices, in Anchorage, Alaska; Phoenix, Arizona; Sacramento, California; Denver, Colorado; Boise, Idaho; Billings, Montana; Reno, Nevada; Santa Fe, New Mexico; Portland, Oregon; Salt Lake City, Utah; Cheyenne, Wyoming; and in the Eastern States Office in Silver Springs, Maryland.

Land records show to whom patents were issued when title to lands in the public domain passed to non-Federal ownership, but records of subsequent transfers are not maintained, unless the lands again are acquired by the Federal Government by purchase or exchange.

Records of the status of Federal lands show which agency has primary jurisdiction; Federal agency withdrawals, reservations, classifications, and other constraints on management of the land by the agency with primary jurisdiction; outstanding mineral leases (and mining claims in some instances), prospecting permits, right-of-way permits, and some other types of contractual obligations; pending applications which give the applicant a preference-right; reservations to the Federal Government -- of minerals, rights-of-way, etc. -- in patented lands; reversion clauses if prescribed uses of patented land change; and other information relating to status of the land or restrictions on its use.

Applicatons to lease coal are filed in BLM State Offices and are assigned serial case numbers, in a manner similar to that followed for other types of land and mineral applications. Coal lease case files are maintained in the State Offices until the leases are terminated, after which the files are sent to Federal records centers for storage. Such files can be retrieved promptly when needed.

Coal leases are authorized and terminated by appropriate officials in BLM State Offices. The Federal agency with primary jurisdiction over the surface resources of land underlain by coal is responsible for recommending coal lease provisions concerning surface resources and for monitoring compliance. Coal extraction is supervised by the Geological Survey.

Geological Survey

The Geological Survey is the principal Federal agency concerned with preparing maps of the physical features of the country and providing earth science information essential to the use and conservation of the Nation's land, mineral, and water resources.

The Conservation Division of the Geological Survey is responsible for geologic, engineering, and economic value determinations needed for Federal coal leasing, and for supervision of coal mining on Federal lands, under the terms of leases issued by the Bureau of Land Management. The area mining supervisor of the Conservation Division approves operations plans which meet requirements of the mineral leasing acts, regulations, lease terms and conditions, and environmental and rehabilitation stipulations. He makes compliance examinations of operations under Federal coal basis and maintains records of operations of lessees, permittees, and licensees.

Mining Enforcement and Safety Administration

Mining Enforcement and Safety Administration (MESA), an agency of the Department of the Interior, is responsible for administering the Federal Coal Mine Health and Safety Act. Coal mine health and safety, assessment and compliance, and education and training are functions of this office. MESA has jurisdiction over all coal mines and mine plants whether or not the operation is pursuant to a Federal coal base.

Bureau of Mines

The Bureau of Mines (BM), conducts research necessary to the governmental function of assisting the private sector to produce an appropriate and substantial share of the national mineral and fuel needs in a manner that best protects the public interest. Specifically, concern is directed toward the satisfaction of current and emerging mineral needs; the real cost of such achievements; the assessment of related social-economic factors; minimization of occupational hazards to workers; reduction of wastes; and assurance that mineral raw materials are supplied and mineral-based products are used with minimal social and environmental cost. To accomplish these objectives, the Bureau performs research, provides information to the public, and conducts inquiries pertinent to the extraction and processing of mineral fuels, Bureau of Mines programs are designed to enhance public benefits from coal mining on both Federal land and private land.

Forest Service

The Forest Service manages approximately 186 million acres of national forests and national grasslands. All lands in Forest Service jurisdication are managed in accordance with the principles of multiple use and sustained yields, as expressed in the Multiple Use Act of June 12, 1960.

Historically, lands managed by the Forest Service have been subject to mineral exploration and mining. Coal leasing is subject to the constraints and direction developed in multiple use plannning.

b. Federal Coal Leasing Procedures

Authorities for managing the Federal coal resources, reviewed in the preceding section, provide for the disposition of coal by lease, except that limited licenses may be issued to supply coal free to charge to individuals or municipalities for strictly local domestic needs. Because of their insignificance, free use licenses are not treated further in this statement.

The procedures and requirements relating to the Federal coal prospecting permits, preference-right leases, and competitive leases are summarized below, in accordance with the normal sequence of events.

Principals in the actions are the applicant, permittee, or lessee; the leasing agency (Bureau of Land Management); the land managing agency; and the operations managing agency (Geological Survey). The land managing agency is the Federal agency with primary jurisdiction for the land in which Federal coal occurs, such as the Bureau of Land Management, Forest Service, Bureau of Sport Fisheries and Wildlife, Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority, Department of Defense, or others.

Geological Survey, as the operations managing agency, ensures that the permittee or lessee complies with the terms of the prospecting permit or coal lease. Operations management includes inspections to ensure compliance with approved prospecting and mining plans, review of reports that permittees and lessees are required to submit periodically, maintenance of accounts of coal mined and rents and royalties paid, issuance of compliance orders, and recommendation to the Bureau of Land Management for permit and lease cancellation for non-compliance or termination for other reasons.

(1) Initiation of Action

(a) Independently, or on the recommendation of Geological Survey, the Bureau of Land Mangement may nominate coal in a specified location for competitive leasing.

(b) An applicant may file an application for a prospecting permit, a preference-right lease, or a competitive lease at a State Office of the Bureau of Land Management (BLM). BLM then records the application, assigns a case number, collects applicable filing fees and rents, verifies the applicant's qualifications, determines the status of the land involved, and determines if a prospecting permit or coal lease would be appropriate. Non-qualifying applications are rejected.

(2) Evaluation Report

BLM requests an evaluation report from Geological Survey (GS). GS reports the nature and extent of coal deposits in the lands; recommends mineral protection stipulations, bond requirements; and minimum production or exploration requirements.

If the application is for a prospecting permit and Geological Survey reports that the land is known to contain workable coal, BLM rejects the application.

If the application is for a coal lease, Geological Survey establishes rentals and royalties, for both preference-right leases and competitive leases. For competitive leases, Geological Survey establishes the minimum acceptable bonus bid. With respect to preference-right lease applications Geological Survey verifies the applicant's discovery of coal of commercial value or recommends rejection of the application if coal was not discovere BLM rejects a preference-right application if GS reports that there was nc discovery of coal of commercial value.

(3) Environmental Analysis and Technical Examination

(a) The Bureau of Land Management (by Instructic Memo 72-135 of April 14, 1972), the Geological Survey (by Instructions of November 24, 1972, and May 3, 1973), and other surface management agencie require their appropriate officials to make environmental analysis prior t (1) Issuance or modifications of a coal prospecting permits or coal lease (2) Adjustment of terms for the continuance of a lease beyond a 20-year period or the continuance of a prospecting permit beyond a two-year perio and (3) Approval of a prospecting or mining plan. Whenever possible, the involved agencies (Geological Survey, Bureau of Land Management, and other surface managing agency, if any), make the environmental analysis and technical examination as a team, using an interdisciplinary approach. The team's report speaks to (1) the present condition of the environment and what effects alternative mining methods may have on the environment; (2) whether or not the lease or permit should be granted, based on environmental considerations; (3) management principles to be converted into lease or permit stipulations; and (4) the need to prepare an environmental statement. An environmental statement describes the proposed action, the environment, impacts on the environment, alternatives to the proposed action, mitigating measures, unavoidable impacts, relationships between benefits of the action and long-term productivity of the area, and irretrievable resource commitments.

Prospecting in itself may not have a serious adverse impact on the environment, but a coal operation which would ensue upon granting a preference-right lease might have such a severe impact on the environment that issuance of the lease would not be in the public interest. Consequently, the prospecting environmental analysis must also consider the probable effects of granting a preference-right lease. If it is shown by the analysis that the public interest would not be served by the issuance of the preference-right lease, recommendations are made to reject the application for the prospecting permit. If it is determined through the environmental analysis process that the ultimate issuance of a preference-right lease would be in the public interest, the environmental and technical investigations serve to develop stipulations for exploration activities to be authorized by the prospecting permit. In that case, GS would recommend approval by BLM.

If the technical and environmental studies and recommendations lead to the conclusion by the Bureau of Land Management that the issuance of a prospecting permit would not be in the public interest, the application is rejected.

(b) If a prospecting permittee finds coal of commercial value, he can apply for a preference-right coal lease. When such an application is filed, additional analyses are made to update the previous prospecting environmental anaylsis. As a result of these further environmental studies, it is conceivable that rejection of the application for a preference-right lease might be recommended. However, the burden of proof rests with the government under procedures in effect in 1973.

If the environmental analysis made after the application for a preference-right coal lease indicates that approval is appropriate, proposed lease stipulations are provided with a recommendation to the Bureau of Land Management for approval.

(c) When the Bureau of Land Management proposes to offer coal for competitive leasing, environmental and technical investigations are made. Based on these investigations, recommendations are made for or against advertising the offering. If leasing is recommended, stipulations are prepared, based on the environmental investigations before the area is offered for competitive bidding.

(d) Modifications, continuance, and renewal of leases and permits are preceded by environmental investigations and recommendations for actions. Stipulations are based on environmental and technical studies.

(e) A detailed environmental analysis is made prior to the approval of an operating plan. A prospecting permittee or coal lessee is required to submit a plan describing his proposed prospecting or mining methodology. If the environmental analysis reveals deficiencies in the plan, recommendations are made for its improvement to ensure that all environmental impacts are mitigated to the maximum extent possible.

(4) Permit or Lease Preparation

If BLM finds that issuance of a prospecting permit or coal lease is appropriate, a tentative document is drawn up for review by the land managing agency and operations managing agency. Appropriate revisions are incorporated in the final document by BLM.

(5) Permit or Lease Activation

After having processed an application, or Federal motion, to the stage where a document is accepted by the agencies involved, activation is accomplished when the Bureau of Land Management: (1) Issues a prospecting permit; (2) Issues a preference-right lease; (3) Publishes a notice of the pending coal lease sale, conducts a competitive auction to determine the successful lessee, secures concurrence of Geological Survey, collects the bonus bid and rental from the successful lessee, and issues the coal lease. If none of the competitive lease bids are acceptable, all are rejected.

(6) Administering Active Coal Prospecting Permits

(a) Permittee pays rentals to BLM during life of permit.

(b) GS informs permittee of regulations, reporting procedures, and other requirements.

(c) Permittee submits prospecting plan to GS, the operations managing agency. Requirements for such a plan are specified in 43 CFR 23, 30 CFR 211, and in Geological Survey guidelines of May 19, 1972. A prospecting plan includes narratives and maps describing proposed actions including road locations, drill site locations, equipment to be used, and rehabilitation measures.

(d) GS reviews plan and secures concurrence of the Bureau of Land Management and other land managing agency, if any (after modifications as may mutually be determined to be appropriate). GS then submits plan to permittee to make necessary changes, if any, to ensure environmental protection and proper operating methods. If revision of the plan is necessary, the final version is again reviewed by BLM and other concerned land managing agencies, if any, for concurrence, after which the plan is approved by GS. All agencies involved base their concurrence with the plan on their environmental analysis, and if appropriate, environmental statements, prepared -- with public involvement -- by interdisciplinary teams.

(e) Only after the prospecting plan has been approved can the permittee commence prospecting operations. He is required to prospect in accordance with the plan, complete required rehabilitation measures, and submit records of drilling or other exploration to GS. During exploration, the operations managing agency makes compliance examinations of the prospecting operations, and the land managing agency makes compliance examinations relating to other aspects of resource management. These might include access rights, surface protection, and rehabilitation. Any deficiencies are reported to GS, to secure compliance from the permittees. GS maintains records of all operating activities, receives report of the land management agency when lands have been satisfactorily rehabilitated, and recommends final action on the permit by BLM, the leasing agency.

(f) A permittee may request BLM to grant a two-year extension of a prospecting permit, if prospecting was not completed during the initial permit period. BLM requests a report from GS on the need for an extension. GS can recommend an extension if the permittee diligently prospected during the first term, but needs additional time to determine the nature of the coal. If appropriate, BLM can grant an extension.

(7) Administering Active Federal Coal Leases

(a) Once a preference-right or competitive coal lease has been issued, following the procedures described above, the lessee pays the annual rental and advance royalties to BLM, the leasing agency. BLM collects rentals for five years or until production starts.

(b) GS, the operations managing agency, informs lessee of regulations, required reports, and other procedures. GS collects rentals or advance royalties after the first five years or after production starts, whichever is sooner.

(c) Lessee submits plan of operation (developed in consultation with leasing agency, land managing agency, and operations managing agency to GS. In case the lease is for Federal coal underlying non-Federal land, the lessee should consult with the landowner, too.

(d) GS refers the operating plan to the land managing agency for assessment of adequacy with respect to protection and management of related resources, based on environmental analysis and environmental impact statements, where appropriate. New mining plans are available for public comment for 30 days. After such modifications as GS may require the lessee to make, GS requests a final review by the leasin agency and land managing agency, and, if all is in order, approves the operating plan; which then becomes part of the base conditions.

(e) Lessee commences operations authorized by lease, including development, production, and rehabilitation. Submits drilling data, mining progress reports, rehabilitation progress reports, and progress maps to GS.

(f) GS makes compliance inspection of mining operations, and land managing agencies make compliance examinations with respect to other aspects of resource management. These might include access rights, surface protection, rehabilitation, and coordination of operations with other resources uses. Any deficiencies are reported to GS to secure compliance from the lessee. GS maintains records of all operations. GS consults with the Bureau of Mines and Mine Enforcement and Safety Administration regarding mining methods, health and safety, and mine or outcrop fires.

(g) Lessee pays royalties on coal mined to GS. Production reports are submitted quarterly. The lessee reports the number of tons of coal mined, the royalties due, coal inventories, and the selling price of the coal produced. An annual independent audit of production records is required. In addition, reports for all leases after 1969 must include: (1) an annual report describing operations, area of land affected, area of land disturbed, amount of land rehabilitated and method of rehabilitation; (2) grading and backfilling progress; (3) progress or planting; and (4) 30 days notice prior to completion of mining and rehabilitation.

(h) GS maintains accounts of coal produced and receipts, supplying them periodically to BLM. GS verifies production records submitted by lessee.

(i) Leases may on occasion be relinquished, cancelled by BLM for non-compliance or non-payment, or allowed to expire. Modifications are possible, and are subject to requirements similar to those which pertain to leasing. Assignments require the advance approval of GS and BLM.

(j) Leases are continued under adjusted terms beyond the initial 20-year period. BLM requests reports from the land managing agency and the operations managing agency concerning appropriateness of continuance and requirements that should apply to a lease continuance. Agencies involved cooperate in making a technical examination, an environmental analysis, and in preparing an environmental statement if appropriate. On the basis of environmental and technical studies including public participation), stipulations and bonding requirements are developed, reviewed, and recommended to BLM for incorporation in the lease, along with recommendations by GS as to rents, royalties, and production requirements. BLM incorporates updated terms and conditions in the adjusted lease. The lessee can seek administrative or legal relief from requirements of revisions.

(k) When a lessee applies for relinquishment, BLM requests a report from GS on the status of accounts, works, and lands, and requests a surface condition report from the land managing agency. GS requires the lessee to correct any deficiencies in rehabilitation of the area or in making payments. Collects on performance bond if necessary. When all requirements are met, BLM terminates the coal lease and releases the performance bond.

c. Enforcement of Federal Requirements and Influence of State Requirements

(1) Enforcement of Federal Requirements

Beginning in the late 1950's, applications for Federal Coal prospecting permits and requests for competitive coal sales increased. These applications were concentrated in the major coal basins of the Rocky Mountain states: Colorado, Wyoming, Montana, North Dakota, New Mexico and Utah. By 1965, it became apparent that the availability of oil and gas would not be sufficient to meet energy requirements. Applications for both prospecting permits and competitive coal sales continued to increase. Prospecting permits covered lands where prospecting was necessary to determine if a coal deposit of commercial value existed. Competitive sale requests were for areas where Geological Survey had determined that workable deposits of coal existed.

By 1970, several hundred permits had been issued, and a like number awaited action by the respective BLM state offices. On January 23, 1971, instructions were issued by the Director of the Bureau of Land Management that all applications for coal prospecting permits, preference-right leases, competitive lease offerings, and readjustment of terms under existing leases were to be sent to his office for review prior to issuance.

This action was followed by Secretarial Order 2952 on February 13, 1973, which directed that all pending coal prospecting permits be rejected and that no further coal permits were to be issued until further notice. Subsequently, all pending coal prospecting permits were rejected, and all new filings for coal prospecting permits are automatically rejected.

With increased activity in coal prospecting and leasing, BLM more specifically defined environmental requirements of permits and leases. Other land managing agencies also participated in developing environmental stipulations before consenting to the terms of permits and leases pertaining to the lands they managed.

On January 18, 1969, 43 CFR Part 23, revised regulations for surface exploration, mining, and rehabilitation of lands became effective. These regulations require that prior to issuance of an exploration permit or lease for coal, as well as other leaseable minerals, under the Mineral Leasing Act of February 20, 1920, or the Act of August 7, 1947 for acquired lands there must be a technical examination.

The National Environmental Policy Act of 1969, along with E.O. 11514, entitled Guidelines of the Council on Environmental Quality, analysis of proposed Federal actions to determine their impact on the quality of the environment.

As of March 1, 1973, there were 531 active Federal coal leases. Of these, 517 leases were in Colorado, Montana, New Mexico, North Dakota, Utah, Wyoming, and Oklahoma. In addition, there were 147 pending preference-right lease applications covering 461,868 acres and 110 prospecting permits for 268,162 acres. All of the prospecting permits were issued prior to January 23, 1971. The holders of these permits can be expected to apply for preference-right leases if exploration discloses workable coal deposits. The responsibility for administering the existing leases and permits and processing the pending applications is large. Many of the previously issued leases will become operational by 1980, others in the following decade.

The 110 prospecting permits require periodic compliance inspections. Many holders of previously issued leases not now in production will be submitting mining plans for review. Each of these reviews will require team effort among the Bureau of Land Management, Geological Survey, and other surface managing agencies. Environmental analyses will precede approval of mining plans.

Increases in numbers of coal prospecting and leasing applications and in coal mining operations during the past decade have not been matched with comparable increases in the manpower of the responsible Federal agencies. To further intensify the need for sufficient capable personnel is the widely accepted objective to protect environmental quality everywhere, including areas where coal is mined.

Federal resource management agencies follow national policies in analyzing the environmental impacts of proposed resource management actions, in using resource management techniques that protect or enhance the environment, and in balancing the use of resources to benefit public interests. It also requires that comparable intensities of management be applied to resources of equivalent importance. One necessary management effort cannot be forsaken in order to achieve perfection in another. All programs should move ahead together.

It is becoming increasingly apparent that professional expertise in several fields is necessary to achieve goals for coordinated resource management. For example, proper planning and management of the Federal coal leasing program requires not only geologists and mining engineers, but also hydrologists, soil scientists, wildlife biologists, foresters, range conservationists, landscape architects, recreation specialists, economists, land use planners, lease administrators, and managerial specialists.

The talents of these specialists are employed in designing the requirements which are incorporated in coal prospecting permits and leases. Certain requirements can be applied nationwide, but others must be specifically designed to apply to the situation on a specific area. It is here that the skills of specialists are most necessary. Coal mining is essential to the welfare of the Nation, but where it is to be mined and under what conditions are determinations requiring skill and judgement of the highest order.

To carefully plan mining operations, but fail to enforce requirements of permits and leases would be folly. The same kinds of expertise are needed, and needed in adequate supply, to ensure that mining and rehabilitation operations proceed properly and on schedule.

Examples of standard prospecting permit and coal lease requirements and special stipulations are included in the Appendix.

Federal resource management agencies with responsibilities for all of the resources of the lands they manage have to have sufficient personnel with the diverse skills required if they are to achieve national resource management objectives. To be taken into consideration are advances in tec nology, shifts in national priorities, dwindling availability of certain resources with increasing demands on others, and changing standards. These factors demand flexibility in resource management procedures and close co-operation among agencies in order to best utilize the skills of each in planning and enforcing contractual requirements.

(a) Manpower and Funding

During the past decade, most of the increase in the workload of Federal agencies that was brought about by increases in coal prospecting, leasing, and mining was necessarily absorbed by decreasi the manpower previously engaged in other work. Ramifications of managing Federal coal leasing include land use planning, wildlife habitat improveme on and adjacent to mined areas, planning transportation and utility system and granting and administering right-of-way permits, modifying range allot ment management plans to allow for coal mining, developing water plans whi provide for alterations in drainage caused by mining, planning and seeing that revegetation plans are carried out on mined areas, and activating pla for use of mined lands after the lessee completes rehabilitation work.

With National priorities for energy requirement having been raised recently, the Federal agencies involved are planning for efficient use of ex pected increases in funding and manpower for the various aspects of their programs related to coal mining. The addition of mining engineers to assist in administering coal mining operations, while necessary, would respond to only one of the several essential facets of coordinated resource management. Consequently, increases in funding and manpower for other aspects of resource management that are affected by coal leasing are necessary and expected -- commensurate with increases in total workload occasioned by increasing coal production.

Since there was a lag of several years in staffing the Bureau of Land Management to adequately administer the accelerating coal mining program, that agency now lacks a broad and experienced cadre on which to base further expansion. Consequently, it will be necessary to competitively employ highly skilled and experienced scientists, as well as people with adequate professional education, but less experience. In-service training, development of organizational structure, and establishment of necessary cooperative relationships with other agencies can be expected to require several years, to achieve top level performance.

The Geological Survey has a staff of 27 mining engineers, with 13 support personnel, whose primary responsibilities are to make mineral leasing engineering and economic value determinations and to supervise all operations on Federal and Indian land mineral leases, licenses, and prospecting permits.

The Geological Survey has established optimum inspection or examination standards to assure compliance with regulations, laws, stipulations, and lease contracts. Active prospecting permits must be examined twice a year, inactive prospecting permits once a year, active leases three times a year, and inactive leases once a year. During 1971 and 1972, the Geological

Survey performed at 44 percent of these standards (all minerals, all lands). To attain even that level, there was a transfer of emphasis from engineering operational management to implementation of the requirements for surface protection under NEPA and surface protection regulations. Non-environmental responsibilities under 30 CFR 211 and 231 lacked the in-depth attention needed for proper management.

Since the surface mining and reclamation regulations (43 CFR 23) became effective in 1969, no additional funds or personnel have been provided to take on the additional responsibility and workload created by them.

To carry out an optimum program of necessary mine inspections and enforcement and engineering management, an additional 46 persons and additional funding of $976,000 annually would be required.

(b) Federal Agency Enforcement Responsibility

Secretarial Order No. 2948 of October 6, 1972 was issued to clarify the "Division of Responsibility Between the Bureau of Land Management and the Geological Survey for Administration of the Mineral Leasing Laws - Onshore."

In brief, the Bureau of Land Management issues and terminates coal prospecting permits and coal leases, but between those actions the Geological Survey supervises operations. The two agencies cooperate in determining the propriety of issuing permits and leases and the nature of requirements to be incorporated in them. Also, "BLM is responsible for compliance examinations of environmental protection requirements outside the operating area and for reporting infractions to GS" so that compliance might be attained. It is assumed that such BLM compliance inspections are to be conducted on national resource lands covered by BLM permits or leases. The order is silent as to the responsibility of other Federal resource management agencies when BLM coal prospecting permits or coal leases cover operations (supervised by Geological Survey) on Federal lands other than national resource lands (managed by BLM), such as national forests under the jurisdiction of thd Forest Service or national wildlife refuges under the jurisdiction of the Bureau of Sport Fisheries and Wildlife. These other agencies conduct compliance examinations and report to Geological Survey with respect to fulfillment of environmental protection requirements.

Resource management agencies are governed by laws, regulations, and procedural policies applicable to them in managing the lands and resources for which they have administrative jurisdiction. To fulfill those responsibilities, they must by some means ensure that coal mining practices are in accord with other resource management objectives. Usually this is achieved through the cooperation of personnel representing all of the Federal agencies that are involved. Interdisciplinary teams representing the Bureau of Land Management as the leasing agency, the Geological Survey as the operations managing agency, and others representing the land managing agency (BLM, FS, BSF&W, BR, DOD, or others) cooperatively conduct technical and environmental examinations prior to and during mining operations.

Land managing agencies sometimes think their roles as "recommenders" are without sufficient authority to ensure that their primary roles as resource managers are fulfilled, although the coal leasing regulations allow them to "prescribe" stipulations for BLM to include in leases.

In the interest of achieving administrative efficiency, three alternative proposals are suggested for consideration prior to the establishment of formal guidelines concerning the role of the Federal land management agency in coordinating coal mining with other resource uses.

Successful multiple use coordination now depends on the personal persuasiveness of the individuals who represent their agencies in developing and administering lease requirements. Failure to participate or overemphasis of certain points may result in lopsided administration for which procedural cures have not yet been manualized.

One alternative would be to establish interagency agreements for administering the various aspects of operations during the term of the lease. For example, the lessee, under the terms of this lease from BLM, would be responsible to a Geological Survey lease administrator for following the approved mining plan, to a Forest Service lease administrator for rehabilitation, and to a Mining Enforcement and Safety Administration lease administrator for employee health and safety.

The second alternative would be to assign agency responsibilities on a time sequence or operation phase basis. For example, a leasing proposal would be examined by an interagency committee headed by BLM; prospecting would be supervised by the land managing agency; the mining and rehabilitation plan would be reviewed, developed, and approved by an interagency committee headed by GS; development would be supervised by the land managing agency; mining would be supervised by GS; rehabilitation would be supervised by the land managing agency; and BLM would terminate the lease when appropriate. Overlaps in sequence complicate this system.

A third alternative to the present system would be for the agency with primary resource management responsibilities to employ the necessary professional expertise to administer all phases of coal leasing along with all other resource management responsibilities within its area of jurisdiction.

(2) Influence of State Laws in Enforcing Mining Requirements

All states with major coal deposits have recently enacted or amended laws which require specific plans to be made before a permit to operate a coal mine will be issued. These state laws are to ensure that disturbances to the environment will be kept to a minimum and that disturbed lands will be rehabilitated to a predetermined condition and use. The laws apply to all land within the state and make no distinction between Federal or private ownership. Prior to the issuance of a state mining permit, the company must submit a detailed mining and reclamation plan to a mining state board or commission for review. In some states a hearing is held for public review and analysis.

Permits cost $50 or more per acre per year, based on the number of acres disturbed annually. The company is also required to post a bond based on the number of acres to be mined or on the cost of rehabilitation. The bond amount may be reduced as lands are satisfactorily rehabilitated. The bond amount varies considerably between states with amounts ranging from $100 per acre or $1,000 per operation to $3,000 per acre.

In general, mining can not be started until a permit is issued and a permit will be issued only after a detailed mining plan is approved. Inspections for compliance are made by the staff of the state mine inspector or may be the responsibility of some other state agency. Coordination between State and Federal agencies is done informally at the local level.

3. Magnitude of Federal Coal Leasing Program

a. Present Coal Leases

As of March 1, 1973, there were 531 Federal coal leases covering 779,267 acres under the administrative jurisdiction of the Bureau of Land Management, in 14 states. About half (55%) of the surface is owned by the Federal Government, and the remaining (45%) surface is privately owned, as shown on Table 12, compiled from records of the Bureau of Land Management.

Table 12 - Federal Coal Leases

Coal Provinces and States	Leases	Surface Ownership		Total Area Leased	Surface Ownershi	
	Number	Federal Acres	Private Acres	Acres	Federal Percent	Privat Percer
Pacific Coast						
Alaska	5	1,520	1,073	2,593	59	41
California	1	80	0	80	100	0
Oregon	3	5,403	0	5,403	100	100
Washington	2	0	521	521	0	100
Sub-total	11	7,003	1,594	8,597	81	19
Rocky Mountain and Northern Great Plains						
Colorado	112	67,472	54,606	122,078	55	45
Montana	17	1,265	34,967	36,232	3	97
New Mexico	28	14,760	26,198	40,958	36	64
North Dakota	20	0	16,436	16,436	0	100
Utah	195	253,274	13,335	266,609	95	5
Wyoming	92	82,737	117,196	199,933	41	59
Sub-total	464	419,508	262,738	682,246	61	39
Eastern and Interior States						
Alabama	1	0	200	200	0	100
Kentucky	1	1,282	0	1,282	100	0
Ohio	1	144	0	144	100	0
Oklahoma	53	1,321	85,477	86,798	2	98
Sub-total	56	2,747	85,677	88,424	3	97
Grand Total	531	429,258	350,009	779,267	55	45

State of Alaska and Alaskan Natives are selecting mineral lands, including coal. Consequently, until the State selections and Native claims have been satisfied, Federal leasing will be limited.

California

The small, isolated deposits of coal in California are located in the northern part of the state. The Federal Government has only scattered parcels. There is one lease of 80 acres in Mendocino County. There has been no production from this lease nor in the state for many years.

The estimated recoverable coal reserve is 25,000,000 tons. The coal is sub-bituminous with a sulphur content of two to three percent.

Because of the small deposits, no development is anticipated except for minor local use.

Oregon

There is one Federal coal lease in Clackamas County and three in Coos County, Oregon, in 1973. The leases were not producing in 1971, and under 500 tons were produced in 1971 for local use.

The coal seams average four feet in thickness. They are relatively impure and are considered to have low to medium sulphur content. No immediate development is anticipated.

Washington

Two leases totalling 520 acres in Washington are located in Lewis County in the western part of the state, north of Centralia. This area has a strippable reserve being used for electric power generation. Nearly all of the coal land is non-Federal.

Colorado has 29,600 square miles of land underlain by coal, with eight coal areas. While 32 counties are underlain by coal-bearing formations, only 14 have Federal coal leases. See Figure 23.

The eight coal areas are:

1. Green River
2. Uinta
3. San Juan River
4. North Park
5. Middle Park
6. South Park
7. Denver Basin
8. Raton Mesa

The first six are in the Rocky Mountain Coal Province whereas the other two are in the Northern Great Plains Coal Province. The Green River, Uinta, and San Juan River areas are major producers.

The North Park area in Jackson County is at an elevation of 8,000 feet and above. Access is remote and difficult. There has been no recent mining. However, the thick coal seams with available water makes the area attractive for a powerplant location.

Middle Park area in Grant County has no known mineable seams, nor are there any Federal leases. South Park in Park County is at 9,000 feet elevation and has had no production.

The Denver Basin located in the north-central part of the state includes 4,900,000 acres. Federal coal lands are less than about 9 percent or 427,800 acres. Much of this basin underlies extensive surface improvements including the Denver Metropolitan area. The coal is 1,000 feet or less below the surface. There are four Federal leases for 2,680 acres on the eastern edge of the basin in Elbert County.

This area could be surface-mined, but there is no apparent immediate plan to do so.

The Raton Mesa area located in Huerfano and Los Animas Counties, in the south-central part of Colorado, has two Federal leases in Los Animas County. There was no Federal production in 1972. All of the south portion of the Raton Basin is in the Maxwell Land Grant. Of the 559,100 acres underlain by coal-bearing formation, Federal ownership is about 32 percent or 181,000 acres. All 1972 production was from private holdings.

The coal is deep-mined and is used for coking at the Colorado Fuel and Iron Company's steel plants at Pueblo, Colorado. The captive CF & I Allen Mine adjoins a Federal lease and some production will come from the lease by 1980.

The Canon City field, an extension of the Raton Mesa, includes no Federal coal ownership. This field has coal similar to Raton Mesa. The coal is used for powerplant fuel and industrial purposes.

The major producing field is the Green River region located in the northwestern part of the state. All Federal production is located in the southeastern portion of the field in Moffat and Routt Counties. Coal is mined by both surface and underground. Federal ownership of the coal bearing formation is about 82 percent of 1,872,000 acres.

There are two strip-mines and two underground mines operating. The coal is used for powerplants, coking, industrial, and local purposes. This area has two underground and two strip-mines operating on Federal leases. There are several other operations on private land.

Of the 31 leases in the two counties, four are producing, eight adjoin the producing areas and are part of the mining units of the ope ations.

The Green River region in this southeastern area has the greatest amount of strippable coal in the state. Water may be available from the Yampa River. Together these factors could support three synthetic fuel plants. Increases have been made in powerplants and further increases have been considered. The coals are sub-bituminous with a few small occurrences of anthracite. It is of good quality with low ash and sulphur and 12,000 BTUs.

The Uinta region lies south of the Green River area in the west-central part of the state. It covers portions of Moffat, Rio Blanco, Garfield, Mesa, Montrose, Delta, Gunnison, and Pitkin Counties.

Within the Uinta region there are a number of coal fields which hav produced considerable coal in the past. Present-day Federal leases however, are mainly in five locations: Book Cliffs, Carbondale, Crested Butte, Somerset, and Grand Mesa. Much of the coal has coking characteristics and is shipped to steel mills. All is mined underground

Reserves in the area are large and water may be available. Accordingly, three synthetic fuel plants could be supported, one near Meeker on the White River, the second on the Colorado River above Grand Junction, and the last on the Gunnison River near Delta. Underground mining costs being high, it is more likely that any increased production will result from the greater need for the metallurgical grade coal rather than for conversion to gas or oils.

The San Juan River region is in the southwestern portion of the state. The region covers all or parts of Montrose, San Miguel, Delores, Montezuma, LaPlata, and Archuleta Counties. Although there are several producing mines, only one in LaPlata County is on a Federal lease. This small operation on 120 acres of Federal mineral estate, no Federal surface ownership and supplies a few thousand tons per year to local residents. There are no Federal leases in the other counties within the San Juan River region.

Peabody Coal Company operates a small strip-mine on private land, supplying coal to a small coal fired powerplant near Nucla, Colorado in Montrose County. Other small mines in LaPlata County are on private land and supply local needs including a small powerplant at Durango. The area is quite rugged and access is poor. There are no railroads. Although most operations are underground, there are some areas of thick coal that may be suitable for strip-mining. The available coal could support a large powerplant in the Durango area and one near Nucla or Naturita. The possible water source would be the Animas River for Durango and the San Miguel River for the Nucla proposal. Another location is in the eastern part of Montrose County. Kemmer Coal Company has four Federal leases and other coal lands that would supply the fuel. Water supplies are inadequate for all the synthetic fuel or powerplants proposed for Colorado. Some of the future developments will require processes that use very little water, or growth will stop when the water supply is fully commited.

New Mexico

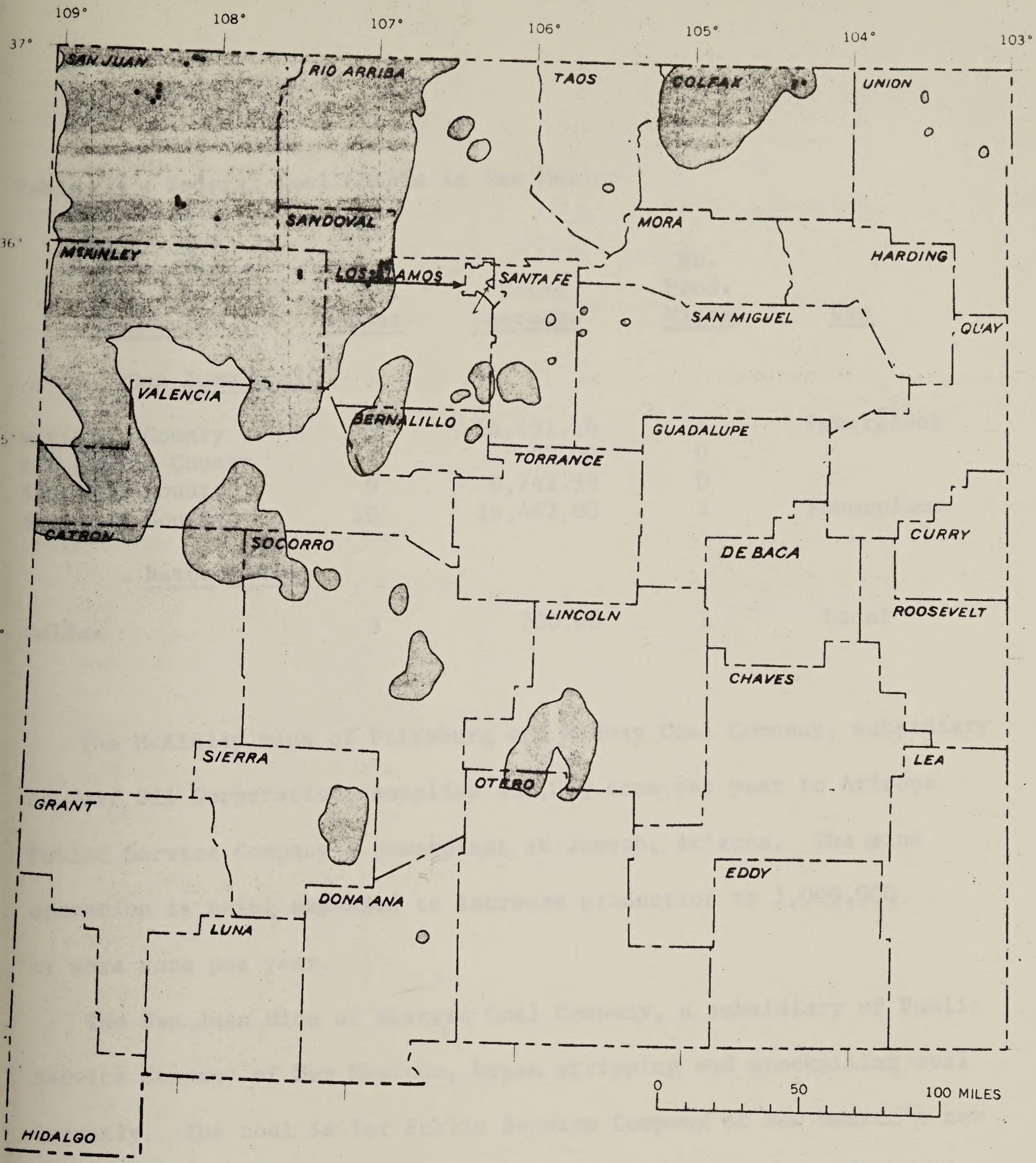
The two major areas in New Mexico are the Raton Basin in the Northern Great Plains Coal Province and the San Juan Basin in the Rocky Mountain Coal Province. See Figure 23A.

In the Raton Basin located in the northeastern part of New Mexico, the Federal Government has mineral rights to only a few isolated tracts and no surface ownership. Nearly all of the coal bearing formations are within the privately owned Maxwell Land Grant. The three leases totalling 200 acres are underground operations. Only one lease is operating and producing a small amount of coal for local use. The underground York mine operated by Kaiser Steel Corporation, is entirely on private lands.

The San Juan Basin is located in the northwestern part of the state. It covers all of parts of five counties, including the eastern portion of the Navajo Indian Reservation.

All of the leases are located near the coal outcrops of basins.

There are several other small coal areas in the state. Several have produced in the past, but there are no operations now. Madrid, Carthage, and Capitan Counties had underground mines that supplied coal to the Santa Fe and Southern Pacific Railroads, plus local demand. None of these coal fields is of interest because of minimal resources, highly faulted strata, and most of the coal near the surface has been mined. Table 14 shows the number of leases in each county.



. Coal Leases

Occurrence of Coal in New Mexico

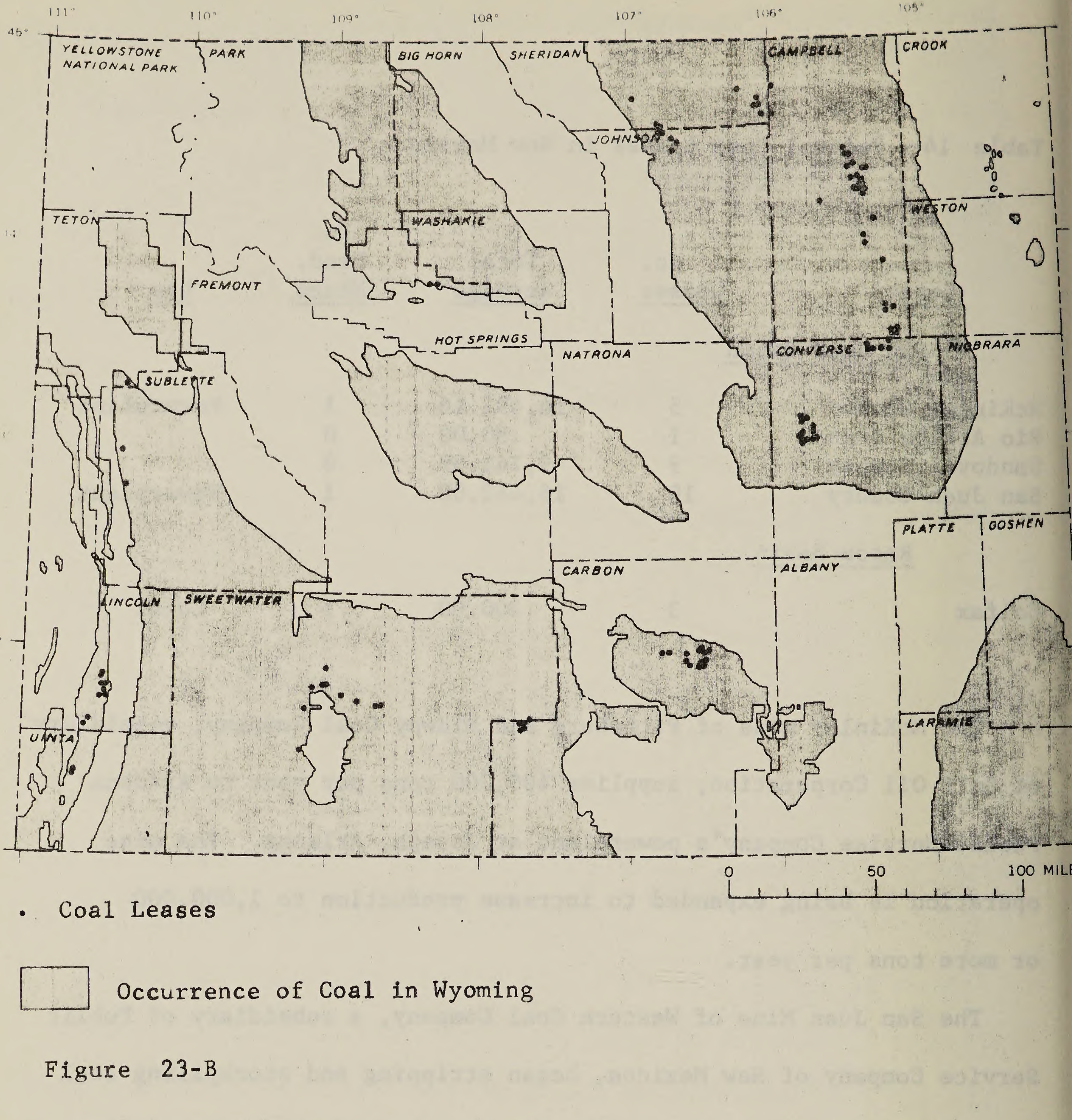
Figure 23-A

Table 14 - Federal Coal Leases in New Mexico

County	No. Leases	Total Acreage	No. Prod. Mines	Use
San Juan Basin				
McKinley County	5	14,491.16	1	Powerplant
Rio Arriba County	1	80.00	0	
Sandoval County	9	9,742.59	0	
San Juan County	10	16,442.00	1	Powerplant
Raton Basin				
Colfax	3	200.00	1	Local

The McKinley mine of Pittsburg and Midway Coal Company, subsidiary of Gulf Oil Corporation, supplies 400,000 tons per year to Arizona Public Service Company's powerplant at Joseph, Arizona. The mine operation is being expanded to increase production to 1,000,000 or more tons per year.

The San Juan Mine of Western Coal Company, a subsidiary of Public Service Company of New Mexicoa, began stripping and stockpiling coal recently. The coal is for Public Service Company of New Mexico's new powerplant nearing completion in 1973, west of Farmington, New Mexico. The coal will be hauled to the powerplant by truck.



• Coal Leases

Occurrence of Coal in Wyoming

Figure 23-B

Wyoming

There are 92 Federal coal leases in Wyoming, 1973, located in ten counties as listed in Table 15 . Locations of coal fields and leases are shown in Figure 23-B

Table 15 - Federal Coal Leases in Wyoming in 1973

County	No. of Leases	Number Producing Strip	Underground	Use
Campbell	29	2		1,3
Carbon	16	3	1	1,3
Converse	14	2		1
Fremont		1		1,2,3
Hot Springs	2	1	1	3
Johnson	6			
Lincoln	11	1		1,2,3
Sheridan	5			
Sweetwater	10		1	1,2,3
Uinta	1			
	94 1/	10	3	

1/ Where lease is in more than one county, it is listed in each.

Uses: 1. Powerplant
2. Coking
3. Industrial and local

Five coal regions occur in Wyoming: Big Horn Basin, Green River, Ham's Fork, Powder River, and Wind River. They extend over about half of the State.

Mining started in Wyoming in 1868 and has continued to the present. Most of the past production has come from the Rock Springs field of the Green River basin, the Hanna field, and the Kemmer field of the Ham's Fork region, and the Powder River basin. After a low

in 1958, production began increasing with a change from underground to strip-mining. Most present production is from the Powder River basin, Hanna field, Rock Springs field, and the Kemmer field.

The land pattern in the latter three coal fields is checkerboarded. These fields are along the Union Pacific Railroad, which received every other section for twenty miles on either side of its right-of-way.

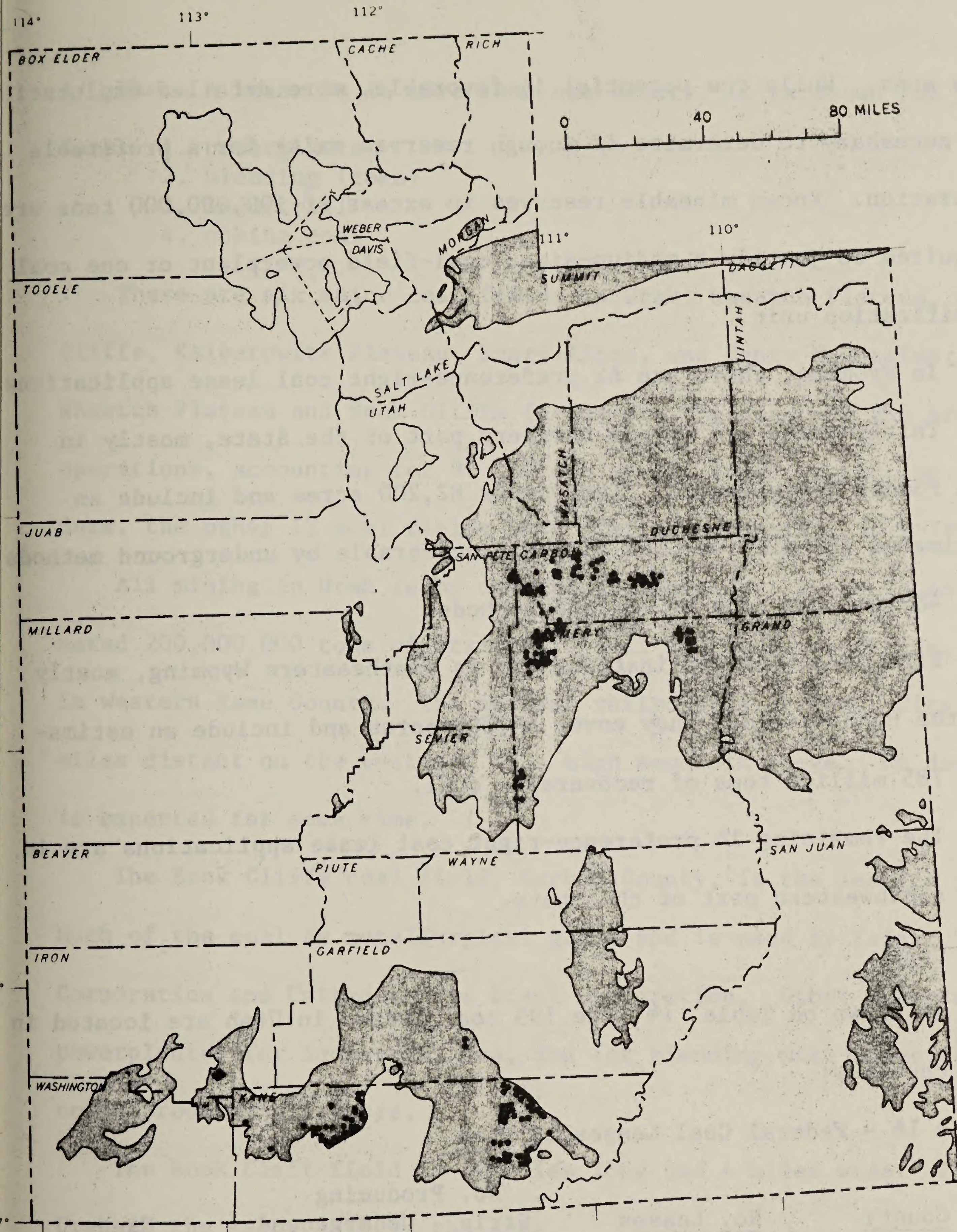
The coal seams in the Powder River region are up to 90 feet or more in thickness. It is considered the most important coal region in the State. The coal now being mined is used for powerplant fuel. Future developments include expansion of existing operations and opening of new mines to provide coal for powerplant use. Contracts have been made or are being negotiated to supply this low-sulphur coal to the Midwest, Texas, Gulf States, and the Pacific Northwest.

The Hanna field was opened in 1868 in Carbon, Wyoming when railroad construction reached that area. In 1882, mining at Hanna was commenced and has continued. The coal seams are up to 30 feet thick. The coal has low sulphur and ash content, and is classed as sub-bituminous at 10 to 12,000 BTU. Mining is both by underground and surface methods. The Hanna field is the site of the Bureau of Mines in-situ coal gasification experiment. In this experiment, a series of holes have been drilled in a circular pattern to a 30-foot seam. The coal is burned in place. Burning is controlled by monitoring the amount of air injected into the center hole. The product gas is withdrawn through one or more of the other holes. Results so far have shown that the product gas has up to 200 BTUs per cubic foot. Regular commercial pipeline gas has from 900 to 1,000 BTUs per cubic foot.

The Rock Springs field in Sweetwater County was opened to supply the Union Pacific Railroad with fuel for steam locomotives. The railroad's change to diesel locomotives in the 1950's eliminated the need for coal. After a 1958 production low, it is increasing. Production in 1973 is used for powerplant fuel and for making synthetic coke. The latter is a new use that has recently been developed. The Rock Springs coal does not coke by the usual methods. But with the development of the synthetic process, a new market is available.

The Kemmer field in the southwest part of the state, a part of the Ham's Fork region, has numerous seams that were formerly mined underground. Present strip-mining is removing coal from mine seams. The coal is used for the nearby Naughton powerplant, local industrial and domestic used, and for a pilot coking plant. The seams are six to 100 feet thick. Several seams are mined from the same pit. Future plans indicate that eight other seams may be mined depending on market needs.

The other coal regions, Big Horn basin, and Wind River, have minor production used locally. No increase in production is foreseen for several years, for these areas, since most mining is concentrated in the major fields. Both the Wind River and Big Horn basins have coal comparable to quality to the other fields. Railroads traverse the



• Coal Leases

Occurrence of Coal in Utah

Figure 23-C

the area. While the potential is favorable, more detailed exploratio is necessary to determine if enough reserves exist for a profitable operation. Known mineable reserves in excess of 100,000,000 tons are required to justify a medium-size, coal-field powerplant or one coal gasification unit.

In Wyoming, there are 62 preference-right coal lease applications. Thirty-three are in the northern part of the State, mostly in the Powder River region. They cover 82,200 acres and include an estimated 285 million tons of coal recoverable by underground methods and 480 million tons by surface methods.

Fifteen of the applications are in southeastern Wyoming, mostly in the Hanna field. They cover 49,200 acres and include an estimated 785 million tons of recoverable coal.

The remaining 14 preference-right coal lease applications are in the southwestern part of the state.

Utah

As shown on Table 16, the 195 coal leases in Utah are located in six counties:

Table 16 - Federal Coal Leases in Utah

County	No. Leases	No. Producing Strip	No. Producing Underground	Use
Carbon	48		8	1,2,3,4
Emery	47		7	1,2,3,4
Garfield	2			
	2			
Kane	92			
Sevier	14		2	3
	206 1/		17	

1/ Where a lease is in more than one county, it is shown for each.

Uses: 1. powerplants
2. blending (coke)
3. industrial
4. coking coal

There are six major coal fields in Utah: Wasatch Plateua, Book Cliffs, Kaiparowits Plateau, Emery Alton, and Henry Mountains. The Wasatch Plateau and Book Cliffs fields are the sites of the present operations, accounting for 97 percent of the total production. To-date, the other 13 coal fields have limited potential. (Figure 23-C)

All mining in Utah is by underground methods. There is an estimated 200,000,000 tons of strippable coal in the Alton fields, located in western Kane County. The nearest railroad is at Cedar City, 60 miles distant on the westside of a high mountain range. No development is expected for some time.

The Book Cliffs coal field, Carbon County, is the leading producer. Much of the coal is metallurgical grade and is used by Kaiser Steel Corporation and United States Steel Corporation. Other markets are for powerplants, for industrial use, and for blending with other coking coals produced elsewhere.

The Book Cliff field is 20 miles long and 4 miles wide. Price, Utah is the major city in the area.

The Wasatch plateau field, located in Emery County, 30 miles southwest of Price, is the second major producer in the state. The Huntington Canyon powerplant site is in this field. The first 430 megawatt unit is scheduled for completion in 1977.

[?] Where a lease is in more than one county, it is shown with...

Reasons: 1. powerplants
2. blending (coke)
3. industrial
4. coking coal

There are six major coal fields in Utah: Wasatch Plateau, Book Cliffs, Kaiparowits Plateau, Emery, Alton, and Henry Mountains. The Wasatch Plateau and Book Cliffs fields are the sites of the present operations, accounting for 97 percent of the total production. To date, the other 13 coal fields have limited potential. (Figure 23-6)

All mining in Utah is by underground methods. There is an estimated 200,000,000 tons of strippable coal in the Alton fields, located in western Kane County. The nearest railhead is at Cedar City, 60 miles distant on the westside of a high mountain range. No development is expected for some time.

The Book Cliffs coal field, Carbon County, is the leading producer. Much of the coal is metallurgical grade and is used by Kaiser Steel Corporation and United States Steel Corporation. Other markets are for powerplants, for industrial use, and for blending with other coking coals produced elsewhere.

The Book Cliff field is 20 miles long and 4 miles wide. Price, Utah is the major town in the area.

The Wasatch plateau field, located in Emery County, 30 miles southwest of Price, is the second major producer in the state. The Huntington Canyon powerplant site is in this field. The first 430 megawatt unit is scheduled for completion in 1973.

The Kaiparowits plateau field, located in Kane and Garfield Counties, has the largest mineral reserve in the State. The coal is of lower quality than that from Book Cliffs or Wasatch Plateau. Interest in the field is in the southeast portion near Lake Powell.

No mining was being done in 1973, but the Kaiparowits powerplant is proposed for this location. A total of 6,000 megawatts is proposed by the end of the century. The first unit of 1,000 megawatts is planned for construction in 1980.

Coal requirements could reach 15,000,000 tons per year. Preliminary plans are for eight individual underground mines to supply fuel. The water needs would come from Lake Powell.

The Emery coal field is located at the south end of the Wasatch plateau in Emery and Sevier Counties. The area has been proposed as as powerplant site. However, other sites are more suitable, because of better water sources and transportation. The two operating mines haul to Price and Salina by truck.

The Henry Mountain coal field located in Garflield and Wayne County has no leases. It does have some potential areas for strippable coal. However, the remoteness of the area and lack of accessible water leaves development to the future.

The Alton and Kolob coal fields are west of the Kaiparowits plateau. The Kolob field produces coal for local residences, but no production has come from Federal leases. The coal is of lower quality than other sources in the state and there is no strong interest.

The Alton field, because of the estimated 200 million tons of strippable coal, has been studied as a possible powerplant site. The lack of a water supply plus higher sulphur content and ash will hinder development. There are 26,500 acres under lease.

Several other smaller fields produced coal for local use, but most are no longer in operation. The low interest is usually due to: potential reserves too small; seams dip steeply; coal seams are leaticular; have high ash contents or sulphur; and have low BTU value.

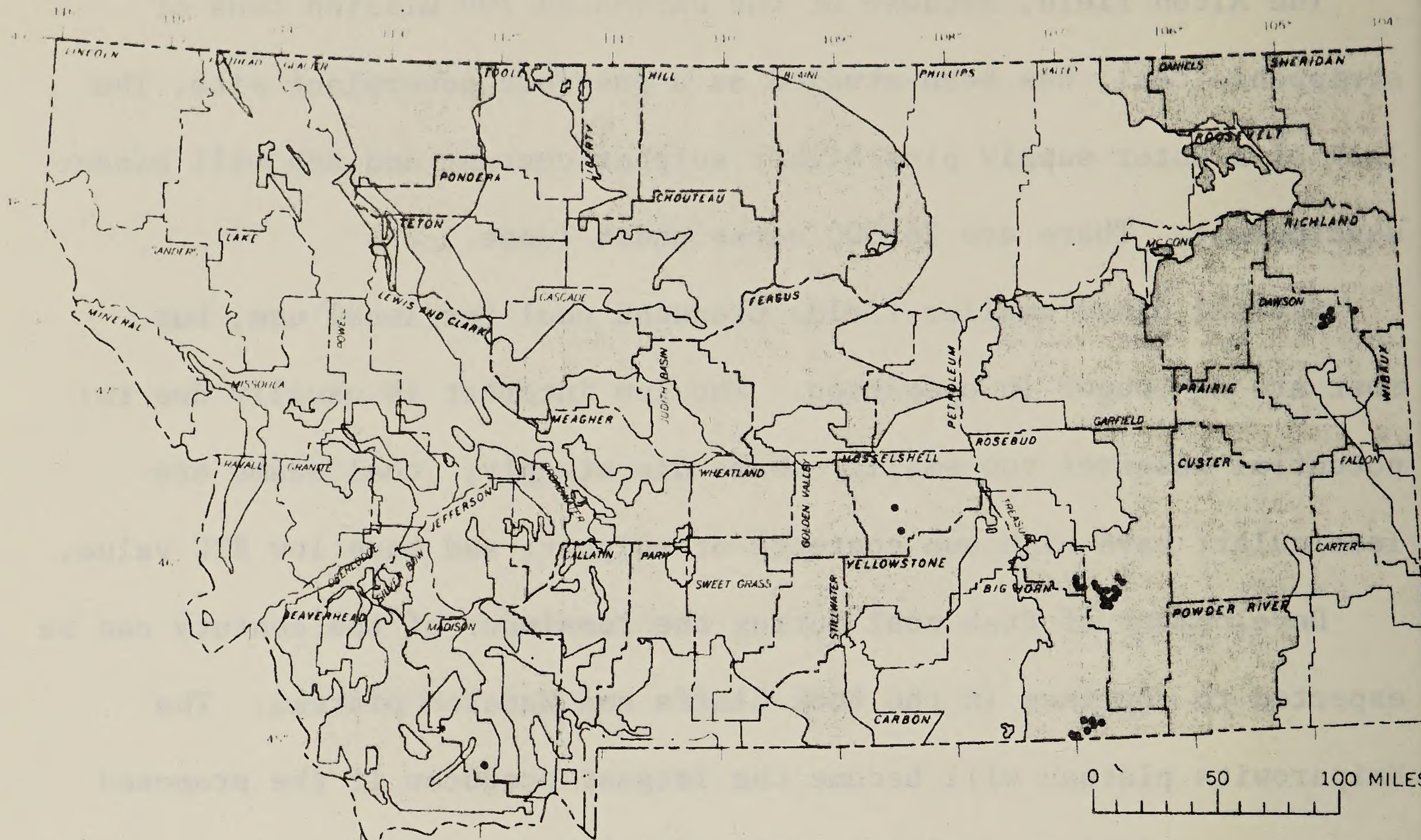
Development of Utah coal during the remainder of the century can be expected to continue in the Book Cliffs and Wasatch plateau. The Kaiparowits plateau will become the largest producer if the proposed electric generating complex is fully developed.

Montana

The 17 Federal coal leases active in Montana in 1973, are located in seven counties, as listed in Table 17. Areas underlain with coal and the locations of the leases are shown in Figure 23-D.

Table 17 - Federal Coal Leases in Montana in 1973

County	No. of Leases	No. Producing Strip	No. Producing Underground	Use
Big Horn	8	1		1
Dawson	2			
Madison	1			
Musselshell	2	1		2
Richland	1	1		1
Rosebud	3	2		1
Treasure	1			
Total	18 1/	5		



. Coal Leases

☐ Occurrence of Coal in Montana

Figure 23-D

/ Where lease is in more than one county, it is listed in each.

ses: 1. Powerplant
2. Local and domestic

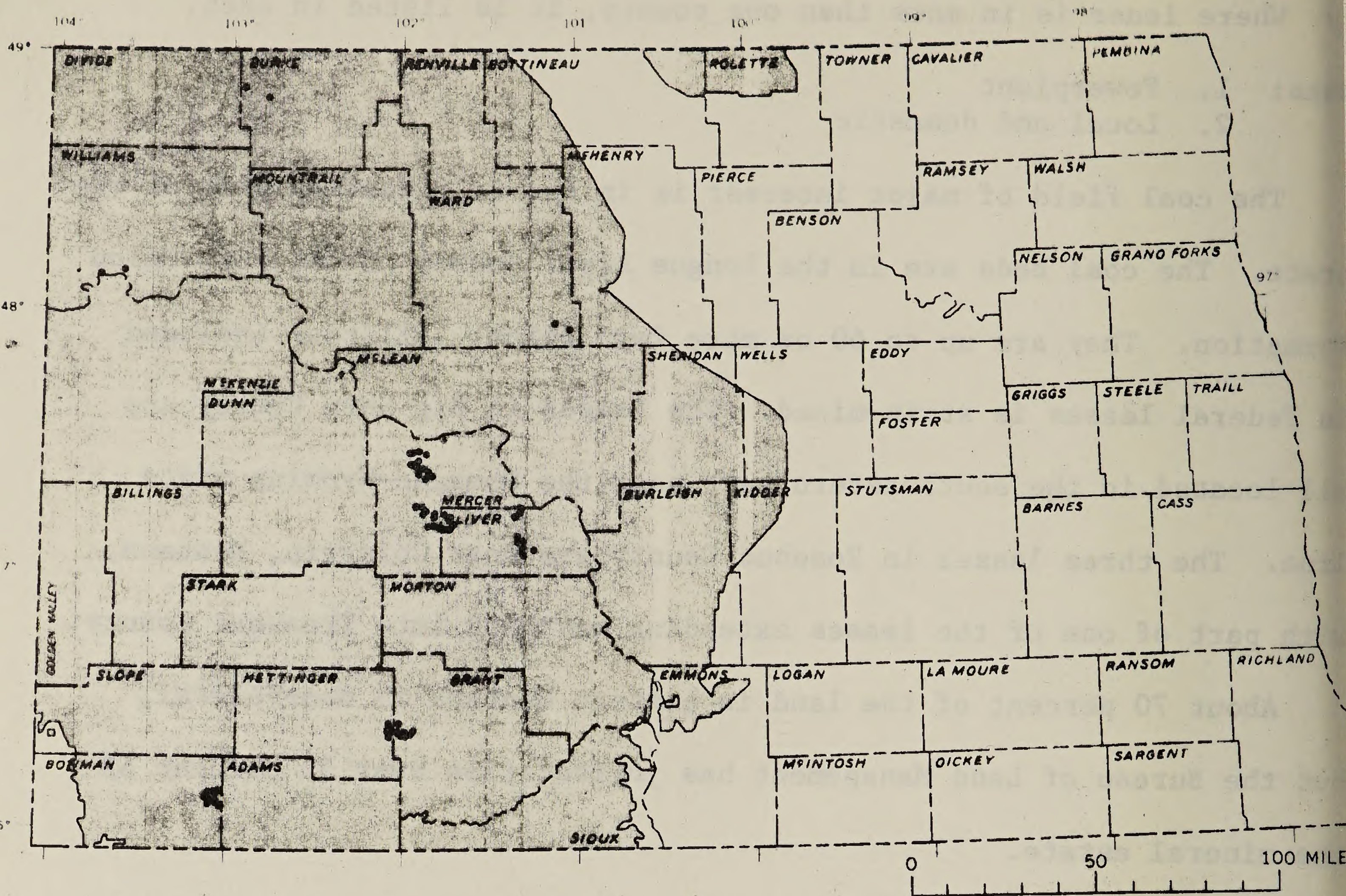
The coal field of major interest is in the southeastern part of the tate. The coal beds are in the Tongue River Member of the Fort Union 'ormation. They are up to 60 or more feet thick. All coal included .n Federal leases is strip-mined. The leases in Big Horn County are ll located in the southeastern part near the Montana-Wyoming state ine. The three leases in Rosebud County are near Colstrip, Montana, vith part of one of the leases extending westward into Treasure County.

About 70 percent of the land in eastern Montana is non-Federal, but the Bureau of Land Management has jurisdiction over 55 percent of the mineral estate.

One small strip-mine is operating in Musselshell County, south of Roundup. It supplies local demand for domestic space heating use.

In addition to existing leases, there are 18 applications for preference-right leases and four existing prospecting permits. The prospecting permits were issued several years ago and the holders can be expected to file for preference-right leases upon discovery of workable coal deposits.

In the past, considerable underground mining was done in the other coal fields in the state: Bull Mountain, Lewistown, Great Falls, Redlodge, etc. In 1973, there was only one operation on a Federal lease in those fields, a strip-mine in the Bull Mountain field. These fields



• Coal Leases

Occurrence of Coal in South Dakota

Figure 23-E

have one or more of the following drawbacks: underground operation, high sulphur and ash, steep dipping, low reserves, poor accessibility, and difficult mining conditions.

Indications are that mining of Federal coal in Montana will increase during the next 20 years to supply plants generating electricity.

North Dakota

The 20 Federal coal leases active in North Dakota, 1973, are located as shown in Figure 23-E

Table - Federal Coal Leases in North Dakota in 1973

County	No. of Leases	No. Producing Strip	No. Producing Underground	Use
Bowman County	2	1		1
Burke	2	1		1
Grant	3			
Hettinger	2			
Mercer	7	3		1
Oliver	4	3		1
Ward	2	1		1
Williams	2			
Total	24 1/	9 2/		

1/ Where lease is in more than one county, it is listed in each.
2/ Mines operating in more than one county are listed in each.

Uses: 1. Powerplant

The coal-bearing Fort Union Formation underlies the western half of the state. Most of the surface ownership is private, but about a quarter is of the mineral estate is Federally controlled. All coal included in Federal leases is strip-mined.

The four operating companies have seven mines located in Bowman, Burke, Mercer, Oliver, and Ward Counties.

While present use of the coal is for power plant fuel, future demand is expected for use in gasification. The lignites of the Fort Union Formation are susceptible to gasification. In anticipation of this use, large blocks of North Dakota lignite have been assembled by the operating companies and others. An economic gasification unit of 250,000,000 cubic feet of pipeline gas per day would require 10,000,000 tons of lignite per year, or 500,000,000 tons for a 50-year supply. Eight units are proposed and up to 20 units may be feasible, depending on available water and recoverable coal.

Most of coal being committed to gasification is privately owned. Three pending Federal lease applications cover 31,953 acres of government coal.

Alabama, Kentucky, and Ohio

There is relatively little Federal land in the eastern states. Those states in the Appalachian region have less than six and one-half percent Federal lands. Federal lands there usually have been acquired through purchase by a Federal agency for a special use, i.e., national forest, flood control, national park, military use, etc.

In Alabama, some lands were patented with minerals including coal, reserved to the United States. Much of the land is in isolated parcels, and the Federal Government may only have surface rights. If mineral rights were obtained, they may not be available for leasing because mineral development is not compatible with the present use. When leasing is permissible, leases may be obtained from the Bureau of

Table 19- Production and Income From Federal Coal Leases, Prospecting Permits, and Licenses 1/

	1957		1962		1967		1972	
	TONS	DOLLARS	TONS	DOLLARS	TONS	DOLLARS	TONS	DOLLARS
Alabama					134,164	20,495		100
Alaska	739,462	97,473	828,179	115,806	258,233	44,495	624,711	91,314
California				240		80		320
Colorado	530,648	77,235	500,000	87,654	2,030,000	346,875	2,386,000	509,911
Idaho		3,688						
Illinois		158	1,092	156		18,390		
Kentucky	21,370	3,224	13,398	4,295	123,466	197,756	363,689	95,135
Montana	25,385	14,537	155,598	15,328	115,000	27,324	81,562	42,500
N. Mexico	33,856	4,490	103,750	13,551	26,750	158,629	206,217	102,111
N. Dakota	412,080	47,107	366,379	38,004	590,000		1,360,940	202,276
Ohio						65,297		72
Oklahoma	420,139	90,558	248,699	72,253	143,831	4,167	410,427	153,356
Oregon	325	87	232		424	474,252	238	2,874
Utah	2,957,352	408,537	2,722,644	541,886	1,648,801	280	1,979,975	568,805
Washington		500		70				522
Wyoming	441,544	58,364	1,029,171	128,325	2,111,890	808,322	2,808,652	578,120
Others	125	53						220
Totals	5,552,286	806,011	5,969,142	1,017,568	7,182,559	2,167,471	10,222,411	2,347,636

1/ From Public Land Statistics, Bureau of Land Management

Land Management. Three existing leases in the Eastern and Interior Coal Provinces are located as follows: one of 282 acres in McCeary and Whitley Counties in southeastern Kentucky; one in Lawrence County, Ohio, of 144 acres; and one of 200 acres in Walker and Tuscaloosa Counties, Alabama, northwest of the center of the State.

Three competitive lease applications pending in 1973, were in Illinois, Pennsylvania, and Alabama. One prospecting permit for 880 acres is in West Virginia.

When leasing is permissible and mining is approaching an isolated tract it is usually desirable to lease to the mining operator. Otherwise the coal would be lost, since the amount of coal in the tract is usually insufficient for an independent mineable unit. Leasing would be under the short-term criteria set forth by the Secretary. Competitive bidding would be required and an environmental analysis made. Protective and rehabilitation requirements would be part of the lease terms.

The Bureau of Land Management's Eastern States Office, 7981 Eastern Avenue, Silver Springs, Maryland, 20910, administers these leases and permits.

b. Production and Receipts

Table 19 shows annual production and income from Federal coal by State. Income consists of payments for rentals, royalties, filing fees, and bonus bids at competitive coal lease sales.

Production from Federal coal lands was fairly constant at about five

Table 20 - Production and Income From Federal Coal Leases, Prospecting Permits, and Licenses, All States

Year	Tons	Dollars
1957	5,522,286	$ 806,011
1958	5,292,485	788,096
1959	5,016,167	957,048
1960	5,447,666	751,789
1961	5,419,326	830,949
1962	5,969,142	1,017,568
1963	5,175,348	912,154
1964	5,460,084	997,613
1965	6,166,066	1,149,021
1966	6,093,642	1,944,960
1967	7,182,559	2,167,471
1968	7,046,963	4,004,031
1969	7,346,070	2,042,048
1970	7,339,775	2,096,826
1971	10,250,468	9,836,313
1972	10,222,411	2,347,636

and one-half million tons per year from 1957 until 1965. It rose to seven million tons in 1967 and remained at about seven million tons until 1971 when there was a sudden increase to almost ten million tons. New mines in Wyoming contributed over one million tons of the increased production in 1971.

Income from Federal coal lands averaged about $800,000 from 1957 through 1961. It began to rise in 1962 and reached $2 million in 1967. Since 1967 total income varied from $2 million to almost $10 million.

The rise in production after 1965 and the rise of income after 1961 were caused by entrance of major eastern coal companies into western coal areas in the late 1950's and early 1960's.

The erratic nature of income after 1967 is attributable to bonus bid for competitive coal lease. Very high unit bids resulted when air quality standards increased the desirability of using low-sulfur western coal. Another factor was the entry of major oil companies into the bidding. No coal lease sales were held in fiscal year 1969, nor since June 30, 1971.

Trends in total Federal coal production and income, bonus bids per acre, and production and income by State are shown in Tables 19, 20, and 21. Figure 24 is a graph of production and income.

Table 21 - Bonus Bids on Federal Competitive Coal Lease Sales

1957 Through 1972

Year	Acres	Bonus Bids	Dollars Per Acre
1957	3,993	$ 6,297	$ 1.58
1958	15,375	19,176	1.25
1959	8,085	224,179	27.73
1960	4,358	9,055	2.08
1961	12,733	20,531	1.61
1962	38,976	202,404	5.19
1963	20,780	143,023	6.88
1964	10,788	39,532	3.66
1965	23,364	146,358	6.26
1966	44,894	753,727	16.79
1967	43,885	721,294	16.44
1968	88,037	3,077,736	34.96
1969	--	--	--
1970	18,493	370,395	20.03
1971	22,546	7,626,954	338.28
1972	--	--	--

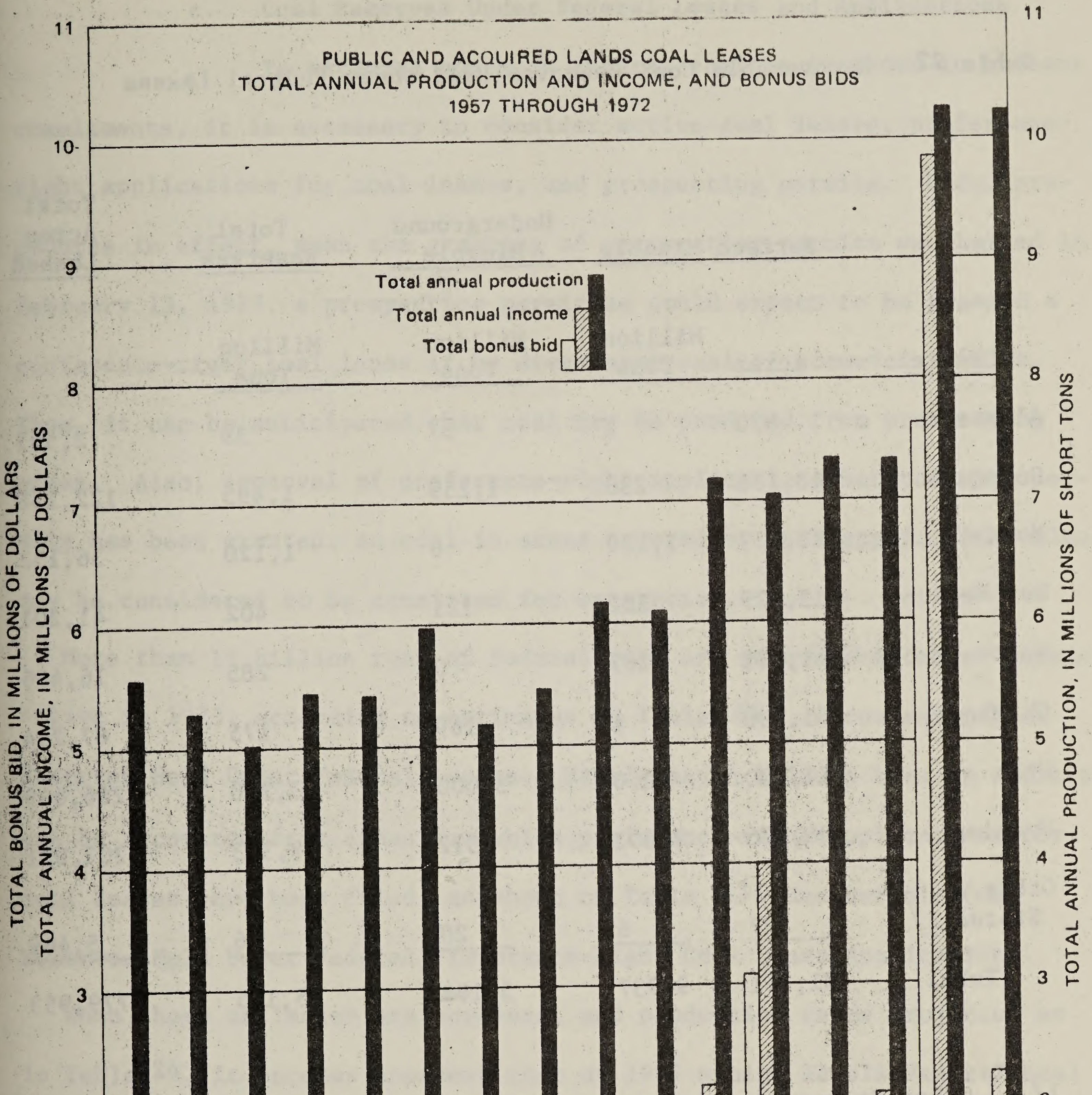

PUBLIC AND ACQUIRED LANDS COAL LEASES
TOTAL ANNUAL PRODUCTION AND INCOME, AND BONUS BIDS
1957 THROUGH 1972
Total annual production
Total annual income
Total bonus bid
TOTAL BONUS BID, IN MILLIONS OF DOLLARS
TOTAL ANNUAL INCOME, IN MILLIONS OF DOLLARS
TOTAL ANNUAL PRODUCTION, IN MILLIONS OF SHORT TONS
1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972

Figure 24

Table 22 - Recoverable Coal Reserves Held Under Federal Leases

State	Surface Minable Acres	Surface Minable Million Tons	Underground Minable Million Tons	Total Reserves Million Tons	Total Acres Leased
Alaska	870	2	37	39	2,593
Colorado	13,251	236	1,259	1,495	122,158
Montana	21,777	1,120	0	1,120	36,152
New Mexico	13,829	281	121	402	41,201
North Dakota	11,571	285	0	285	16,436
Oklahoma	1,790	6	169	175	87,254
Utah	11,500	200	3,000	3,200	266,669
Wyoming	106,276	7,801	592	8,393	202,021
Other States 1/	397	6	20	26	5,469
Total	181,261	9,937	5,198	15,135	779,953

1/ Other States are Alabama, California, Kentucky, Ohio, Oregon, Washington, and West Virginia

Source: Geological Survey, Conservation Division.

c. Coal Reserves Under Federal Leases and Applications

To estimate how much Federal coal is included in present commitments, it is necessary to consider active coal leases, preference-right applications for coal leases, and prospecting permits. Under procedures in effect, when the granting of prospecting permits was halted in February 13, 1973, a prospecting permittee could expect to be granted a preference-right coal lease if he discovered coal of commercial value. Thus, it can be anticipated that coal may be produced from prospecting areas. Also, approval of preference-right applications heretofore generally has been granted, so coal in areas covered by such applications also may be considered to be committed for extraction.

More than 15 billion tons of Federal coal are recoverable under leases active in 1973, according to estimates in Table 22, Recoverable Coal Reserves Held Under Federal Leases. Nearly seven billion tons in addition can be recovered from areas for which preference-right applications for coal leases have been filed, as shown on Table 23, Recoverable Coal Reserves Held Under Federal Preference-Right Coal Lease Applications.

When those estimates are combined, and production rates projected as in Table 24, it becomes apparent that at 1975 mining levels Federal coal already committed will last 540 years. Even with expected acceleration of mining rates, by the year 2000, there will be sufficient committed reserves of Federal coal to last 118 years. That would be true even if in the meantime, no additional Federal coal leases were to be issued. That estimate includes coal reserves, but not the total coal resources under lease. "Reserves" are quantities determined by detailed mapping and

Table 23- Recoverable Coal Reserves Held Under Federal Preference-Right Coal Lease Application 1/

	Surface Minable		Underground Minable	Total Reserves	Total Applicati
	Acres	Million Tons	Million Tons	Million Tons	Acres
Alaska	0	0	0	0	0
Colorado	3/	3/	3/	1,190	38,283
Montana	26,306	400	0	400	26,306
New Mexico	45,351	513	0	513	45,351
North Dakota	0	0	0	0	0
Oklahoma	0	0	15	15	3,810
Utah	1,920	17	421	438	26,586
Wyoming	36,575 4/	638 4/	2,876 4/	4,299 5/	154,421
Other States 2/	0	0	5	5	1,282
Total	110,152	1,568	3,317	6,860	296,039

1/ Includes only those lands and reserves where preliminary reserve calculations have been done. Other preference-right lease application lands considered as prospecting permit lands for purposes of this report.

2/ Other states include Alabama, California, Kentucky, Ohio, Oregon, Washington, and West Virginia.

3/ Reserves not yet split into underground and surface minable categor

4/ Represents minable reserves for northern one-half and southwestern one-quarter of Wyoming only. Reserves for southeastern one-quarter Wyoming not yet divided into surface or underground. Reserves for southeastern one-quarter Wyoming included in Total Reserves, Wyomin

5/ Includes 785 million tons recoverable reserves in southeastern one-quarter of Wyoming which have not been separated into or shown in this Table as either underground or surface minable.

Source: Geological Survey, Conservation Division drilling that are suited to extraction by current mining methods and economics. "Resources" represent all known coal within broad limits of thickness, grade, or overburden. Historically, about 50 percent of the total coal resource has been recoverable by underground mining methods and about 85 percent by surface mining methods. These estimates are primarily based on conditions and experience in the Eastern and Interior Coal Provinces. Recovery by surface mining in the Northern Great Plains and Rocky Mountain Coal Provinces probably will be close to 85 percent, also. However, recovery by underground mining methods may be less, because, paradoxically, the coal beds are thicker. Recoverability when beds are more than 15 feet thick decreases with increasing thickness, because of difficulties in supporting the overburden.

In the tabulations, tonnage figures represent recoverable reserves which could be removed from the coal lands using present technology. Mining losses have been deducted from the reserves given in the tables. Reserves were calculated by Federal geologists and engineers using data from published sources, government records, and leases and permittee exploration and mining information.

Factors limiting coal reserves vary with location and nature of the coal seams. Generally, coal seams greater than four feet in thickness and under less than 3,000 feet of cover were considered minable. The thinner of two underground minable beds within a 40 to 50 foot interval was excluded from reserves. Recoverability factors considered included pitch, rock partings, marketability, bed thickness, mining experience and technology, depth, and roof-floor conditions. Generally, surface minable re-

Table 24- Recoverable Coal Reserves on Federal Lands Committed to Leasing and Projected Production from Federal Coal Lease Lands for 1975 Through 2000

State	Total Recoverable Tons Committed to Lease Million/Tons	Production 1975 Estimated Million Tons/Year	Life of Reserves 1/ at 1975 Rate Years	Production 1980 Estimated Million Tons/Year	Production 1985 Estimated Million Tons/Year	Production 2000 Estimated Million Tons/Year	Life of Reserves 1/ at 2000 Rate Years
Alaska	39	0.1	390	0.1	0.2	0.2	195
Colorado	2,685	4.3	625	7.3	10.3	16.3	165
Montana	1,520	6.0	253	9.0	15.0	20.0	76
New Mexico	915	1.1	830	4.8	7.0	15.0	61
North Dakota	285	3.0	95	6.0	10.0	20.0	14
Oklahoma	190	1.0	190	1.5	2.0	3.0	63
Utah	3,638	3.0	1,210	6.9	20.0	30.0	121
Wyoming	12,692	18.9	670	34.2	46.5	70.8	179
Other States 2/	31	1.5	21	0.5	0.5	0.5	60
Totals	21,995	38.9	540	70.3	111.5	175.8	118

1/ Represents total of surface and underground minable recoverable coal under Federal coal leases and preference-right lease applications for which coal reserves have been calculated. Includes no reserves from the 336,769 acres of committed prospecting permit and preference-right coal lease lands for which reserve data is not available.

2/ Other states include Alabama, California, Kentucky, Ohio, Oregon, Washington, and West Virginia.

Source: U.S.G.S., Conservation Division

serves represent all coal beds four feet thick or thicker, lying within 150 to 200 feet of the surface in an area that could be surface mined by methods other than augering or contour stripping. Acres minable by underground methods are omitted. Except for states showing zero underground minable reserves, it can be assumed that most of the land contains multiple coal seams and, therefore, underground mining could occur on most of the lands listed under total acres.

Reserve calculations are not complete for Colorado and the southeastern quarter of Wyoming. Only total reserves for these areas, with no breakdown by mining method, are shown. Acres and tonnages given in the tabulation of preference-right lease application reserves are only those for which at least preliminary reserve calculations have been completed. A much larger acreage is actually under preference-right lease application.

In 1973, prospecting permits included the following acreages, for which tonnages of coal reserves had not been calculated:

State	Acres
Alaska	7,641
Colorado	94,128
Montana	10,878
New Mexico	32,958
Utah	106,755
Wyoming	77,823
Oklahoma	5,707
West Virginia	879
Total Acres	336,769

To summarize, in 1973 the following Federal acreages were committed, or tentatively committed, to coal mining:

Active Leases	779,953 Acres
Preference-Right Lease Applications	296,139 Acres
Active Prospecting Permits	336,769 Acres
Total	1,412,761 Acres

(Included with prospecting permits, but excluded from preference-right applications are 7,641 acres under preference-right applications for which coal reserves had not yet been estimated).

Total recoverable Federal coal reserves that are committed under preference-right lease applications, as calculated in June 1973, are:

	Surface Minable	Underground Minable	Total Minable
	Million Tons	Million Tons	Million Tons
Active Coal Leases	9,937	5,198	15,135
Preference-Right Applications	1,568	3,317	6,860
Totals	11,505	8,515	21,995

Projections of expected production, based on these estimates of committed Federal coal reserves, are shown in Table 24, Recoverable Coal Reserves on Federal Lands Committed to Leasing and Projected Production From Federal Coal Lease Lands for 1975 through 2000. The projections of production were estimated by Geological Survey mining supervisors who maintain close contact with lessees, coal consumers, and public agencies concerned with coal production.

d. Potentially Leaseable Coal

Although there are large tracts of Federally managed surface land, the Federal mineral estate and particularly the Federal coal resource is diversified and fragmented. In some cases only a partial interest is retained (for example: 3/16 interest). For this reason no precise national inventory or Federal coal has been completed. However, they are being prepared for specific areas.

Table 25 gives the general extent of Federal coal-bearing lands in eight principal states. It was compiled from tallies and estimates and indicates the ownership pattern in potential coal leasing areas. The largest Federal coal areas are in Wyoming with lesser amounts in Colorado, New Mexico, North Dakota, and Utah. Although Alaska with 22 million acres appears to be the largest, pending claims under the Native Claims Act and selections by the State of Alaska will probably transfer a large portion of this out of Federal jurisdiction.

No tabulations of Federal coal reserves have previously been completed, partly because of the complex ownership problem and partly because of the lack of detailed geologic information in all areas. A rough approximation can be made from the fact that the published calculated reserves for a given area are generally proportionate to the area distribution of coal. Also, it was assumed that the ratio of Federal to non-Federal ownership that exists in the general coal-bearing areas would exist in the reserve areas.

Table 25- States With Major Federal Coal Acreages

State	Federal Coal 1/ 2/ Million Acres	Percent	Non-Federal Coal Million Acres	Percent	Total 2/ 3/ Million Acres
Alaska	23.4	97	.8	3	24.2
Colorado	8.7	53	7.9	47	16.6
Montana	24.6	75	8.2	25	32.8
New Mexico	5.5	59	3.9	41	9.4
North Dakota	5.6	25	16.8	75	22.4
Oklahoma	.4	4	8.9	96	9.3
Utah	4.1	82	.9	18	5.0
Wyoming	12.3	48	13.3	52	25.6

1/ Southwestern Energy Study, Appendix J, p 48, 1972.
2/ BLM State Office Estimates
3/ Averitt, Paul, Coal Resources of the U.S., January 1, 1967: U.S. Geological Survey Bulletin 1275, p. 32, 1969.

Using these premises, Table 26 was compiled showing the tons of strippable and underground coal by state and the approximate value of the coal in Federal ownership based on present prices. It should be emphasized that these figures are very general and are given only to show the magnitude and relationships in different areas.

Excluding Alaska again, it is apparent that interest in future Federal coal leasing will generally focus around coal deposits, in

Wyoming, Utah, and Colorado and to a slightly lesser extent in North Dakota and New Mexico.

Current applications and new coal leases are being adjudicated in accordance with the Secretary's new coal leasing policy of short and long term criteria. The short-term actions are temporary measures designed to meet existing and immediate needs for Federal coal resources while striving to minimize environmental impacts. Individual lease applications will be processed on a case-by-case basis in accordance with the above criteria. The long-term actions look toward development and use of a system for determining the size, timing, and place of coal leases. This system is being developed by BLM and is called EMARS, (Energy Minerals Allocation Recommendation System). However, until EMARS is fully operational, the short-term leasing program is being used.

Table 26 - Estimate of Federal Coal Reserves* and Values In Principal Leasing States for Surface and Underground Deposits

		Total Reserve (1) (2)	Federal Reserve (3)	Total Value of Federal Reserve (4)(5)(6)
		Million Short Tons	Million Short Tons	Million Dollars
Alabama	- Surface	134		
	Underground	7,537		
Alaska	- Surface	4,411	4,279	
	Underground	60,629	58,810	466,228
California	- Surface	25		
	Underground	294		
Colorado	- Surface	500	265	
	Underground	39,829	21,111	125,050
Montana	- Surface	6,897	1,700	
	Underground	103,940		
New Mexico	- Surface	2,457	1,450	
	Underground	28,239	16,661	53,123
North Dakota	- Surface	2,075	519	
	Underground	173,240	43,310	344,167
Oklahoma	- Surface	111	4	
	Underground	1,529	61	410
Oregon	- Surface			
	Underground	167		
Utah	- Surface	150	123	
	Underground	11,714	9,605	70,820
Washington	- Surface	135		
	Underground	2,984		
Wyoming	- Surface	13,971	6,706	
	Underground	46,357	22,251	87,480

Table 26 - (Continued)

(1) U.S. Bureau of Mines, I.C. 8531: Strippable Reserves of Bituminous Coal, and Lignite in the United States, p. 23, 1971

(2) Averitt, Paul, Summary of U.S. Mineral Resources, U.S. Geological Survey, p. 820, 1972.

(3) Computed from estimated ownerships ratios given in Table

(4) Synthetic Fuels, Cameron Engineering, Vol. 9, No. 2, June 1972, p. 4-31.

(5) 1972 Keystone Coal Industry Manual, McGraw-Hill, p. 429.

(6) Bituminous Coal Facts, 1972, National Coal Association, p. 68.

* Refers to coal that can be recovered with existing technology and equipment or that may be avialable in the forseeable future. Only those coals less than 3,000 feet in depth are included. Strippable coal resources are adjusted to conform to the stripping ratio which varies by area. Coal that cannot be mined because of proximity to natural or man-made features is excluded.

II ENVIRONMENT WHERE FEDERAL COAL OCCURS

Nearly all Federal coal resources are found in the Northern Great Plains Coal Province and the Rocky Mountain Coal Province. The other four coal provinces in the country contain only minor amounts of Federal coal. Their environments are described only briefly and in the broadest terms, since environmental analysis in these diverse coal provinces will be prepared on a case-by-case basis.

Existing environments of the two coal provinces of major importance for Federal coal leasing are described. Environmental components described include: geology, topography, climate, hydrology, soils, vegetation, and wildlife. Current land uses are described in terms of agriculture, forest products, livestock range, wild horse and burro habitat, watershed, mining, recreational, and urban uses.

Human population patterns and considerations are described as to their social, economical, political, and cultural/regligious conditions. Less tangible, but very important human-value resources of the environment are the esthetic, historic, archeologic, and geologic features on and adjacent to Federal lands in the coal provinces.

Ecological Interrelationships. All organisms share a common need to satisfy the requisites (food, shelter, moisture, respiratory gases, etc.) for continuing life and reproducing kind. A vast array of interactions serves to meet these environmental dependencies. These interactions include relationships between the individual organism and organisms of the same and of different kinds, and between the organism and its non-living environment (Kormondy, 1969).

Abiotic (non-living) Environment. Ecological interrelationships occur in physical-chemical settings of non-living or abiotic environmental components. These include basic chemical elements and compounds such as water and carbon dioxide, calcium and oxygen, carbonates and phosphates, and organic compounds which are the by-products of organism activity or death. There are also such physical factors and gradients as moisture, winds, air currents, and solar radiation with its concomitants or light and heat. Within this abiotic environment, living organisms interact in a fundamentally energy-dependent fashion (Kormondy, 1969).

Biotic (living) Community. Living organisms - plants, animals and microbes - form biotic communities which occupy a complex of environments. These organisms compete for the life-sustaining light, warmth, atmospheric gases, water, and nutrients provided by the abiotic environment. Each in its turn creates part of the environment affecting the others (Spurr, 1964). These organisms are of two major kinds, autotrophic and heterotrophic. Autotrophic organisms are self-nourishing; heterotrophic organisms meet nutritional needs by feeding on other organisms. More specific classification is according to function, as follows:

Producers are autrophic organisms which are able to manufacture food from simple inorganic substances (Odum, 1959). In this process, radiant energy (sunlight) is used to convert carbon dioxide, water, and nutrient minerals into carbohydrates that serve as food for the producer's own growth and metabolism (Kormondy, 1969). Producers are largely the green, chlorophyll-bearing plants - the trees of a forest, the grass of a field, the algae of a pond. Of less significance as producers are phyotosynthetic and chemosynthetic bacteria.

Consumers are heterotrophic organisms, chiefly animals, which ingest organic matter. A primary consumer (herbivore) derives its nutrition directly from plants; a secondary consumer (carnivore) obtains its nutrition indirectly from the producer by feeding on the primary consumer. Included in the consumer class are mammals, birds, reptiles, fish, worms, parasitic fungi, and certain bacteria.

Decomposers are heterotrophic organisms which reduce, or break down, complex organic compounds, absorb some of the products of decomposition, and release the remainder in simple forms usable by the producers. Bacteria and fungi are the chief decomposers, but such macro-organisms as millipedes, earthworms, and mites also reduce complex organic compounds.

Ecosystems. A general abiotic environment and associated biota (a general biotic community) together comprise an ecological system, or ecosystem (Kormondy, 1969), in which living organims and non-living matter interact to produce an exchange of materials between the living and non-living parts. An ecosystem, then, is a complex of vegetation, bacteria, fungi, protozoa, arthropods, various other invertebrates,

vertebrates, oxygen, carbon dioxide, water, minerals, and dead organic matter. Such a complex is never completely in balance; an ecosystem is constantly changing diurally, seasonally, and with long-term climatic cycles (Spurr, 1964).

Resisting sudden, radical changes are checks and balances, forces and counterforces, which maintain a semblance of equilibrium between organisms and environment, thus tending to stabilize the ecosystem as a whole. These factors are known as homeostatic mechanisms (Odum, 1959). These include processes which regulate the storage and release of nutrients, the growth of organisms, and the production and decomposition of organic substances. As an example of the function of these mechanisms, consider the rate of photosynthesis of a whole biotic community. This may be much less variable than that of individual organisms or species within the community because, when one individual or species slows down its rate, another may accelerate in a compensatory manner. As another example, when treated sewage is discharged into a stream at a moderate rate, the aquatic ecosystem is able to purify itself by homeostatic processes and to restore its previous quality within a few miles downstream. These mechanisms are not yet fully understood, but their important role in maintaining a natural ecological balance is known and recognized.

While the abiotic (non-living) environment controls the activities of organisms, the latter influence and control the abiotic environment in many ways. Changes in the physical and chemical nature of inert materials are constantly being effected by organisms which return new compounds and isotopes to the non-living environment. Such organic influence can be very strong and its products significant; e.g., plants build soils which are radically different from the original substrates (Odum, 1959).

When the environment changes as a result of actions of organisms that increase soil fertility, or because of decreased light intensity, climatic variation or any other modification, conditions may become favorable for some organisms other than those already present. There may then be replacement of one species by another or of one biotic community by another, with more replacements following in later succession (Spurr, 1964).

Radiant energy, in the form of sunlight, is the ultimate source of energy for any ecosystem. Energy flow, the nutrient cycle, and the hydrologic cycle are fundamental processes which give life to an ecosystem.

Energy Flow. Chlorophyll, the green coloring matter of plants, converts carbon dioxide and water, in the presence of sunlight, into carbohydrates, with oxygen as a by-product, by a process known as photosynthesis. In effect, photosynthesis transforms radiant energy into chemical energy which nourishes the producer plant. During the process, the green plant also incorporates into its protoplasm a variety of inorganic elements and compounds. As the plant is utilized by herbivores, its stored chemical energy (and nutrients) are transferred to the con-

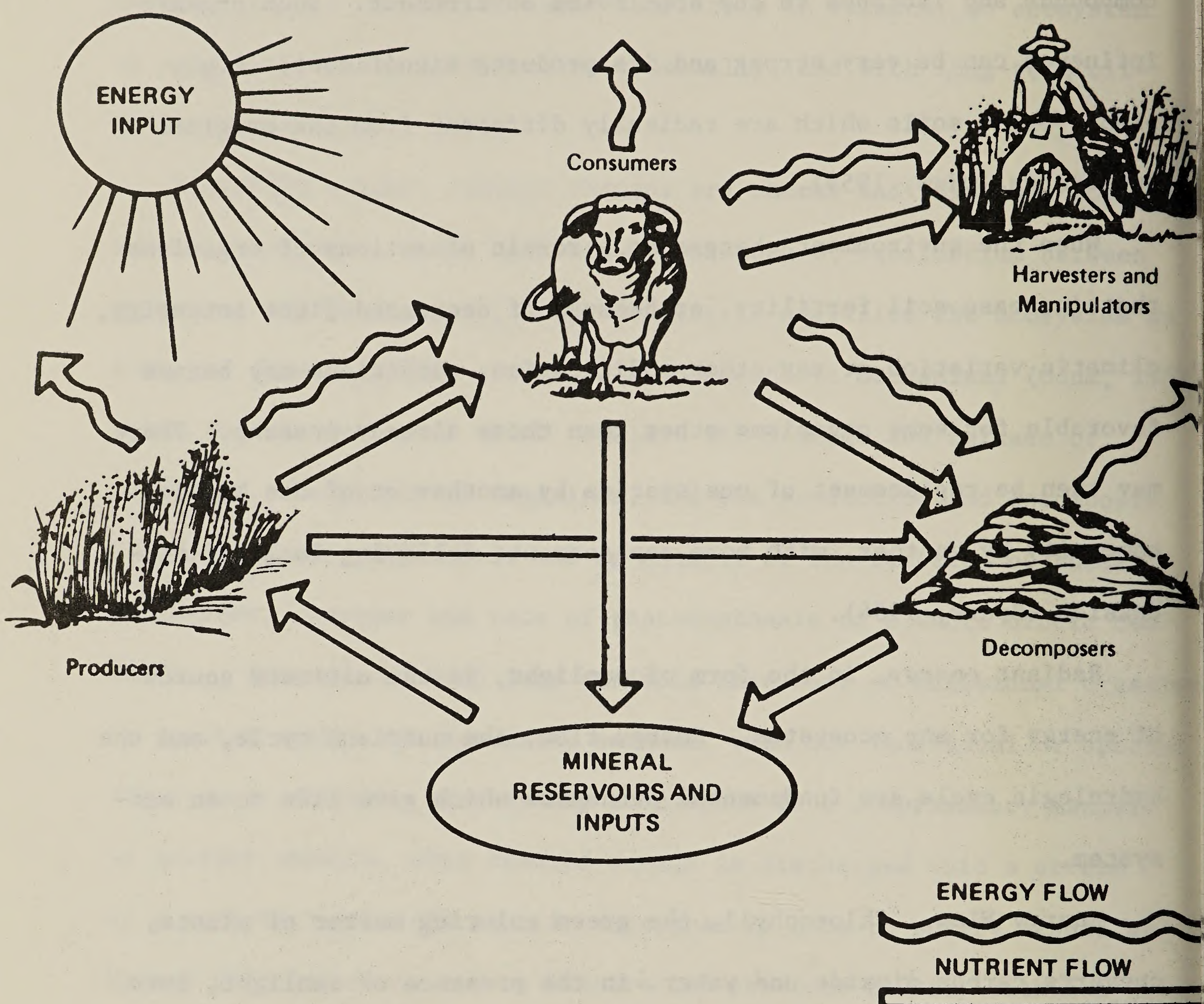


FIGURE 25 A SCHEMATIC ILLUSTRATION OF PATHWAYS OF FLOW OF ENERGY AND MATTER THROUGH A TERRESTRIAL ECOSYSTEM.

SOURCE: Van Dyne, G.M. 1969. "Some Mathematical Models of Grassland Ecosystems," P. 6, in R.L.Dix and R.G.Beidleman (ed.), "The Grassland Ecosystem : A Preliminary Synthesis." Range Science Department Science Series No. 2, Colorado State University, Fort Collins, Colorado.

sumers. Likewise, there follows a transfer of energy (and nutrients) from herbivores to carnivores and eventually to the decomposers. Figure 25 shows a schematic pathway of emergy and matter flow through an ecosystem.

This energy flow is one-way and noncyclic because, at each transfer along the food chain, energy losses occur. Within each link of the chain, beginning with the producer plant itself, some of the nutrient matter is used to build protoplasm while the stored energy in the reamining food serves as fuel for metabolism and movement. These activities convert the stored energy to heat, which is dissipated into the atmosphere and thus lost from the ecosystem. Thus, energy flows through the ecosystem; it does not cycle. Life is sustained by continually acquiring solar radiation with its influx or new energy (Kormondy, 1969).

Nutrient Cycle. Nutrients produced by green plants via photosynthesis are primarily simple carbohydrates (glucose). Two minor groups of producers, the photosynthetic bacteria and the chemosynthetic bacteria, use methods other than the process used by green plants to create carbon compounds to nutrient value. Further chemical changes, which occur with successive utilization along the food chain, convert the simple products of synthesis into more complex carbohydrates, proteins, fats, and other nutrients.

These foods continuously circulate throughout the ecosystem from environment to producer, from producer to consumer, from consumer to

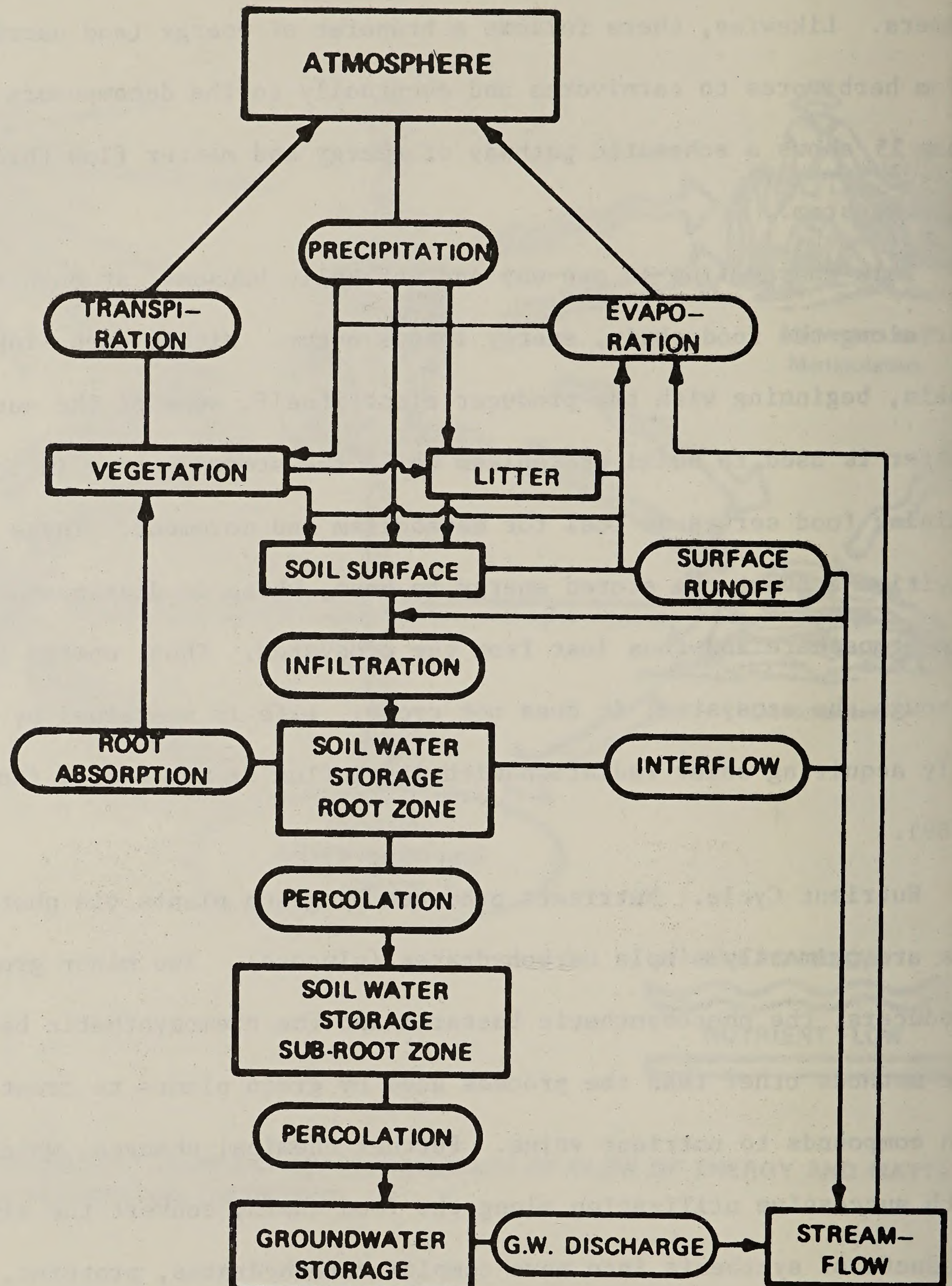


FIGURE 25A FLOW DIAGRAM OF THE GRASSLAND HYDROLOGIC CYCLE

SOURCE: Striffler, W.D. 1969. "The Grassland Hydrologic Cycle," P. 103, in R.L.Dix and R.G. Beidleman (ed.), "The Grassland Ecosystem : A Preliminary Synthesis." Range Science Department Science Series No. 2, Colorado State University, Fort Collins, Colorado.

decomposer, and from decomposer back to the environment, where they are potentially available for recyclying. Thus, nutrients remain in the ecosystem; they are not lost in the manner of energy (Kormondy, 1969).

As the decomposers satisfy their own needs for growth and metabolism they concurrently perform an invaluable service to the ecosystem; this is the mineralization of organic matter. By their digestive activity, the decomposers release basic elements (nitrogen, phosphorus, potassium, calcium, etc.) to the environment for reuse by producers. These elements are stored in the soil until extracted by the roots of vegetation, sometimes with the aid of mycorrhizal fungi (consumers) associated with the roots, thus completing the cycle. Elemental nitrogen released from organic compounds by decomposers may be transformed into nitrate (the nitrogen derivative most readily used by green plants) in the soil, and stored there, or it may be released into the air. Atmospheric nitrogen is continually returning to the nutrient cycle through the action of nitrogen-fixing bacteria, streptomycetes, algae, or natural electrification by lightning.

Hydrologic Cycle. The nutrient cycle is made possible only by the circulation of water from soil to roots of vegetation, to the atmosphere, and from the atmosphere back to the soil. Soil nutrients must be in an ionic state, in solution, to be absorbed by root systems; this requires the presence of soil moisture (Spurr, 1964). Water also controls the rate of nutrient movement through the conductive tissue of plants, the decomposition of plant litter, and the development of the soil profile which, in turn, affects the availability of nutrients to plant roots as recycling begins. The hydrological cycle is shown in Figure 25A.

A major feature of the hydrologic cycle is the interchange of moisture between the earth's surface and the atmosphere via precipitation and evaporation. Significant amounts of water are used by the biota of ecosystems, and there is a substantial return of moisture to the atmosphere by transpiration from living plants, as well as by evaporation. The relative and absolute amounts of precipitation and evaporation significantly influence the structure and function of ecosystems (Kormondy, 1969).

In its broadest sense, the hydrologic cycle involves the oceans, continents, the fresh waters and the Earth's atmosphere. At the level of the ecosystem, the cycling of water includes precipitation from the atmosphere, runoff in the form of stream flow, and a series of intermediate processes influencing the precipitation-runoff relationship. Among these are interception of precipitation by vegetative cover, infiltration and percolation of water through the soil, evapotranspiration from soil and vegetation, surface runoff, and water storage at various levels of the system.

Ground water is an integral part of the hydrological cycle. The ground water reservoir is recharged wherever permeable rocks crop out and water, from either direct precipitation or surface runoff, can infiltrate and flow downward by gravity. Once in the subsurface, ground water remains in the hydrological cycle by moving downgradient (from areas of high pressure to areas of low pressure) through permeable rock to points of ground-water discharge. Ground water can be discharged, to complete the cycle, by many means such as through springs, to streams, by evaporation where ground water is at or very near the land surface, by transpiration where ground water is in proximity to root systems, directly to oceans, or mechanically through pumping wells which penetrate aquifers. Aquifers are water-saturated rocks that transmit and yield water in useful quantities.

Ecological Variations. Different ecosystems may vary widely in productivity, one index of which is the amount of vegetation produced over a given period of time. Although biomass (the total weight of the biota, including stored food) is not a consistent measure of productivity, high rates of primary production are often associated with large biomass.

Variations in productivity from ecosystem to ecosystem are due primarily to differences in climate and soil. These factors control energy flow, nutrient cycling, the vital processes by which the ecosystem lives. Generally, productivity is highest in ecosystems where abundant solar energy, ample precipitation, and soils rich in nutrients promote rapid nutrient cycling and growth. The stability of the plant community is related to its productivity. Communities with low productivity are generally fragile, while highly productive communities generally recover rapidly from the impacts of heavy use of other disturbance (Darling and Milton, 1966).

A. Pacific Coast Coal Province (Including Alaska)

1. Geology

Coal fields in Washington, Oregon, California, and Alaska comprise the Pacific Coast Coal Province.

a. Coal Areas in Washington, Oregon, and California

The principal coal fields of the states along the Pacific coast lie in the Pacific Mountain physiographic system which extends through California and the western parts of Oregon and Washington as a series of two major mountain chains and a series of intermontane basins and troughs, (Fenneman, 1931). The system includes two principal physiographic provinces. The Pacific Border province is characterized by a chain of mountains along the coast and a broken line of valleys east of these mountains. The Cascade-Sierra Mountain province paralleling it to the east, includes the Cascade mountains of Washington Oregon, northern California, and the Sierra Nevada mountains in southern California.

The mountains of these provinces consist of metamorphic and sedimentary rocks, granitic intrusive rocks, Tertiary basin-fill deposits, and extensive areas of volcanics. The mountains are due in part to igneous intrusions and crustal movement and in part to volcanic accumulation. The topography ranges from rolling hills and flat alluvium-filled valleys to towering volcanoes along the rugged crest of the Cascades.

In California, scattered small deposits of coal are reported throughout the state in 43 counties, but mining or intensive prospecting has been carried on at less than a dozen localities. The coal is mostly Eocene and Miocene in age and ranges in rank from lignite to high-volatile B bituminous. The higher rank coals are largely due to structural deformation and are found in the highly folded and faulted rocks along the Coastal Ranks, (Landis, 1966).

Oregon also has many small deposits of coal scattered across the southwestern and northern parts of the state. Early mining activity was concentrated in the Eocene Coaledo Formation in the Coos Bay field near the coast, but thin beds, faults, and steep dips made mining difficult. Coal deposits in the state range from sub-bituminous C at Coos Bay to bituminous rank in the unique deposits in the John Day basin area. At the John Day area, coals ranging as thick as three feet are reported enclosed by tuff and interbedded flows of andesite and other igneous material in the Mascall Formation of Miocene age. In southwestern Oregon, coals of the Eocene Umpqua Formation are covered by extensive lava flows, (Mason, 1969).

Washington has larger and more extensive coal deposits than does Oregon. The coal deposits range in rank from lignite to anthracite, but most are sub-bituminous and bituminous. Some are of coking quality. The coal is mostly Eocene in age, but ranges from Pre-Tertiary to Miocene. The moderately high ranks of the Eocene coals are largely due to compression during intense structural deformation. High ash contents of some of the coals was caused by volcanic ash falls during accumulation of the coal, (Beilkman and Gower, 1960).

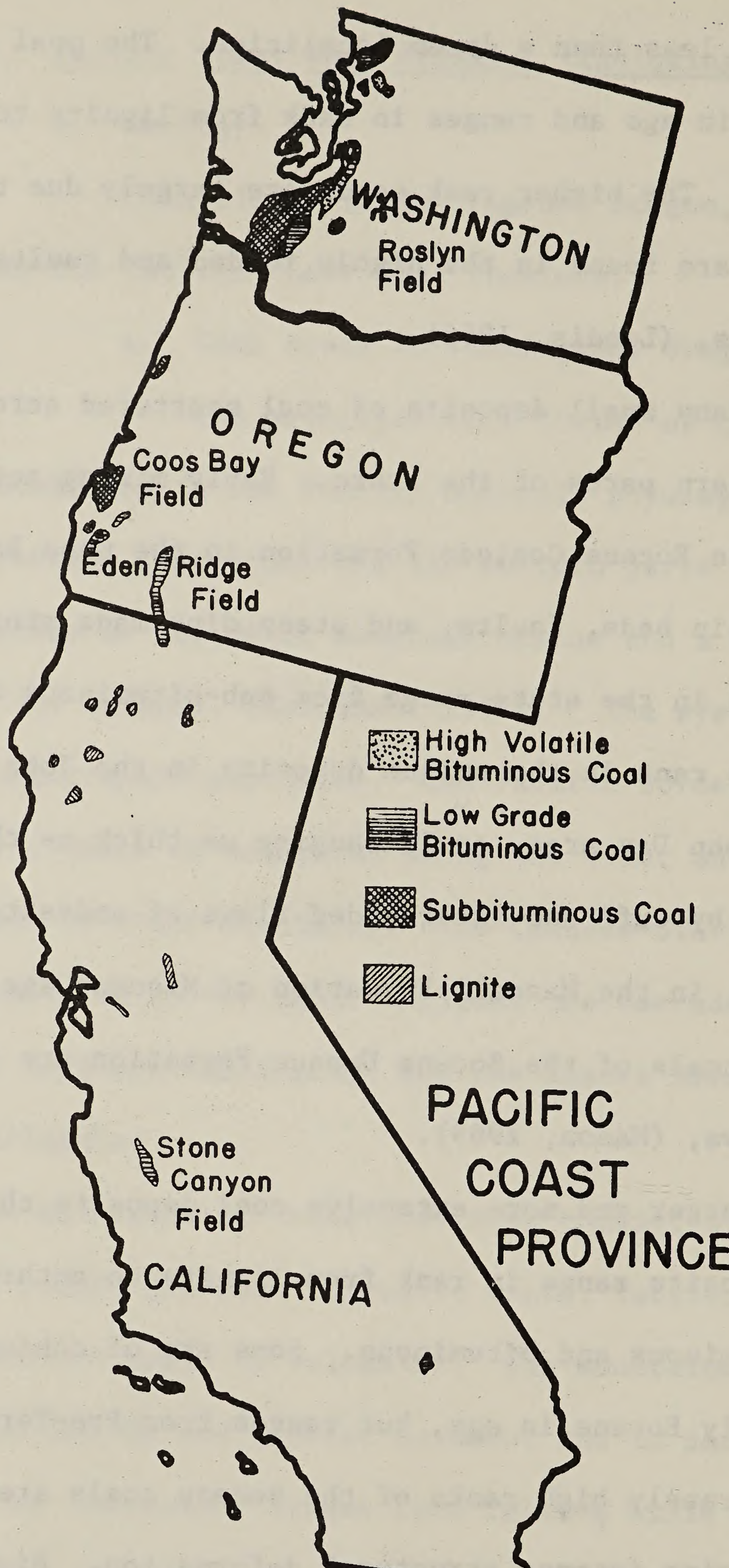

WASHINGTON
Roslyn Field
OREGON
Coos Bay Field
Eden Ridge Field
High Volatile Bituminous Coal
Low Grade Bituminous Coal
Subbituminous Coal
Lignite
PACIFIC COAST PROVINCE
Stone Canyon Field
CALIFORNIA

Figure 26


NORTHERN ALASKA FIELDS
ALASKA
High Volatile Bituminous Coal
Lignite
Subbituminous Coal
EAGLE FIELD
NENANA FIELD
JARVIS CREEK FIELD
BROAD PASS FIELD
SUSITNA FIELD
KENAI FIELD
BERING RIVER FIELD
CHIGNIK FIELD
HERENDEEN BAY FIELD
UNGA ISLAND FIELD

Figure 27

The principal coal areas lie along the western margin of the Cascade range in a discontinuous belt that extends from the Canadian border south to the Columbia River. However, the major coal-producing area has been the Roslyn field on the east flank of the mountains. In the Roslyn area, several coal beds ranging as thick as seven feet are mined. The coals increase in value and rank to the west toward the mountains.

The Centralia-Chehallis district on the west side of the mountains extends over an area of more than 200 square miles. In this area, coal beds are contained in the Upper Eocene Skookumchuck Formation and are of generally lower rank, ranging from lignite to sub-bituminous B, but are also of greater thickness, ranging as thick as 40 feet.

Most of the coal areas of Washington are characterized by gently to steeply-dipping strata, faults, and locally extensive glacial cover that makes prospecting and surface tracing of the coal beds difficult.

b. Coal Areas in Alaska

In Alaska there are some known coal fields, other areas only partially explored that are considered to be underlain by coal-bearing rrrocks, and numerous reported occurrences scattered nearly throughout the state. Coal occurs in all of the major physiographic areas, (Barnes, 1960), but appears concentrated in the Interior Plains on the north coast, and in the Pacific Mountain System in the southern part.

The principal recognized coal fields, or regions in Alaska are:

Central Alaska, Cook Inlet-Susitna, Alaska Peninsula, and Southeast Alaska regions in the Pacific Mountain System; and the Northern Alaska region that lies partly in the Arctic Coastal Plain and partly in the Arctic foothills of the Rocky Mountain System, (Barnes, 1964) and (Wahrhaftig and Gates, 1964).

The Pacific Mountain System parallels the south coast curving around the Gulf of Alaska. It consists of two mountainous belts separated by a series of discontinuous depressions. The Pacific Border Ranges province is a northern equivalent of the Pacific Border province that extends along the west coast of the United States. In Alaska, the mountains of the province have been heavily glaciated and the topography which ranges from 0 to 19,000 feet in altitude, is extremely rugged, and is characterized by horns, cirques, aretes, and U-shaped valleys.

The Coastal Trough province separates the two rugged mountain provinces of the system. It consists of the Copper River Lowland and the Cook Inlet-Susitna Lowland which contains one of the principal coal regions of Alaska.

The Alaska-Aleutian province forms the northern part of the Pacific Mountain System. The province consists of the Coast Mountains, the Alaska Range, the Aleutian Range, and the Aleutian Islands. These mountains resemble the Pacific Border Ranges in most respects in that they are high, glaciated, and rugged with altitudes that range from sea-level to higher than 20,000 feet at Mount McKinley.

The Intermontane Plateaus system lies between the Alaska and Brooks Ranges. It is an assemblage of dissected uplands and broad alluvium-floored lowland basins largely drained by the Yukon and Kuskokwin River systems. Several occurrences of coal are reported in this area which encompasses most of the Central Alaska coal region, but deposits have been mined only for river boat usage. The active Nenana field, considered geographically a part of this coal region, lies south of Fairbanks in the northern foothills of the Alaska Range.

The great Northern Alaska coal region lies partly in the Arctic Foothills of the Brooks Range (Rocky Mountain System), and partly in the Arctic Coastal Plain, the Alaskan counterpart of the Interior Plains System of the conterminous United States. The Arctic Coastal Plain is a smooth plain rising imperceptibly from the Arctic Ocean to a maximum altitude of 600 feet at its southern margin. The plain is almost without relief except for low hills and is characterized by thousands of lakes and swamps.

The Arctic Foothills province lies above 600 feet altitude and consists of rolling plateaus and low linear mountains rising southward up to the broad northern flanks of the Brooks Range.

Northern Alaska Coal Region. Upper Cretaceous coal-bearing rocks underlie an estimated 27,000 square miles beneath an area north of the Brooks Range and west of the latitude of the Colville River. These beds have been moderately to gently folded, increasing in intensity to the south toward the mountains. Some 37 bituminous coal beds ranging from three to fifteen feet thick crop out along the banks of the major rivers in the area. These outcrops suggest that much, if not most, of the entire area is underlain by coal beds. Coal-bearing rocks of Paleozoic aage are present along the northwest coast. Though high in rank, they are structurally complex and probably of little economic value.

Central Alaska Coal Region. The Central Alaska coal region includes the coal fields of the Intermontane Plateaus System. The coal of this region is mainly of late Cretaceous and Early Tertiary in age with at least one locality reported in the Nation River Formation of Paleozoic age. The coal on the region is reported to range from lignite to good bituminous in rank, and as thick as nine feet of clean bituminous coal on the middle fork of the Koyukuk River and 85 feet of lignite in the Seward district. The localities are mostly small isolated exposures, and though several outcrops might be present in an area, surficial cover or structural complications commonly preclude tracing particular beds any great distance. The Nenana field is included in the Central Alaska region by Barnes (1964), but physiographically it lies in the Northern foothills province of the Alaska Range. The coal field extends for about 80 miles along the north flank of the mountains ranging from one mile to more than 30 miles in width. The sub-bituminous coal beds are from a few inches to 60 feet in thickness and are contained in Tertiary rocks that have been folded and faulted into a series of basins.

Cook Inlet-Susitna Coal Region (The Susitna-Kenai Coal Fields). Lying within the Coastal Trough physiographic province, the Cook Inlet-Susitna coal region is bounded on the north and west by the Alaska Range and on the south by the Kenai-Chugach mountains. The area includes a long narrow wedge of moderately-deformed marine clastic rocks of Late Mesozoic age and predominantly non-marine, poorly-consolidated Tertiary coal-bearing rocks that overlie older rocks. The coal of the several fields within the region ranges from lignite to Susitna to anthracite in the vicinity of thick sills intruded into the Chickaloon Formation at Matanuska. Thickness ranges from as thick as 23 feet for high-volatile biuminous coal at Matanuska to more than 50 feet of lignite in the Susitna field. Most of the region is complicated by folding and faulting in the enclosing beds.

Alaska Peninsula Region. Coal of Cretaceous and Tertiary age is present on the Alaskan Peninsula. The beds are variable in thickness and range in rank from lignite to bituminous. The coal-bearing beds of sand, clay, and gravel are moderately folded and broken by faults. No mining has been attempted in the area for many years.

Southeastern Alaska Region. The Southeastern Alaska region includes a narrow coastal belt along the southeast shore of Alaska and the "panhandle" (southeast Alaska), as well. The coal is mostly Tertiary lignite in the small fields and localities scattered along the coast to the southeast. The rank increases to semi-anthracite and anthracite in the highly-deformed crushed and sheared beds of the Lower Tertiary Kushtaka Formation in the Bering River field. The coal occurs in a large number of beds from a few inches to 60 feet thick. Much surface and underground prospecting has been done in the Bering River area, but it is unknown if any mines are yet operating in the area.

2. Topography

The Pacific Coast Coal Province, including Alaska, is essentially mountainous with wide variations in relief. Mountains in the Cascade Range and Sierra Nevadas exceed 14,000 feet in elevation. In Alaska, Mt. KcKinley tops 20,000 feet. The Alaskan mountains are the highest and roughest in the country. These include the Brooks, Kuskokwim, and Alaska Ranges. Between these mountain ranges are the Central Valley in California, the Puget-Willamette Lowlands in Washington and Oregon, and the Arctic Lowlands and central basin in Alaska. The mountains of this area are youthful and may still be uplifting. The mountains trend north-south with frequent isolated volcanic cones.

3. Climate, Air

The Pacific Coast Coal Province has the greatest variety of climate in the country. The annual precipitation varies from less than eight inches in the desert of southern California to over 128 inches in the Olympic Peninsula of Washington. The valleys typically have a lower annual precipitation than the mountains, but the highest amount of precipitation occurs along the coast of northern California, western Oregon and Washington, and the southern coast of Alaska. Some of these coastal areas and coastal mountains may receive more than five inches of precipitation within a 24-hour period. Most of the precipitation occurs in December, January, February, and March. June, July, and August are the driest months. However, interior Alaska receives most of its moisture in July, August, and September.

The temperatures along the coast are more moderate than in the interior. The steady flow of the Japanese current across the Pacific Ocean tends to keep the temperatures from changing rapidly. The temperature in southern California average higher than 50° F in January and more than 90° F in July. In comparison, the temperatures of interior Alaska average 10° below zero in January and average above 50° F in July. The differences in temperature are primarily affected by elevation, latitude, and distance from the ocean. The freeze-free days range from more than 300 per year in southern California to less than 30 in northern Alaska. The higher mountains typically have less than 90 freeze-free days per year, while the highly productive agricultural land of California has more than 240 freeze-free days.

Winds along the coast typically come out of the west most of the year. Much of the wind in the fall and winter come out of the southwest in Oregon and Washington. The wind in Alaska is usually from the continent, southwest to the sea, except in the summer when the winds are out of the southwest. The coastal areas are subject to fog much of the year.

4. Hydrology

The Pacific Coast Coal Province has large supplies of both surface and ground water available. However, not all parts of the region are blessed with an abundance of water. Many large diversion canals and aqueducts transport surface water from areas of high runoff to areas of low runoff. Most of the surface waters in the area have low dissolved solids contents. Sediment concentrations in major streams are generally low except during peak flow periods.

Ground-water yields are high in many areas of the province. The water is generally of good quality, but locally may be poor.

In the Alaskan part of the Pacific Coast Coal Province, large amounts of good quality surface water are available. However, except for the low lying areas along the Gulf of Alaska, runoff is highly variable. Except for high sediment yields from many glacier-fed streams, the quality of the water is generally excellent. An exception are the streams which drain extensive marshy and swampy areas. These streams have high contents of iron and organic compounds.

Most ground-water supplies are obtained from river alluvium. Large supplies of ground water can be obtained from alluvium, but the water generally has a high iron content. Ground water in areas overlain by permafrost is usually or poor quality.

5. Soils

Dominant soils within the Pacific Coast Coal Province are listed in Table 27. Some characteristics, uses, and limitations are given for each of the listed soil series. Specific items for each soil such as the unified classificaiton of the subsoils for engineering uses

Table 27 - Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the Pacific Coast Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Hugo	California (USDA, 1972c)	SC	4-8	B	0-70	conifer forests shrubs, grasses and forbs	forestry
Limitations - Good timber producing soils, well-drained, very gravelly soils, very severe erosion hazard.							
Clearlake	California (USDA, 1972c)	CH	8-10	D	0-3	grasses, shrubs and forbs	hay, grain & orchards
Limitations - Shrink swell potential is high, three to five feet to seasonal watertable surface cracks when dry, runoff is slow until surface is sealed then it is rapid, drainage improve productivity.							
Yolo	California (USDA, 1972c)	ML, CL	9-12	B	0-3	annual and perennial crops	cultivated crops and orchards
Limitations - Subject to flooding, well-drained.							
Orford	Oregon (USDA, 1970)	MH	9-12	C	0-65	conifer forest	wood crops
Limitations - Well-drained uplands, severe erosion hazard.							
Active Daneland	Oregon (USDA, 1970)	SP-SM	--	--	0-60	none	recreation
Limitations - Unstable and subject to severe soil blowing, droughty, vegetation is difficult to establish.							

Table 27 - (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Hembre	Oregon (USDA, 1969)	ML	9-12	B	0-70	conifer forest	wood products
Limitations -	High erosion hazard in cutbanks, highly productive stable mantles.						
Nehalem	Oregon (USDA, 1969)	ML or CL	9-12	B	2-8	grass and legumes	pasture
Limitations -	Alluvial bottoms, subject to flooding.						
Amity	Oregon (USDA, 1972b)	ML or CL	9-12	C	0-8	annual and perennial grasses	pasture, grains and seed
Limitations -	Somewhat poorly drained, low terraces, compaction hazard is severe, watertable restricts use.						
Kinney	Oregon (USDA, 1972b)	ML	5-9	B	0-70	conifer forest	wood products
Limitations -	Well-drained uplands, unstable on steep slopes, erosion hazard severe on steep slopes, subject to frost heaving.						
Cinabar	Washington (USDA, 1972a)	ML	12+	B	0-85	conifer forests, annual & perennial grasses and	hay, pasture & wood products
Limitations -	Well-drained, terrace, erosion hazard on cutslopes and compacted areas is severe.						

Table 27 - (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Puyallup	Washington (USDA, 1972a)	SM	6-9	B	0-3	row crops hay pasture and orchards	farming
Limitations - Somewhat excessively drained, subject to flooding, pervious when compacted.							
Grove	Washington (USDA, 1960)	GP-GM	3-6	A	0-60	conifer forests	wood products, feed crops, homesites
Limitations - Glacial outwash plains, gravelly soils, droughty and low in fertility.							
Coal Creek	Alaska (USDA, 1968)	CL	9-12	D	0-3	sparse birch, white spruce, cedar & willow	wood crops, hay, pasture
Limitations - Poorly drained, silty soil in stream valleys, extremely acid topsoil.							
Fairbanks	Alaska (USDA, 1963)	ML	3-6	B	0-45	spruce, birch, alder	wood products
Limitations - Very susceptible to erosion by water.							

and hydrologic groups are given as well as general information. Thus, the information may be used by engineers, hydrologists, and soil scientists, as well as the general public to gain some knowledge of the soils. The listed soil series are not inclusive. They occur extensively, but they must be viewed as examples. A detailed on-site soil survey must be made before the total soil resource is known. More detailed information of the soils characteristics and limitations may be obtained from the soil survey reports listed among the selected references.

Wilde (1958) summarizes the importance of soil organisms by stating that they are essential to the existence of plants and animals. Organisms are a vital part of the cyclic pattern of matter in nature and are the tools with which nature fashions soil from lifeless geologic matrix and plant and animal residue.

Organisms in the soil may be classified as saprophytes or parasites. Saprophytes break down dead organic material while parasites attack living material. Soil organisms may also be grouped as being heterotrophs or autotrophs. Heterotrophs obtain carbon and energy from organic matter. Autotrophs obtain carbon from carbon dioxide and energy from the sun (photoautotrophs), or from chemical reactions (chemoautotrophs). The indigenous populations are termed autochthonous while the fluctuating populations are termed zymogenous, (Davy, 1969).

Soil inhabiting micro-organisms are the viruses, protobacteria, bacteria, actinomycetes, and fungi. Viruses are all parasitic, and protobacteria are parasitic upon bacteria. There are from ten to the eighth power to ten to the ninth power bacteria per milliliter of soil. Heterotrophic bacteria are sensitive to temperature, organic matter, acidity, inorganic nutrients, soil disturbance, organic carbon, and oxygen. Different types of bacteria thrive in different temperature regimes. Psychrophiles like temperatures less than 20° C, mesophiles like temperatures from 25° C to 35° C, and thermophiles like temperatures from 45° C to 65° C. Population of bacteria are dependent upon organic matter for survival. A neutral soil reaction (pH=7.0) is considered to be optimum. Sugars and starches are beneficial to growth. Soil disturbance incorporates organic matter into the soil or exposes it to the air where chemical oxidation may consume it. Bacteria populations drop rapidly below the surface soils.

Actinomycetes are autochhonous, and the populations remain higher th bacteria in the subsoil. Streptomycetes are important as they fix nitrogen in root associations on non-leguminous species such as alder and snowbrush.

Fungi are heterotrophic and prefer a neutral soil reaction, but have a broad range in pH tolerance. Fungi require oxygen while carbon dioxide is an inhibitor. Fungi may be separated into five groups depending upon their food supply. These groups are: sugar fungi, lignin decomposers, copraphic, predaceous, and root inhabiting. The root inhabiting fungi are very important and may be pathogenic or beneficial. Mycorrhiza fungi are very important for satisfactory growth of many species of trees. They make nutrients more available, dissolve primary minerals so plants may uptake them as nutrients, and for practical purposes, enlarge surface areas of roots. and protect them from pathogenic invasions.

Algae are photoautotrophs and are more important on bare ground than under heavy vegetation. Algae are self-supporting and some species fix nitrogen.

Lichens are algae-fungi associations. Lichens may be separated into crustose, foliose, or fruticose depending upon their morphology. Lichens do not compete with higher plants. Lichens are one of the prime organisms which start rock on its way to becoming soil. Higher plants move in after the lichens build up a suitable base for food and anchorage. Some lichens have the blue-green algae as partners and can fix nitrogen.

Protozo are single-celled animals which live in the soil. They are usually abundant if the soil fertility is low.

Multi-celled soil dwelling animals are as follows:

- Rotifers - feed upon plant debris.
- Roundworms - nematodes are an example. Nematodes need moisture to to active. Contrary to popular belief, about half the nematodes are saprophytes and are beneficial.
- Annelid worms - earthworms fall into this group of animals. They secrete an alkaline solution containing amalase. Earthworms are killed when exposed to ultra-violent light. Earthworms are important in incorporating litter into the soil.

- Vertebrates are mammals which burrow into the soil. Rabbits, marmots, etc., are examples. Moles, shrews, snakes, lizards, and some birds also may be included.
- Arthropods include insects and many live in the soil.
- Hexopods are six-legged animals of which many live in the soil. A main staple of their diet is plant roots.
- Callembola - Springtails fall into this group. They are saprophytic and may be considered the seagulls of the soil.
- Myriapods include the centipeds and millipeds.
- Octopods are eight-legged and include the spiders, mites, and ticks. Mites are responsible for the digestion of about 15 percent of the weight of new litter.

6. Vegetation

The coniferous forest of the Pacific Coast Coal Province consists of three, well defined forest types:

The taiga coniferous forest spreads across interior Alaska; narrow fingers follow water courses to the timberline of the Brooks Range.

The montane coniferous forest (and alpine communities) covers the Cascade Mountains in Washington and Oregon, and the Siskiyou Mountains in Oregon, and the inner Coast Range and Sierra Nevada in northern California from woodland transition to timberline.

The northwest coastal forest, the most dense coniferous forest type, extends along the Pacific Coast from southern Alaska to western Washington, western Oregon, and northwestern California.

Prairies also exist in this province. They are separated into three distinct areas:

The Palouse prairie consists of mid-grass species. However, extensive areas have been replaced by sagebrush as a result of overgrazing. Large wheat crops are produced in portions of the region.

The California prairie originally consisted of mid-grasses of the bunch grass type similar in form to those of the Palouse.

The Coastal prairie resembles the mixed prairie of the northern temperate grassland. However, the short grasses occur in the coastal prairie primarily because of overgrazing; they are climax dominants in the mixed zone of the northern temperate grassland. Desert shrubs most common are sagebrush, rabbitbrush, and greasewood. Common grasses are wheatgrass, and Idaho fescue. Woodland-bushlands occur in drier areas adjacent to the forests. Oak is a common species growing in this area.

7. Wildlife

Most animals found in the coal-bearing areas of the Pacific Coast Coal Province are characteristic of either the northwest coastal forest sub-biome, the boreal coniferous forest sub-biome (tiaga), the broad schlerophyll community, or the tundra biome.

Coastal and Boreal Coniferous Forest Wildlife. In the northwest coastal forest, there is usually a dry layer of duff and an organic soil rich in microorganisms. Shade from the large trees results in a poorly developed vegetative understory. The Roosevelt elk, black-

tailed deer, black bear, and cougar are characteristic larger animals. The mountain beaver, brush rabbit, Douglas chickaree, northwest coast bat, and coast mole are common residents. Typical birds include the Pacific horned owl, northern spotted owl (threatened), bald eagle, sooty grouse, and pileated woodpecker.

Many of the small mammals, birds, and amphibians found in coastal forests depend on the variety of insect life that abounds in the damp mild environment, as well as the great mass of seeds produced by evergreen trees. Deer and elk commonly utilize natural or man-made openings in the dense overstory, such as caused by fires or logging, taking advantage of resulting nutritious ground vegetation. Closed canopy forests that provide winter cover and escape shelter are a crucial part of game animal habitat.

Among the less common species are the endangered Columbian white-tailed deer found in parts of Oregon and Washington, the fisher, the flammulated owl, and the Larch Mountain salamander which is considered endangered by the State of Oregon.

Boreal coniferous forest species common in parts of the Alaska coal regions are moose, lynx, wolverine, red squirrel, snowshoe hare, northern flying squirrels, spruce grouse, and crossbills. Most animals are shy and retiring. They use the dense evergreen growth for cover and for protection in winter weather. They can tolerate cold winters with much snow. The herbivores are principally browsers. Some--such as the moose, snowshoe hare, and grouse-- depend, at least in part,

on broad-leaved plant communities in burns or natural openings.

West Coast and Alaska streams produce the anadromous steelhead and five commercially important species of salmon: the chinook, sockeye, chum, pink, and coho. Migratory populations of coastal cutthroat trout occur in coastal streams from California to Bristol Bay, Alaska. Resident rainbow and cutthroat trout are common in some coastal forest waters along with a variety of warmwater and non-game fishes.

Many forms of aquatic and semi-aquatic wildlife inhabit the estuaries and immediate coastal zone where coal occur. Some of these are:

Mammals	Birds	Fish
Sea otter	Common Loon	Sea or surf perches
Pacific harbor seal	Brown pelican	Flounders
California harbor seal	Western gull	Greenlings
California sea lion	Common murre	Ling cod
	Black brant	Rock fishes
	Surf scoter	Pacific herring
		Northern anchovy
		Smelt

Many other species of shorebirds and waterfowl use this important coastal habitat as residents or migrants. These species are dependent on clean brackish or saltwater and the adjacent beaches or mudflats for their immediate habitat or for the plants or animals that constitute their food supplies. Dungeness crabs are numerous in most bays and they are eagerly sought as a sport catch. This species also supports an important commercial fishery. The eelgrass plant community is very important to some species of fish, gaper clams, and crustacea.

Broad Schlerophyll Wildlife. The broad schlerophyll community is primarily oak brushland. It contains many important wildlife species

which are dependent on the great variety of transition zone hardwood trees and shrubs. Acorns provide food for tree and ground squirrels, certain woodpeckers, and woodducks, and are readily used by blacktailed deer in the fall and winter. Ceanothus, manzanita, scrub oak, and mountain mahogany are preferred browse species for wintering deer. The Pokegama - Jenny Creek area of the California border provides winter range for the largest migrating blacktailed deer herd in Oregon. Several subspecies of mule deer range throughout the broad schlerophyll community in California and southern Oregon. Typical mammals include the mountain lion, bobcat, coyote, skunk, and brush rabbit. The Merriam chipmunk, California mouse, and five-toed kangaroo rats are confined to chaparral.

Other mammal species include the ducky-footed woodrat, Oregon gray fox, ringtail, and the Pacific pale bat. The valley quail, scrub jay, Sacramento towhee, red-shafted flicker, and the acorn woodpecker are characteristic birds. The sharp-tailed snake, Siskiyou Mountain salamander, and leopard salamander are common species in this community. Freshwater fishes are similar to those mentioned in the previous section as occurring in the coastal forest.

Tundra Wildlife. Even with the low temperatures, short growing seasons, low precipitation, and intermittent freezing and thawing of the thick, spongy mat of low tundra vegetation, many mammals and birds remain in the tundra biome throughout the year. They include the caribou, musk ox, arctic hare, arctic fox, lemming, and ptarmigan. Other charac-

teristic mammals of the Arctic slope include the polar bear, arctic wolf, wolverine, Alaska red fox, marmot, Parry's ground squirrel, red-backed mouse, and several moles and shrews.

The uplands are inhabited by caribou (except in winter), Dall's sheep, grizzly bear, marmot, ground squirrel, rock ptarmigan, horned lark, and lapland longspur.

Large numbers of birds migrate to the tundra to nest and rear their young during the brief summer. Few birds remain in winter; even the snowy owl may move southward. Willow ptarmigan usually present year-around.

Hordes of insects live in the low elevation of the tundra. Most hibernating insects withstand temperatures down to 50° below zero. Mosquitoes, gnats, flies, beetles, bugs, bumblebees, wasps, moth larvae, spiders, and mites may overwinter in plant tufts and under stones and driftwood.

The tundra lakes, ponds, and bogs do not support large populations of aquatic life due to a lack of minerals and nutrients. Characteristic fish are lake trout, arctic char, grayling, and whitefish. The arctic grayling is abundant and well distributed in tundra waters. The she-fish inhabits the major rivers. The chum and pink salmon are anadromous fish that spend part of their life cycle in tundra streams. Sockeye salmon fry migrate from streams to lakes and spend one or two years in the lakes before they migrate to the sea.

Endangered species include the arctic peregrine falcon, which breeds

above the Arctic Circle; and the Aleutian Canada goose, which nests on some of the islands in the Aleutian chain; and the musk ox, which once eliminated in Alaska, has been reintroduced.

Tundra waters generally are of such high purity that any influence of man can be detected in water quality and in changes in aquatic biota.

8. Land Uses

Primary coal deposits in the Pacific Coast Coal Province are in the states of Alaska and Washington. The North Slope deposit in Alaska is located entirely within tundra and muskeg. Due to the location and character of the area, land uses are limited. Primary use is by wildlife and domestic reindeer. Abundant and varied fish and wildlife populations bring use by tourists and Alaska citizens. Fishing and hunting is particularly significant to native Alaskans as historically wildlife has furnished the sole means of survival. Recent times have brought mineral exploration and development activities to the tundra. The extensive northern oil and gas field is within the coal region.

Southern Alaska coal deposits in the vicinity of Cook Inlet are primarily within the forested area. Major land uses include timber production, outdoor recreation, and use by wildlife. Oil is produced within the coal area on the Kenai peninsula.

Land use in the coal area of Washington state include agriculture (cropland and grazing), timber production, general recreation and wildlife uses. Some deposits are in the vicinity of intensive uses including commercial, residential, and industrial.

9. Population Patterns and Considerations

This province contains widely divergent population factors. However, Federal coal occurs in rural areas rather than in densely populated areas. Land uses include agriculture and timber production in California, Oregon, and Washington.

The Alaska portion of this province differs greatly from other areas in that the population is very sparse, mostly Indians and Eskimos.

10. Human Value Resources

a. Esthetic Values Where Federal Coal Occurs

Washington

Small, scattered pockets of Federal coal occur on the western slopes of the Washington Cascades where dense coniferous forests cover rugged land forms. Strong linear contrasting forms with deep, green colors broken on occasion by massive rock outcrops produce a scale that is full of interest and variety.

Oregon - California

Scattered coal deposits are found in the Siskiyou Mountains, southwestern Oregon and in the Klamath - Trinity Mountain area of northern California. Land forms are rugged, often breaking up vegetative types with large exposed rock-slide faces. Deep gorges and valleys cut through the area and emphasize the ground scale.

Alaska

The land form within this portion of the province is nearly flat, however, small upheavals occasionally occur which are caused by underlying ice wedges.

Very little changes are apparent in either texture or color. A soft pattern of grassy greens envelops the area with only an occasional small drainage crossing the line of vision. In some areas small ponds dot the landscape.

Lines are difficult to distinguish. In the absence of a man-made intrusion, the strongest line is at the horizon.

Unless there is a structure or road within view, it is difficult to grasp human scale in this biome. Some localized scale, as well as interest exists in the grazing herds of caribou and reindeer that freely roam the tundra.

b. Historic

Evidence of early settlement and use includes trails, roads, structures, and objects related to historic gold activity, logging, and coal mining. Southern Alaskan fields were first worked by Russians in the 1850's, and this area also contains sites related to other early Russian and American exploration and settlement. Other historic sites are related to coal fields along the Pacific Coast.

Western Oregon was a terminus of the famous Oregon Trail. Early seaports for fur-traders and shipping dot the coastline.

c. Geologic

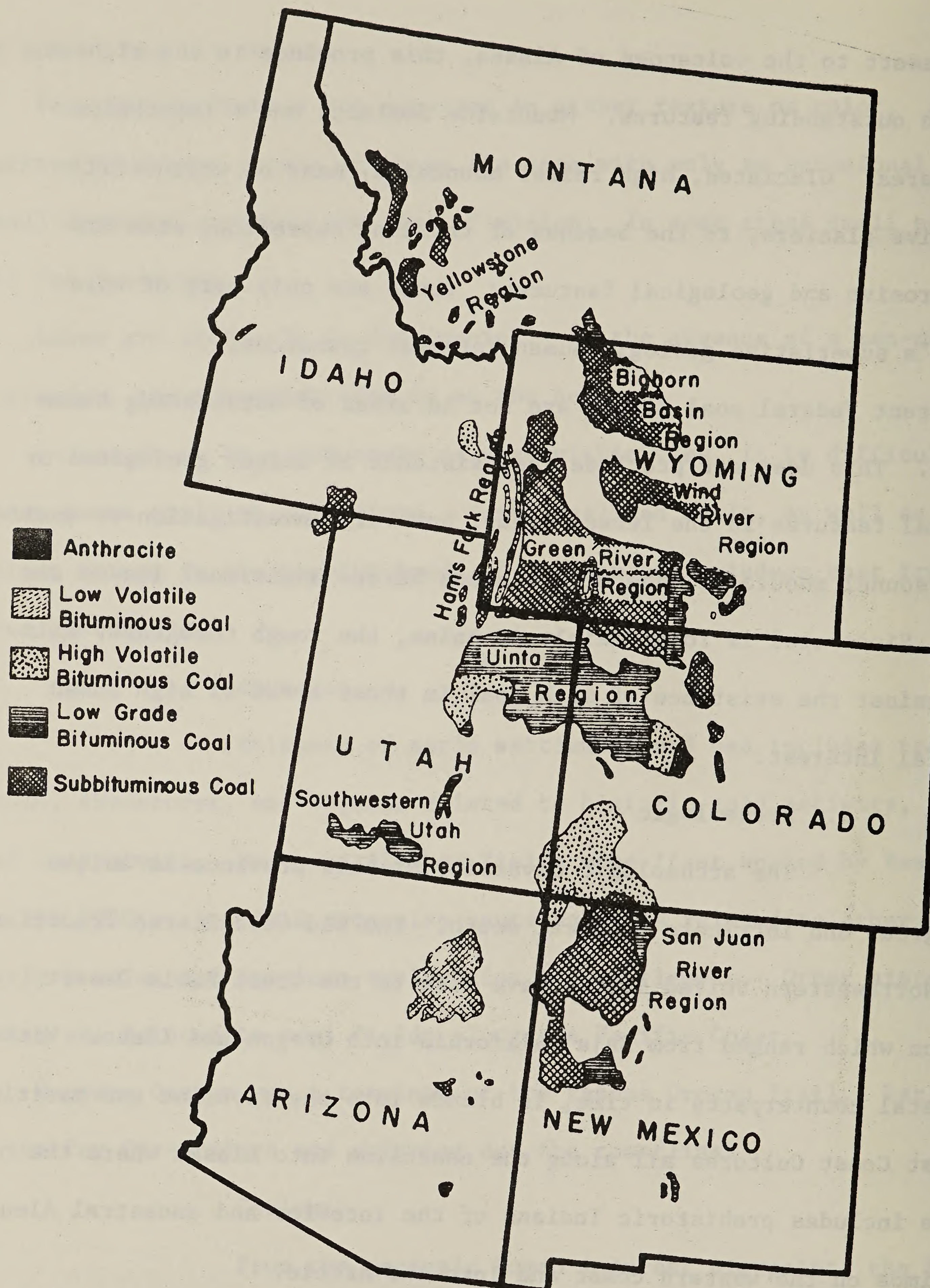
From the geologic human interest viewpoint, the Pacific Coast Coal Province (including Alaska), is the most diverse and interesting area of all. From Pleistocene Lakes, now long dry, in the California Desert to the volcanoes of Alaska, this province is the richest of all in outstanding features. Mountains dominate one's impression of this area. Glaciated, high relief mountains, many of which still have active glaciers, to the beaches of the long shoreline, with its marine erosive and geological features; these are only part of this province's superlative geologic human interest resources.

Current Federal coal leases are not in areas of outstanding human interest. This does not preclude the existence of unique geological or geothermal features in the leased areas, however. Investigation by qualified personnel should be made of the areas before additional leases are issued. Since coal is found mainly in bains, the rough topography militates against the existence of much coal in those areas of high human geological interest.

d. Archeologic

The archeologic diversity of this province is unique and of great and intricate cultural depth. The Old Cordilleran Tradition of the Northwestern United States gave rise to the Great Basin Desert Tradition which ranged from Baja California into Oregon and Idaho. With its coastal counterparts in time, it blends into the riverine and maritime Northwest Coast Cultures all along the coastline into Alaska where the province includes prehistoric Indians of the Interior and ancestral Aleuts and Eskimos on the western coast and into the Arctic.

These early people's descendants who have not moved to the cities live in much the same way as their ancestral predecessors, hunting, gathering, fishing, and occasionally working for day wages when the opportunities arise.



ROCKY MOUNTAIN PROVINCE

Figure 28

B. Rocky Mountain Province

1. Geology

The Rocky Mountain Coal Province contains a greater variety of coal than any other province in the United States. It encompasses parts of all the physiographic provinces comprising the Rocky Mountain system and part of the Colorado Plateau physiographic province and the extreme eastern toe of the Basin and Range physiographic provinces. The Rocky Mountain system is bordered on the east by the Great Plains.

On the west, the mountains give way to high plateaus, and the change in elevation is not so great as it is on the eastern margins. The western margin is also marked by distinct changes in geologic structure and vegetation.

The following listing illustrates how the various coal regions of the Rocky Mountain Coal Provinces, (Trumball, 1960), and (Campbell, 1972), are related to the basic physiographic subdivisions of Fennaman, (1931).

Physiographic Province	Coal Region	Location
Northern Rocky Mountains	Yellowstone	West Montana
Middle Rocky Mountains	Big Horn Basin Ham's Fork	Northwestern Wyoming Western Wyoming
Wyoming Basin	Green River Wind River	Wyoming, Colorado Wyoming
Colorado Plateau	Uinta Southwestern Utah San Juan River	Utah, Colorado Utah Colorado, New Mexico

Basin and Range	Small fields in central and southern New Mexico

a. Northern Rocky Mountain Physiographic Province

The Northern Rocky Mountains Physiographic Province consists of deeply dissected mountain uplands and intermontane basins. Two principal types of ranges are present. The first is the Idaho type, characteristic of most of the state, carved from the huge Idaho igneous batholith. The deep and intricate dissection of these granitic ranges has converted much of the region to a rugged wilderness. The second type of mountain range is the Montana type, which is found in all parts of the province outside the Idaho batholith. These ranges are linear, have north to northwest trends, and are separated by broad basins of probable tectonic origin. Faulting, both normal and reverse, is more common in this part of the Rocky Mountains than in any other. Thrust faults are prevalent in western Montana, whereas normal faults are the rule elsewhere. Coal deposits are limited to the Yellowstone region and several small isolated fields in southwestern Montana.

The coal fields in the Yellowstone region, (Jones & Hunt, 1952) and (Campbell, 1929), are neither large in area nor great in commercial importance. The coal is of high volatile A to C bituminous rank and some has been produced for the manufacture of coke. The coal occurs in rocks of Upper Cretaceous age probably equivalent to the Eagle Sandstone. In genera[l] the coal beds are thin, impure and commonly greatly disturbed by folding and faulting.

There is a major difference in geologic character between the Northern Rocky Mountain province with its Idaho-and-Montana-type mountains and the Southern and Middle Rocky Mountain provinces. Mountains in these latter provinces consist for the most part of great anticilines with granitic cores generally flanked by outward dipping sedimentary strata and separated by synclinal sedimentary basins, or "parks". The rocks are similar in both the Middle and Southern Rocky Mountain provinces; however, the structures are more varied in the Middle Rocky Mountain area. The Wyoming Basin province interrupts the continuity of the Southern Rocky Mountain System as a giant sag between the Southern and Middle Mountain Ranges. It consists for the most part of a number of separate sedimentary basins divided by uplifted axes within the Wyoming Basin province.

b. Middle Rocky Mountain Physiographic Province

This province contains only the Big Horn Basin and Ham's Fork coal reegions plus some isolated fields not defined by any particular region.

Big Horn Basin is a broad structural basin in northeastern Wyoming covering about 4,400 square miles bounded by the Big Horn Mountains on the east, the Owl Creeks on the south, and the Absaroka Range on the west. It is an area of broad dissected plains with some local badlands and folds around the margin.

Coal-bearing rocks include the Mesaverde, Meeteetse, and Lance Formations of Late Cretaceous age and the Fort Union Formation of

Paleocene age, (Berryhill, Brown, Brown, and Taylor, 1950). These rocks are exposed around the rim of the basin in a belt 3 to 15 miles wide. The coal beds in these formations are generally lenticular and rarely persist at mineable thickness more than five miles along the outcrop. Local folds with dips as steep as 50 degrees cause mining problems and result in irregular distribution of coal outcrops. The coal-bearing rocks extend below deep cover in the central part of the basin, but little is known about the thickness and distribution of the coal beds in the subsurface.

Coal from fields in the Big Horn region ranges from lignite to high volatile sub-bituminous, C in rank. The beds range in thickness from a few inches to more than eight feet, but, as mentioned above, they are quite lenticular.

The Bridger, Silvertip, and Red Lodge fields are part of a northern extension of the Big Horn Basin into Montana. High volatile C bituminous coal is mined in the Bridger and Silvertip fields from rocks in the Eagle Sandstone of Late Cretaceous age. The coal at Red Lodge is mined from the younger Fort Union Formation, but it is of equivalent rank to the coal in the Eagle Sandstone.

The Ham's Fork Coal region is in the extreme western part of Wyoming and includes small parts of Utah and southeastern Idaho. The coal-bearing rocks crop out in long narrow belts extending from the mountainous northern part of the region to the less rugged southern part near the Utah-Wyoming border.

The area lies in the highly complex Wyoming overthrust belt, a zone of thrust faults and folded rocks that have resulted in the development of a series of parallel mountain ranges and synclinal valleys. One of the faults is reported to have a displacement of more than 20,000 feet along the side of the Salt River range.

The coal-bearing formations exposed in the region are the Bear River, Frontier, and Adaville Formations of Late Cretaceous age and the Evanston Formation of Paleocene age. The Frontier Formation, the main coal-bearing unit, forms north-trending outcrop bands generally less than two miles wide. It is composed of 2,200 and 3.800 feet of clay, shale, and sandstone and numerous coal beds which occur throughout the formation. The Adaville Formation, which lies 3,000 to 6,800 feet above the Frontier, is similar and it also contains numerous beds of coal.

The coal beds in the region range between high volatile, bituminous A in the Frontier coals to sub-bituminous B in rank in the Adaville. Thicknesses greater than 100 feet are reported for coal beds in the Adaville Formation. The higher quality Frontier coals obtain thicknesses as great as twenty feet. The steep dips make mining difficult in most parts of the region. Strip-coal resources of about one billion tons are reported.

c. Wyoming Basin Physiographic Province

The Wyoming Basin includes within its borders both the Wind River and Green River coal regions, as well as the Hanna coal field east of the Green River region. The floor of this basin is a plateau with a maximum east-west dimension of about 250 miles and a north-south dimension of nearly the same. Its total area is nearly 40,000 square miles. It is bordered for the most part by abrupt mountain slopes, indented by long spurs and studded by isolated mountains. The altitude of the plateau surface is generally between 6,500 and 7,500 feet. Through an opening between the Big Horn and Laramie Mountains, this basin floor is continuous with the Great Plains. By a similar opening east of the Uinta Mountains, it is continuous with the Colorado Plateau. Because of the semi-arid climate of this area, deflation hollows, alkali flats, playas, sand and silt dunes, and badland topography are common.

The Wind River coal region occupies the Wind River Basin in central Wyoming, (Figure 28). The basin is a large northwest-trending asymmetrical syncline that is surrounded by mountain ranges. The Big Horn and Owl Creek Mountains separate it from the Big Horn basin to the north; the Wind River Mountains divide it from the Green River basin to the south and west; and the Casper Arch separates the Wind River and Powder River basins. Around the edges of the basin, narrow ridges are formed by steeply-dipping sedimentary rocks. The dips are less steep toward the center of the basin.

Coal-bearing formations include the Cody Shale, which is 3,050 to 4,480 feet thick; the Mesaverde, 800 to 1,960 feet thick; and the undivided Lewis and Lance Formation, 350 to 3.715 feet thick. The Fort Union Formation also contains coal and ranges from 350 to 4,165 feet thick. Except for the Fort Union, which is of Paleocene age, all of the units are of Late Cretaceous age. They consist of sandstone, sandy shale, shale, and coal. These formations crop out only around the rim of the basin; in the center part, they are unconformably overlain by younger rocks. These rocks also cover some of the coal-bearing units in some parts of the border zone causing discontinuous outcrop patterns.

The coal beds in the region are mostly sub-bituminous in rank and range from a few inches to a maximum of seventeen feet thick and are characterized by steep dips causing difficult mining conditions.

The Green River coal region lies in the southern part of the Wyoming Basin physiographic province and encompasses an area of about 17,000 square miles in southwestern Wyoming and northern Colorado. The region is bounded on the north and northeast by the Wind River, Gros Ventre, and Granite Mountains; the Rawlins Hills and the Sierra Madre Mountains on the east; the Wyoming overthrust belt on the west; and the Uinta Mountains on the south. The region includes several separate structural units. The Green River basin occupies the western part separated from the Great Divide basin to the east by the large Rock Springs anticline. The Great Divide basin is further divided into the Washakie basin to the south and the Red Desert basin to the north.

Rocks in the interior parts of the basins are nearly horizontal or dip gently toward the centers, but dips increase sharply around the flanks and around the Rock Springs anticline, where dips range from 5 to 20 degrees.

Coal-bearing rocks include the Mesaverde group and the Lance of Late Cretaceous age, the Fort Union of Paleocene age, and the Wasatch Formation of Eocene age. In Wyoming, at the Rock Springs field, the Mesaverde group consists of the Blair Formation, which is barren of coal; the overlying Rock Springs Formation, the most important coal-bearing unit; the barren Ericson Sandstone; and the Almond Formation, which contains some coal in its lower part. In the Colorado portion of the field, the Iles and Williams Fork Formations contain the Mesaverde Group coal beds. The coal-bearing section of rocks is several thousand feet thick and is composed mainly of sandstone with beds of siltstone, shale, and coal.

The coal beds range in thickness from a few inches to 42 feet and in rank from sub-bituminous C to high volatile bituminous C, with coals of higher rank occurring locally in areas of igneous intrusives and intense structural deformation. In past years, the high quality coals of the Mesaverde Group have been the most extensively mined and the most important in the area; but several hundred million tons of strippable Fort Union and Wasatch coal are presently being developed for thermal power generation. The coal beds in most parts of the region lie so deeply buried in the basins, that they will probably never be of economic interest; but several thousand square miles in the region are underlain by coal beds of mineable thickness that can be mined when warranted by demand and economics.

The Hanna field is included here in the discussion of the Green

River region although it is not specifically considered a part of the Green River basin area. The Hanna basin is a structurally downwarped area separated from the Green River basin by the Rawlins Hills on the west, and bounded on the north and south by mountains. To the east, it merges with the Laramie basin.

A total of 130 coal beds have been mapped in the coal-bearing Mesaverde and Medicine Bow Formations of Late Cretaceous age, the Ferris Formation of Late Cretaceous and Paleocene age and the Hanna Formation of Eocene age. The coal beds are sub-bituminous C to high volatile bituminous C in rank and range as thick as eight feet in discontinuous levels in the lower formations and as thick as 35 feet of clean coal in the Hanna Formation. The Hanna basin area is characterized by rugged bleak surface features and steep dips ranging from 10 to 25 degrees in the areas of outcrop of the thicker coals.

The Rock Creek field adjoins the Hanna Basin field on the southeast and contains coal beds ranging as thick as 9.5 feet in the Hanna Formation and about eight feet in the Mesaverde. Large areas of the surface are covered with gravel and the coal-bearing rocks are difficult to trace in the field.

d. Southern Rocky Mountain Physiographic Province

The Southern Rocky Mountain province encompasses most of the Rocky Mountains and Sangre de Cristo mountain ranges in Colorado and New Mexico, but includes only the small coal areas of North, Middle, and South Parks, which are park-like intermontane basins in the northern

and central Colorado Mountains. The Southern Rocky Mountain province consists of broad, deeply-dissected north-south strips of mostly granitic crystalline rocks generally flanked by steeply-dipping sedimentary rocks that form hogback ridges. The parks are small elliptical structural and sedimentary basins lying between mountain ranges. South Park contains only limited coal resources. Sub-bituminous coal of Paleocene age was mined in the early days from steeply-dipping beds five to seventeen feet thick on the west side of the basin.

Coal beds in Middle Park reportedly occur only as thin impure beds in the Paleocene Middle Park Formation. More prospecting is needed to adequately evaluate the area.

North Park contains several major coal beds of sub-bituminous B rank in the Paleocene Coalmont Formation (probably equivalent to the Fort Union). These coal beds range as thick as 77 feet and are contained in about 3,500 feet of coal-bearing strata underlying an area of roughly 850 square miles. Dips in the areas where coal was mined range from less than 10° to 85°, no doubt causing considerable mining difficulties.

e. Colorado Plateaus Physiographic Province

The Colorado Plateau Physiographic province is a vast roughly circular area covering approximately 130,000 square miles of Arizona, New Mexico, Colorado, and Utah. It includes the Uinta, the San Juan River, and the Southwestern Utah coal regions of the Rocky Mountain coal province, as well as several isolated fields and basins.

For the most part, the rocks of this plateau province are horizontal or nearly horizontal sedimentary strata. The landscape is highly dissected and sculptured in many places into canyons, mesas, and buttes, and consists of wide plateaus and uplifts, and broad basin areas. The boundaries of this plateau province are: to the north and northeast, the base of the Rocky Mountains; at the west and northwest, a bold escarpment extending southward from the Wasatch Range to the Grand Wash Cliffs at the western margin of the Grand Canyon region; and, at the southeast and south, the hydrographic boundary, the drainage divide between the Gila and Colorado Rivers, is taken for convenience as the southern limit of this plateau province.

The Uinta coal region encompasses about 16,500 square miles in part of east-central Utah and northwestern Colorado and includes both the Uinta and adjoining Piceance structural basins. The region is bounded by the Uinta Mountains on the north, the Wasatch Mountains on the west, the high escarpment of the Book and Roan Cliffs on the south, and the steeply-dipping rocks on the flanks of the Rocky Mountain uplift to the east. The region is considered a single structural basin for the sake of simplicity even though the Piceance basin is separate structurally in a stricter sense. The Uinta Basin is strongly asymmetrical. The rocks on the southern flanks dip gently northward toward the center of the basin with dips rarely exceeding 10 or 15 degrees. The north and northeast flanks are highly complex with major faults, steeply-dipping to overturned beds, and multiple successive unconformities which allow youngest Eocene rocks to lie unconformably on Precambrian basement rocks

Coal-bearing rocks from the south rim of this great basin area, and from this rim they dip towards the middle of the basin and are buried beneath thousands of feet of younger rock.

The main coal-bearing rocks in the Uinta region are in the Mesaverde Group of Late Cretaceous age. In eastern parts of the basin, these rocks are the William Fork and Iles Formations; in the center part, they are the coal-bearing Black Hawk and Neslen Formation. In the western part of the basin, coal beds six inches to eighteen feet thick are reported from the lower Mancos Shale. Coal is not generally found in this position in the section, but in fields to the southwest, the Mancos is the principal coal-bearing unit. Coal beds two to seven feet thick are also reported from the Frontier Sandstone member of the Mancos in the Vernal field in the northwest part of the region. Thin and impure coals are also reported in beds of Mississippian age.

The character of the coal changes throughout the basin and detailed description of these changes, together with discussions on thickness and occurrence is not possible in this report. In general, the coal beds range from five to fifteen feet thick and thicknesses as great as forty feet are reported. They range in rank from sub-bituminous C to coking high volatile A bituminous throughout most of the basin. The Castlegate and Sunnyside areas of the Book Cliffs field in Utah and the Somerset field in Colorado are large producers of medium-to strongly-coking bituminous coal. The Coal Basin district of the Carbondale field near Glenwood Springs, Colorado, is famous for a particular quality medium-volatile coking coal that is shipped and widely used as a blend with other coals to improve coking quality. In the Crested Butte field in Colorado, some beds have been metamorphosed to anthracite and semi-anthracite by igneous intrusions.

The coals of the Uinta basin are not as numerous or extensive as those of the Green River basin to the north, but even so, the Uinta region contains an enormous quantity of coal. Because of the depth of cover, strip-mining potential is limited, and a probably only small portion of the total coal will ever be mined.

The Southwestern Utah coal region has received considerable attention since the building of Glen Canyon Dam and the filling of Lake Powell, especially since plans were made for large-scale thermal power-plants in the area. The region is characterized by high cliffs rising above the flat-lying older sedimentary rocks to the south and by rolling plains dissected by canyons at the top of the section, away from the escarpment.

The region consists of the Kaiparowitz Plateau, Alton, and Kolob areas in southwestern Utah. The Kaiparowitz Plateau lies in a shallow synclinal basin bordered on the west by a steep monoclinal flexure and to the south by several parallel anticlines and synclines. The Alton and Kaiparowitz areas are separated by the Paunsaugunt fault. The Alton and Kolob areas are separated by the Sevier fault; and the Kolob is limited on the west by the Hurricane fault.

The Straight Cliffs Sandstone of Late Cretaceous age is the main coal-bearing unit in the region. It contains four coal beds ranging from two to thirty feet in thickness, that are persistent throughout the area and several thin, discontinuous beds as well. The coal occurs in a zone 300 to 600 feet above the base of the formation. The coal beds are mostly flat-lying to gently-dipping and range in rank from sub-bituminous A to high volatile C bituminous. The coal is of generally lower quality than that of the Uinta region, but it is completely adequate for use in thermal powerplants. Underlying the Straight Cliffs, the Tropic Shale and Dakota Sandstone Formations also contain coal beds, but they are commonly thin and not persistent. The coal-bearing zone in the lower part of the Straight Cliffs Sandstone in the Kolob area contains workable coal beds up to seven feet thick. Mining potential in the region is primarily underground; however, about 200 million tons of coal are reported strippable in the Alton area.

To the west, in the Harmony field, coal beds have been metamorphosed to semi-anthracite around an igneous intrusion.

In the Henry Mountains area, coal beds occur in the Upper Cretaceous Ferron and Emery Sandstone members of the Mancos Shale in a shallow structural basin on the west side of the Henry Mountains. The coal is of high volatile C bituminous rank and ranges from two to seven feet thick. Some of the coal is mineable by strip-methods, but the area is quite remote and the long-distance to market has discouraged development.

The San Juan River coal region lies south of the San Juan Mountains, partly in Colorado and partly in New Mexico. It is a great basin-shaped depression encompassing an area of about 11,000 square miles. The strata in the central and southern parts of the region dip gently toward the center of the basin, but on the north and east side, the dips steepen along the flanks of the bordering San Juan and Nacimiento Mountains. On the west side, monoclinal folds tilt the beds up sharply. The coal-bearing rocks crop out as a narrow belt around the margin of the basin, and they dip under the thick cover of younger rocks toward the center. Where the dip is gentle, resistant sandstone beds form low cuetas; in areas of steeper dips, they form sharp hogback ridges. The outcrop of the coal beds parallels these ridges in a linear fashion along the west margin of the basin.

Coal-bearing rocks of the region include the Cretaceous Dakota Sandstone, the Crevasse Canyon, Menafee, Cliff House Sandstone, and Fruitland Formations, all of Late Cretaceous age, and the Nacimiento Formation of Eocene age. The coal beds in the Dakota Sandstone and Nacimiento are thin, lenticular, and discontinuous and not of present commercial interest. The major coal beds of the area are contained in the sandstone and shale beds of the Crevasse Canyon, Menafee, and Fruitland Formation.

The coal beds occur along the western side of the region in a very complex stratigraphic sequence deposited in marginal marine environment during a time of alternating uplift and subsidence of the basin thus causing several transgressions and regressions of the marine shore across the area.

The lenticular coal-bearing sandstones and shales of the formations in the Mesaverde Group range from at least 1,800 feet thick in the southwest portion of the basin to only 220 feet in the northeastern part.

About 1,500 feet of barren rocks separate the coal-bearing formations of the Mesaverde from the Fruitland. The Fruitland ranges from 0 to 530 feet in thickness and is similar to the units of the Mesaverde Group. The thickest and most extensive coals occur in the lower part of this formation at or near the contact with the underlying barren, Pictured Cliffs sandstone. As the Fruitland is traced to the southeast, the number and thickness of the coal beds decreases until commercially important beds are no longer present. The Fruitland is stratigraphically equivalent to the Vermejo and Laramie Formations of the Raton Mesa and Denver regions to the east in the Northern Great Plains coal province.

The coals of the Fruitland are generally thicker than the Mesaverde coals, but contain more shale partings and are higher in ash content. The Mesaverde coals rarely exceed ten feet in thickness and are generally less than five feet. Thicknesses as great as 38 feet, including partings, have been reported for the coal beds in the Fruitland Formation.

The coals of both units are of sub-bituminous rank throughout most of the region, but in the northwestern and northeastern parts, the Mesaverde coals are higher in rank, high volatile A to B bituminous, and some are of coking quality .

The Dakota Sandstone underlies extensive areas in the Colorado portion of the San Juan River region, but the coal beds are rarely thick enough to be mined and are generally discontinuous and dirty. The coals range considerably in rank; generally they are high volatile C to B bituminous with a high ash content. In the northern tip of the region at the Nucla Naturita field, three beds of Dakota coal three to five feet thick are mined for use at the Nucla powerplant.

The Black Mesa field lies wholly within the Hopi and Navajo Indian Reservation lands in northeastern Arizona, and is considered here only for completeness. The principal coal-bearing rocks are the 300 foot Toreva and the 750 foot Wepo Formation of the Upper Cretaceous Mesaverde Group. The coal is high volatile C bituminous in rank and occurs in beds averaging four to six feet thick and reportedly locally as thick as fourteen feet. The coal-bearing rocks form the rim and the relatively flat top of Black Mesa.

f. Basin and Range Physiographic Province

Only a small portion of the Basin and Range physiographic province is included in the Rocky Mountain coal province. Topographically, the Basin and Range province is distinguished by isolated, rougly parallel mountain ranges separated by sediment-filled, nearly-level desert basins. The area common to both the coal and physiographic provinces is characterized in the western part as having the typical half-mountain, half-plain topography of the Mexican Highland section. This western part extends east of the Rio Grande Valley as far as pronounced basin ranges continue to alternate with basins.

The eastern part, the area containing a large portion of the isolated coal fields of the southern Rocky Mountain province, forms the Sacramento section, a meeting-ground of the three major physiographic systems of this portion of the United States. The Rocky Mountains, Interior Plains, and Intermontane Plateaus systems represented by the Southern Rocky Mountain, Great Plains, and Colorado Pleteaus physiographic provinces clearly contribute their characteristic features to the general configuration of the area.

This area contains a number of separate coal fields and isolated outliers of coal-bearing rocks too small and commercially unimportant to be considered here separately. Coal in these fields occurs in rocks of the Upper Cretaceous Mesaverde Group in beds as thick as seven feet. The coal is mostly bituminous in rank and some areas have produced excellent quality coke as well as anthracite. Some of the better known fields include the Cerrillos, Datil Mountain, Carthage, Jornada del Muerto, and Sierra Blanca in New Mexico and the Pinedale and Deer Creek fields in Arizona. Some have been developed to some extent because of local proximity to markets or because they contain coal of a particular nature or of better quality than could be obtained from the larger regions. However, the geologic structure of most of the fields is commonly quite complex and problems associated with faulting and igneous intrusions has discouraged large-scale operations.

2. Topography

The topography of Rocky Mountain Coal Province is the roughe[st] and most mountainous of the United States, excepting portions of Alaska. Elevations vary from 4,000 feet to more than 14,000 feet above sea level. The province consists generally of northwesterly trending mountain range[s] paralleled by numerous valleys. Some of the mountain ranges are the Front Range, Park Range, Sangre De Cristo, Sawatch, West Elk, and San Juan Ranges, and Uncompahgre Plateau in Colorado; the Laramie, Big Horn, Medicine Bow, Wind River, Granite, Wyoming, Absaroka, and Teton Ranges in Wyoming; the Beartooth, Crazy, Big Belt, Bridger, Beaverhead, Pioneer, Sapphire, Cabinet, Purcell, Mission Range and Lewis Ranges in Montana; the Bitteroot, Clearwater, Salmon River, and Sawtooth Ranges in Idaho; the Wasatch, Henry, Uinta, and Pavani Ranges and numerous high plateaus in Utah, the San Francisco Mountains plus high mesas and plateau[s] in Arizona; the Sangre De Cristo, San Francisco, Zuni, Jemez, and Manzan[o] Ranges in New Mexico. These are by no means all of the mountains in this province, but enough to emphasize their number. Exceptions to the genera[l] directional trend of the mountains are the San Juan in Colorado and the Uinta Mountains in Utah, which are east-west oriented. Most of the mountains trend north to northeasterly.

The Continental Divide meanders through New Mexico, Colorado, Wyoming, and Montana, nearly equally dividing the province from east to west. The local relief can vary from a few hundred feet in valleys and high plains over great distances to extremes of over 3,000 feet in less than a mile. The rugged beauty of the mountains was the incentive for the designation of numerous national parks, monuments, and recreation lands.

Along with the mountains in the province are several large topographic basins. Several of these are closely associated with coal deposits, such as the Green River, Wind River, and Big Horn Basins in Wyoming. Several small valleys in western Montana have noncommercial coal deposits. The Snake River Valley covers a large portion of southern Idaho, but has no coal. The Uinta Basin of east-central Utah is a plateau and swings easterly into west-central Colorado and has major coal deposits. The high plateau of southern Utah and Colorado and northern Arizona and New Mexico offer sharply dissected topography, especially along the river canyons.

The San Juan Basin in New Mexico and the San Luis Basin in Colorado are broad areas surrounded by mountains. The rough topography of the entire area limited travel to a few trails in the early days of the development of the West. The topography still limits the routes for roads and is a factor in road costs.

3. Climate and Air

The climate of the Rocky Mountain Coal Province is primarily controlled by the elevation, and central continental location. The province extends from southern Arizona and New Mexico to the Canadian border of Idaho and western Montana. The temperatures, rainfall, wind, frequency of storms, amount of snowfall, and other factors making up the climate vary widely.

The mean annual precipitation of the high mountains exceeds 32 inches of precipitation per year. These areas are located in northern Idaho

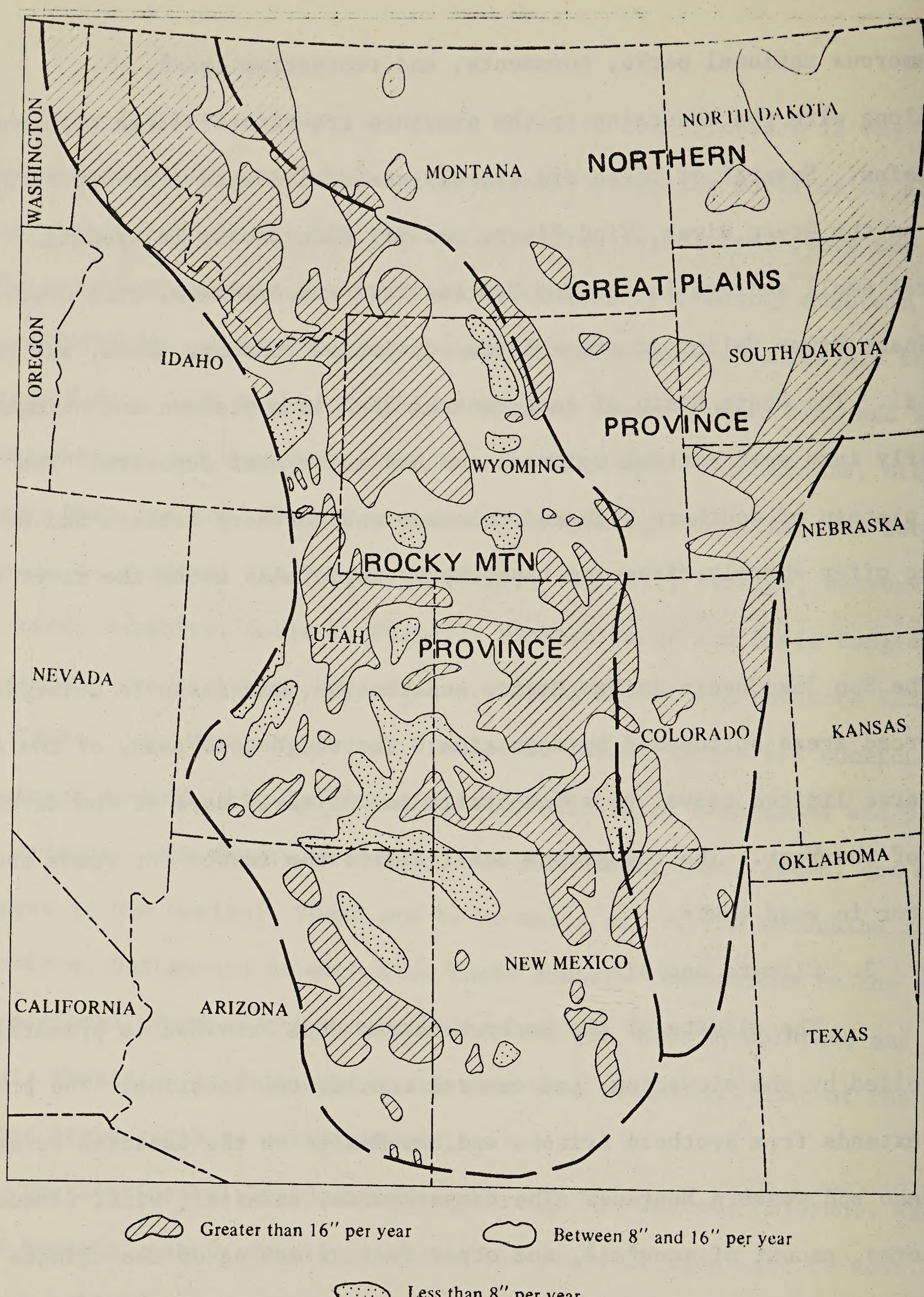


Figure 29 Mean Annual Percipitation

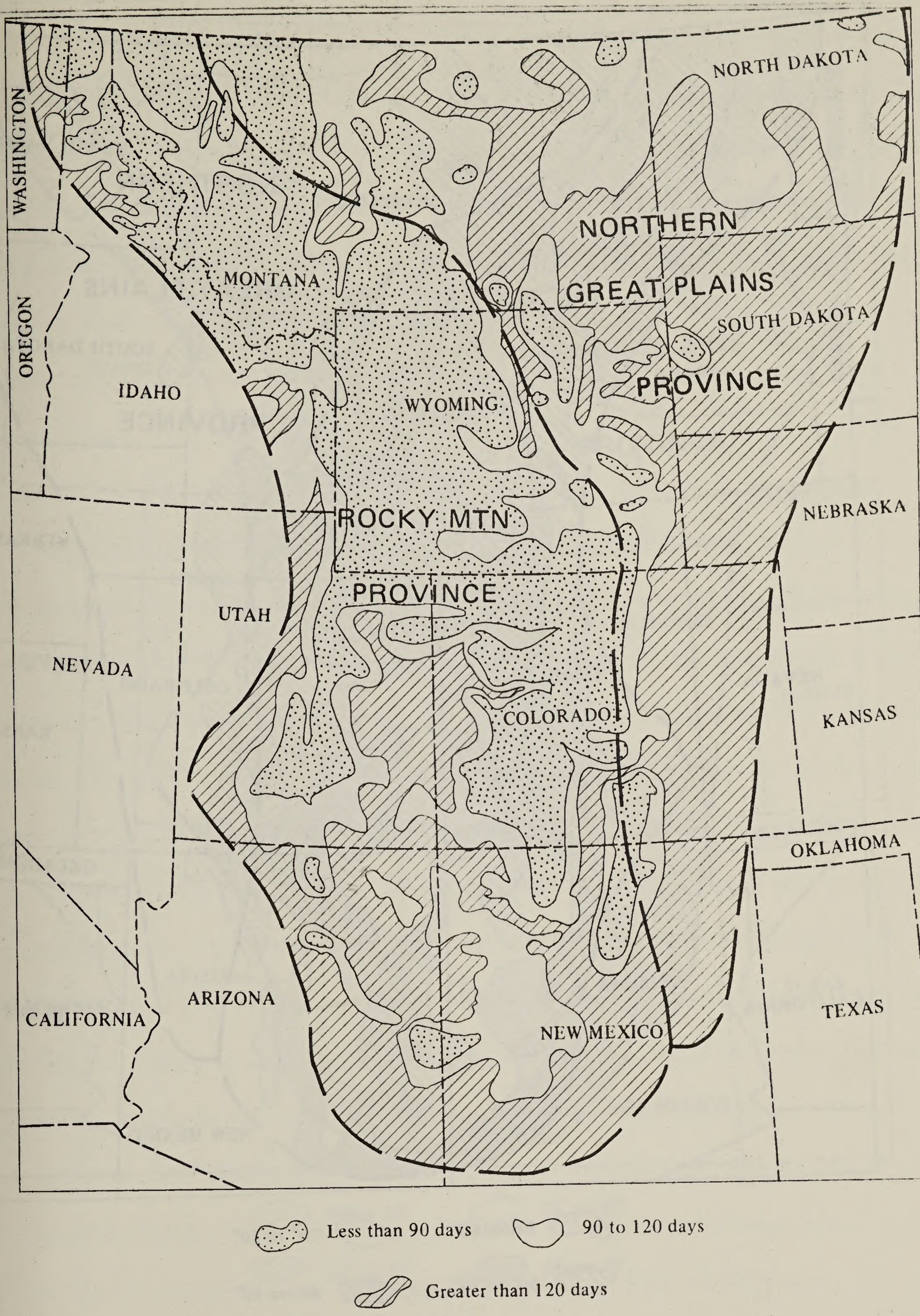


Figure 30 Mean Annual Freeze Period

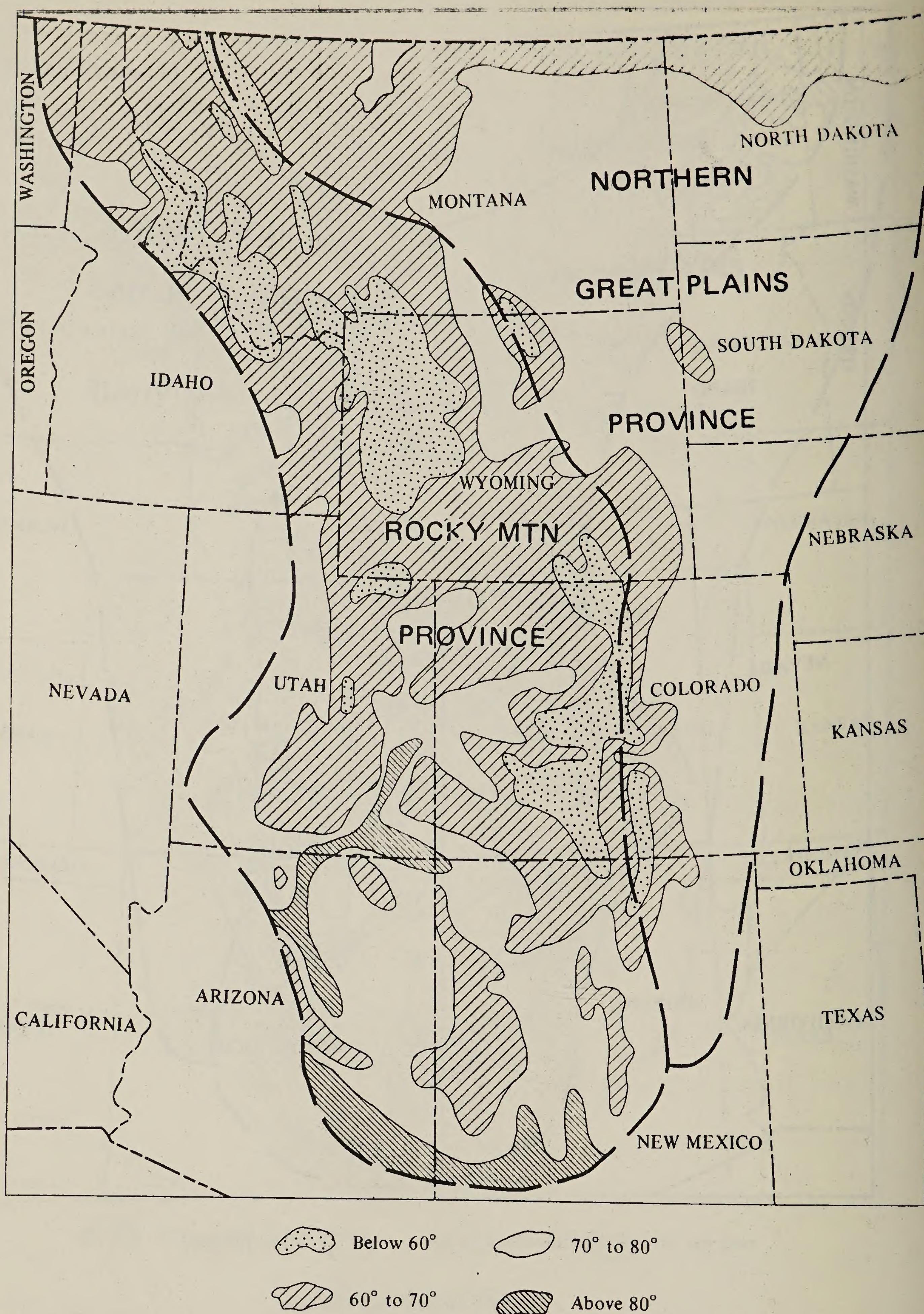


Figure 31 Mean July Temperature

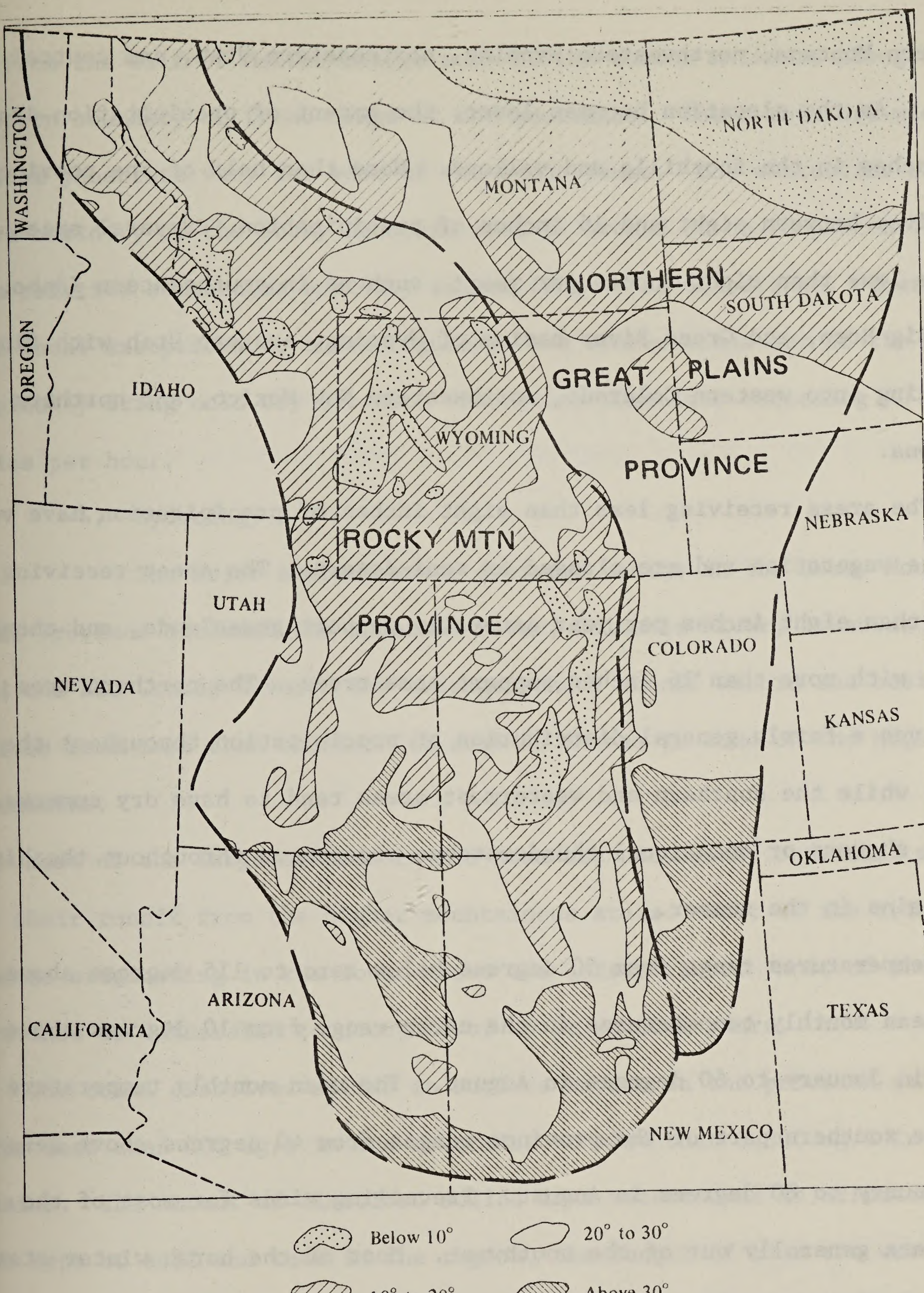


Figure 32 Mean January Temperature

western Montana, northwestern Wyoming, northeastern Utah, and central Colorado. As the elevation becomes lower, the amount of precipitation drops t 16 inches in the foothills and valleys. More than half of the province receives between eight and 16 inches of precipitation. Several areas receive less than eight inches per year; such as in southeastern Idaho, the Big Horn, and Green River basins of Wyoming, eastern Utah with fingers sticking into western Colorado, northwestern New Mexico, and northern Arizona.

The areas receiving less than eight inches of precipitation have very sparse vegetation and are classed as semi-desert. The areas receiving more than eight inches per year generally support grasslands, and those areas with more than 16 inches support some trees. The northern area receives a fairly general distribution of precipitation throughout the year, while the southern and westermost areas tend to have dry summers. Light showers or occasional thunderstorms are common throughout the high mountains in the summer.

Temperatures range from 50 degrees below zero to 115 degrees above. The mean monthly temperatures in the north range from 10 degrees above zero in January to 60 degrees in August. The mean monthly temperature in the southern part of the province ranges from 40 degrees above zero in January to 80 degrees in August. Prevailing winds for most of the area are generally out of the southwest. Most of the harsh winter storms are out of the northwest. The wind patterns are frequently affected by the mountain structures. Strong violent winds frequently funnel through some of the mountain passes and canyons. Winds out of the southeast coming up from the Gulf of Mexico brings much of the summer moisture along the eastern boundary or front range of the mountains. These moisture winds seldom penetrate very far west of the front range. The wintertime relative humidity of the Rocky Mountain area is around 50 to 70 percent. The relative summertime humidity ranges from 40 to 60 percent. There are local exceptions to these figures. The winter winds out of the north typically bring cold dry air with velocities sometimes exceeding 40 miles per hour.

4. Hydrology

The major surface water drainage basins in the Rocky Mountain Coal Province includes the Colorado River, Columbia River, Arkansas River, and the Rio Grande River. The average annual runoff within the basin varies from less than one inch to over 30 inches in some of the high mountains.

Most of the large streams in the area are perennial, obtaining most of their runoff from the higher mountainous areas. Most of the tributaries originating in the lower areas are intermittent. Most of this province is vulnerable to droughts of up to several years.

The total dissolved solids in surface waters in the province ranges from less than 100 mg/l in the mountains to more than 1,800 mg/l in the basins. The amount of dissolved solids in a watercourse is affected by the type of soil and rock in the region, the length of time the water has been in the watercourse, and the extent to which the flows are effected by other water sources. Although the specific chemical composition is an important consideration in determining whether water can be used for specific purposes, the total amount of dissolved solids in the water generally is the controlling factor as to whether a water supply is chemically suitable for most general uses.

The average suspended-sediment concentrations in streams in the province ranges from less than 200 ppm to more than 30,000 ppm. Suspended-sediment concentrations as high as 700,000 ppm have been measured during peak flows on some tributaries to the Colorado River. The suspended sediment in the stream is comprised of particulates such as sand and silt.

The ability of streams to carry suspended-sediment increases with stream velocity. Suspended-sediment tends to be greater in areas where soil is not held in place by dense vegetative cover. Groundwater in this province occurs in alluvium and bedrock aquifers. Alluvium in the region generally is a good aquifer, and is capable of yielding moderate amounts of groundwater (a few hundred gpm), to wells and as much as several thousand gpm to wells at a few places. Unlimited pumping from alluvial aquifers is restricted in most states in this province, due to the effects of pumping on prior appropriated water rights on the nearby stream's flow. The quality of water in the alluvium is generally acceptable for most uses, but in some areas, it is highly mineralized.

The principal and most widespread bedrock aquifers in the province are beds of sandstone and limestones. Yields of most sandstone aquifers are low to moderate, while the highly variable limestone aquifers may yield up to 1,000 gpm to wells. In general, where the aquifers are highly permeable, good quality water is obtained even to depths of 1,000 feet or more. However, where the aquifers have low permeability, highly mineral-ed water is obtained even at shallow depths. The dissolved solids content of most bedrock aquifers increases from recharge areas in the mountains to the center of the basin. Many large areas in this province, including areas underlain by coal, have no nearby perennial surface water supplies, and the groundwater supplies are limited or of poor quality. Much of the good quality water potential in the province has not been fully explored.

Hydrology of four coal regions in the province is discussed below.

a. Big Horn Basin Region

The Yellowstone River and its tributaries, the Clark Fork River, and the Big Horn River, are the major perennial streams in the Big Horn Basin region. Most of the smaller streams are intermittent. During high flows, the surface waters generally have a low dissolved solids content, but during the low flows, the water is highly mineralized in part due to the return of irrigation water. The sediment concentration in the streams in the region is generally high.

River alluvium generally supplies the highest yields of good quality groundwater. Though locally the water is of poor quality.

Groundwater supplies from bedrock aquifers are generally small, and the quality of the water ranges from acceptable to poor.

b. Uinta Region

The Uinta Region is drained by the Colorado and Green Rivers. Both these rivers are perennial, while most of the tributary drainage in the region is intermittent. The dissolved solids content of most tributary waters is high, especially during low flow, with sodium, sulfate, and chloride the major ions. During high flows, the sediment concentrations on both the major and tributary streams in the area is very high.

Most of the groundwater supplies in the region are obtained from alluvial wells. However, in many areas the alluvium contains poor quality water, especially below irrigated areas. Small supplies of groundwater can be obtained from bedrock aquifers in some areas, but little information is available on the quantity and quality of water available over most of the region.

c. San Juan River Region

The main stream draining the San Juan River Region is the San Juan River. This is a perennial stream which supplies a large proportion of the water resources for the Region. Waters in the headwater stream contain less than 100 mg/l dissolved solids and are a calcium bicarbonate type. The headwater streams generally contain little sediment. In the middle and lower reaches of the tributaries and the main stream, especially below irrigated lands, the sodium and sulfate content of the water increases progressively downstream. During low flows, parts of the San Juan River and many of its tributaries have dissolved solids contents greater than 1,000 mg/l. Many of the tributaries in the middle and lower reaches of the basin are intermittent. During high flow periods, the suspended-sediment content of the San Juan River and many of its tributaries may exceed 50,000 ppm.

Groundwater is obtained from stream alluvium and a few bedrock aquifers. The river alluvium yields moderate to large supplies of groundwater, but in many areas, the water is of poor quality. The bedrock aquifers general-yield small to medium supplies of groundwater, but in the lower parts the region, the quality of water is often poor. The groundwater potential of the bedrocks aquifers in large areas of this region have not been fully explored.

d. Green River Region

The main stream draining the Green River Region are the mpa River, and the Green River. Both streams are perennial, but most of eir tributaries are intermittent. The quality of surface waters in the ea range from good in the higher elevations to poor in the lower elevaons. During low flow periods many tributary streams have over 1,000 g/l dissolved solids. The major ions in most surface waters of the area re calcium, sodium, sulfate, and chloride. The suspended-sediment content f surface waters is generally high, and during high flows exceeds 30,000 pm in many tributaries.

The groundwater resources of the area are largely unexplored, but some lluvial wells and bedrock wells are present. Alluvial wells generally ield moderate to large amounts of water, but in many areas, the water is of poor quality. Bedrock aquifers generally yield small amounts of water to wells, and the quality is quite variable.

5. Soils

Soils within the Rocky Mountain Coal Province are described by coal regions. A table for each region, or for two regions where the soils are similar, lists some dominant soil series which occur in that particular area. Some characteristics, uses, and limitations are given for each of the listed soil series. Specific items for each soil such as

Table 28–Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Big Horn and Wind River Regions of the Rocky Mountain Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Boyd	Wyoming	CH	4-6	D	0-12	grasses, small grains	rangeland
Limitations - Clayey soil, high shrink-swell, severe compaction hazard, moderate erosion hazard.							
Dunlap	Wyoming	ML-CL	8-10	B	0-18	hay, small grains	pasture, cropland
Limitations - Moderate erosion hazard on gentle slopes, severe erosion hazard on steeper slopes.							
Midway	Wyoming	CH	2-5	D	0-35	grasses, small grains	rangeland cropland
Limitations - Shallow, clayey soil with high shrink-swell characteristics, calcareous, difficult to manage. Severe water erosion hazard on steeper slopes, severe compaction hazard.							
Rosebud	Wyoming	SM	6-10	B	0-35	grasses, small grains	rangeland cropland
Limitations - Moderate to severe water erosion hazard, severe wind erosion hazard.							

Table 28-(Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Chipeta	Wyoming	CL	1-2	D	3-30	grasses	rangeland
Limitations - Shallow soil, severe erosion hazard, rapid runoff, active gully erosion, clayey soil.							
Arvada	Wyoming	CH	4-8	D	0-6	grasses, small grains	rangeland
Limitations - Saline, Clayey soil, high shrink-swell, difficult to manage, severe compaction hazard.							
Cherry	Wyoming	CL	10-14	C	0-25	crops and grasses	cropland rangeland
Limitations - Slight to moderate erosion hazard, poor road fill material.							
Billings	Wyoming	ML	6-10	C	0-10	irrigated crops grasses	cropland rangeland
Limitations - Alkaline soils, well drained, moderate erosion hazard, soils can be managed well.							
Rough-broken	Wyoming		1	D	10-100	sparse grasses	limited rangeland
Limitations - Includes rock outcroppings, steep canyon walls, shallow stony soils on very steep slopes. Soils have a very severe erosion hazard.							

Table 29-Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Green River Region of the Rocky Mountain Coal Province

Soil Name	Location	Unified Classi-fication	Available Water Capacity (inches)	Hydro-logic Group	Relief (%)	Vegetation	Major Use
Billings	Utah (USDA, 1959)	ML	6-10	C	0-10	irrigated crops, grasses	cropland, rangeland
Limitations - Alkaline soils, well drained, moderate erosion hazard, soils can be managed.							
Chipeta	Utah (USDA, 1959)	CL	1-2	D	3-30	grasses	rangeland
Limitations - Shallow soil, severe erosion hazard, rapid runoff, active gully erosion, clayey soil.							
Fruita	Utah (USDA, 1959)	SM	2-5	B	0-10	blue gramma, sagebrush cactus	pasture
Limitations - Calcareous materials about 15 inches deep, severe wind erosion hazard.							
Green River	Utah (USDA, 1959)	SM	2-5	B	0-3	cottonwood, greasewood, willows	pasture
Limitations - Poorly drained soils, seasonal water table at about 11 inches, very shallow soils, but roots extend into C horizon, subject to flooding.							

Table 29-(Continued)

Soil Name	Location	Unified Classi-fication	Available Water Capacity (inches)	Hydro-logic Group	Relief (%)	Vegetation	Major Use
Shavano	Utah (USDA, 1959)	SC	3-5	B	2-50	aspen, blue gramma	rangeland
Limitations - Severe erosion hazard, shallow soil, about 15 inches to sandstone bedrock, droughty soil.							
Ravola	Colorado (USDA, 1955)	ML	6-8	B	0-6	grains, saltgrass, wheatgrass	irrigated cropland, rangeland
Limitations - Alkaline and saline soils, severe erosion hazard.							
Badland	--	--	--	-	10-80	juniper grasses	limited rangeland
Limitations - Active eroding, high surface runoff, nearly bare shale hills, very severe erosion hazard.							

Table 30-Some Characteristics, Uses, and Limitations of Dominant Soils Occurring in the San Juan River Region of the Rocky Mountain Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Menefee	Utah (USDA, 1962)	CL	2-4	D	2-40	pinon-juniper grasses	rangeland
Limitations - Shallow soil, some areas are cobbly. Mancos shale is within 20 inches of the surface, severe erosion hazard. Management alternatives are limited by depth and slope.							
Monticello	Utah (USDA, 1962)	ML	7-10	B	2-10	wheat, beans, pinon-juniper grasses	cropland, rangeland
Limitations - Wind erosion hazard is severe,management opportunities are good, fertility and organic matter content is good.							
Montvale	Utah (USDA, 1962)	ML-CL	1-2	D	2-25	pinon-juniper sagebrush, grasses	rangeland
Limitations - Soil is less than 20 inches deep, stony throughout, severe erosion hazard, low fertility.							
Northdale	Utah (USDA, 1962)	ML	5-7	C	2-10	wheat, beans, pinon-juniper, grass	cropland, rangeland

Table 30-(Continued)

Soil Name	Location	Unified Classi- fication	Available Water Capacity (inches)	Hydro- logic Group	Relief (%)	Vegetation	Major Use
Limitations - Severe erosion hazard, high fertility, permeability is moderate.							
Sandstone-Rockland	Utah (USDA, 1962)	--	---	D	2-100	sparse juniper, bluegrass	limited grazing
Limitations - Outcroppings of Dakota sandstone, fragile sites occur within the canyons.							
Berent	New Mexico (USDA, 1968)	SM	3-5	A	0-25	grasses	rangeland
Limitations - Severe wind erosion hazard, many areas severely eroded by water.							
Las Lucas	New Mexico (USDA, 1968)	CL	6-8	C	0-25	grasses	rangeland
Limitations - Severe erosion hazard, high fertility, gullies present.							
Penistaja	New Mexico (USDA, 1968)	SM	4-6	B	0-5	grass, sagebrush	rangeland
Limitations - Moderate water erosion hazard, severe wind erosion hazard. Management practices need to be on the contour; some slickspot areas.							

Table 30-(Continued)

Soil Name	Location	Unified Classi-fication	Available Water Capacity (inches)	Hydro-logic Group	Relief (%)	Vegetation	Major Use
Jekley	New Mexico (USDA, 1967)	CL	2-6	C	3-40	ponderosa pine, grass	forest
Limitations - Moderate to severe erosion hazard, shallow soils, cold soil temperatures, high fertility.							
Kiln	New Mexico (USDA, 1967)	ML-CL	.5-2	D	3-40	ponderosa pine grass, oak	forest
Limitations - Moderate to severe erosion hazard, very shallow soil (10 inches to limestone), non-calcareous.							

Table 31-Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Southwestern Utah Region of the Rocky Mountain Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Badland	Utah (USDA, 1970)				10-80	grasses, juniper	limited range
Limitations - Active eroding, nearly bare shale hills, much surface runoff, very severe erosion hazard.							
Billings	Utah (USDA, 1970)	ML	6-10	C	0-10	irrigated crops and grasses	cropland rangeland
Limitatons - Alkaline soils, well drained, moderate erosion hazard, soils are manageable.							
Chineta	Utah (USDA, 1970)	CL	1-2	D	3-30	grasses	rangeland
Limitations - Shallow soil, severe erosion hazard, rapid runoff, active gullies, very susceptible to raindrop splash erosion, clayey soil.							
Kenilworth	Utah (USDA, 1970)	SM	3-5	B	0-20	juniper, pinon	rangeland
Limitations - Shallow, droughty soils, calcareous, severe hazard for reseeding, moderate erosion hazard, deer winter range, stoney soil.							

Table 31-(Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Persayo	Utah (USDA, 1970)	CL	1-3	D	1-20	galletagrass, shadscale	rangeland
Limitations -	Shale bedrock at 12 inches, inclusions of saline soils, erosion hazard is severe, active rill and gully erosion.						
Beryl	Utah (USDA, 1960)	SM	1-3	B	0-1	small grains, potatoes, grasses	rangeland
Limitations -	Shallow to calcareous layer, severe wind erosion hazard, associated with Duneland. Contains gypsum so soil will respond to irrigation management.						
Dixie	Utah (USDA, 1960)	ML-CL	3-6	C	0-5	sagebrush galletagrass	rangeland
Limitations -	Caliche layer 20 to 40 inches deep, moderate erosion hazard. Some areas have stoney surfaces.						

Table 31-(Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Escalante	Utah (USDA, 1960)	ML	6-9	B	0-1	sagebrush, grasses, small grains potatoes	rangeland cropland
Limitations - Severe wind erosion hazard, sand and gravel occur below 40 inches, low fertility and low organic matter.							
Neola	Utah (USDA, 1960)	ML	1-3	D	0-7	yellowbrush, Indian rice-grass	rangeland
Limitations - Shallow, well chained soils, cemented caliche layer, severe wind erosion hazard, low fertility and organic matter.							
Uvada	Utah (USDA, 1960)	CH or CL	1-3	D	0-2	greasewood, shadscale	rangeland
Limitations - Slickspot soils, clayey textured, difficult to manage, high sodium content.							

Table 32-Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Uinta Region of the Rocky Mountain Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Billings	Colorado (USDA, 1955)	ML	6-10	C	0-10	sugar beets corn, grain, greasewood shadscall	irrigated crops rangeland
Limitations -	Alkaline and saline soils, moderate erosion hazard, many areas dissected by streams, can be managed.						
Ravola	Colorado (USDA, 1955)	ML	6-8	B	0-6	crops, saltgrass, wheatgrass	irrigated crops, rangeland
Limitations -	Alkaline and saline soils, severe erosion hazard, weak structure.						
Badland & Rough Broken	Colorado (USDA, 1967)	--	--	-	5-40	grasses, juniper	limited range
Limitations -	Very severe erosion hazard, severely gullied, shale outcroppings, much surface runoff, rock outcrops.						

Table 32-(Continued)

<table>
<tr><th>Soil Name</th><th>Location</th><th>Unified Classification</th><th>Available Water Capacity (inches)</th><th>Hydrologic Group</th><th>Relief (%)</th><th>Vegetation</th><th>Major Use</th></tr>
<tr><td>Chipeta</td><td>Colorado (USDA, 1967)</td><td>CL</td><td>1-2</td><td>D</td><td>2-10</td><td>sparse cover of grasses</td><td>rangeland</td></tr>
<tr><td colspan="8">Limitations - Shallow soils, fine textured, severe erosion hazard, active gully erosion, large amount of overland flow.</td></tr>
<tr><td>Mesa</td><td>Colorado (USDA, 1967)</td><td>SM</td><td>4-6</td><td>B</td><td>0-10</td><td>grasses</td><td>rangeland, tilled crops</td></tr>
<tr><td colspan="8">Limitations - Substratum contains 30 to 70T gravels, moderate erosion hazard.</td></tr>
<tr><td>Ashly</td><td>Utah (USDA, 1959)</td><td>SM, or GM</td><td>1-2</td><td>A</td><td>0-5</td><td>rabbit brush, cottonwood, willows</td><td>rangeland, pasture</td></tr>
<tr><td colspan="8">Limitations - Seasonal high water table, very shallow soil, about 15 inches to gravel layer, subject to overflow.</td></tr>
</table>

Table 32-(Continued)

Soil Name	Location	Unified Classi-fication	Available Water Capacity (inches)	Hydro-logic Group	Relief (%)	Vegetation	Major Use
Fruita	Utah (USDA, 1959)	SM	2-5	B	0-10	blue gramma, sage, cactus	pasture
Limitations - Calcareous materials about 15 inches deep, severe wind erosion hazard.							
Green River	Utah (USDA, 1959)	SM	2-5	B	0-3	cottonwood, greasewood, willows	pasture
Limitations - Poorly drained soils, seasonal water table at about 11 inches, very shallow soils but C horizons contain roots, subject to flooding.							
Shavano	Utah (USDA, 1959)	SC	3-5	B	2-50	aspen, blue gramma	rangeland
Limitations - Severe erosion hazard, shallow soil, about 15 inches to sandstone bedrock, droughty soil.							

he unified classification of the subsoils for engineering uses and hydrolo-ic groups are given as well as general information. Thus, the information ay be used by engineers, hydrologists, and soil scientists as well as the eneral public to gain some knowledge of the soils. The listed soil series re not inclusive. They occur extensively in the region under which they re identified, but they must be viewed as examples. A detailed, on-site oil survey must be made before the total soil resource is known. More etailed information of the soils characteristics and limitations may be btained from the soil survey, listed in the selected references.

Descriptions of soil organisms in the Pacific Coast Coal Province also apply to the Rocky Mountain Coal Province and the other coal provinces.

6. Vegetation

In the Yellowstone Coal Region, small scattered coal fields lie in various biomes -- grassland, cold desert, and montane coniferous forest.

Included in the Big Horn Basin Coal Region is an intermixture of the grassland, cold desert, and a somewhat drier portion of the montane coniferous forest, (inland Douglas-fir) biomes. A cold desert area is covered with widely scattered saltbrush and greasewood plants indicating salty soils. In this northeastern portion of the basin, where annual precipitation is only four inches, low saltbrush plants grow 18 inches apart and produce little. With more precipitation, sagebrush and grasses produce more. On the surrounding mountain slopes, with up to 24 inches of rain and snow, inland Douglas-fir grows.

The Wind River Coal Region includes portions of the cold desert and

rassland biomes similar to those in the Big Horn. There is little salt-rush-greasewood, however,

The Green River region is mostly covered by a sagebrush -grass mixture. ncluded in the Green River region is more saltbrush-greasewood, indicating alt near the surface. There is also some montane coniferous forest re-resented by inland Douglas-fir.

At Kemmerer, Wyoming, nine inches of annual precipitation comes mostly s snow, (56 inches), and 60 to 80 percent of the snow sublimates, (evap-rates), without being absorbed into the ground. The moisture left in he area for the usual evaporation, runoff, and use by plants and animals s then less than 4.5 inches every year, (May, 1967).

The Uinta Coal Region has varied vegetative cover ranging from salt-rush-greasewood, (indicating much salt in the soil), and sagebrush of the old desert, through pinon-juniper and mountain mahogany-oak of the wood-and-bushland biome to drier to wetter coniferous forests including pondero-sa pine, inland Douglas-fir, and spruce-fir communities.

The San Juan River Coal Region includes galleta and grama grass areas of the grassland biome. These grasses do better here because they have adapted to growing during the warm season, July-August, when most of the annual precipitation falls as rain. In the northern temperate grasslands, little galleta is found. Blue grama may form almost pure stands, but it is not so productive under the spring-early summer rainfall pattern as in the southwest where rainfall comes during the late summer. Four-wing salt-brush and winterfat do well and the more northern needle and thread grass is found. Also, in the San Juan River Region, pinon-juniper of the wood-

and-bushland biome and ponderosa pine-inland Douglas-fir of the drier part f the montane coniferous forest biome.

The southwestern Utah Coal Region is predominantly the dry pinon-juniper f the woodland-bushland biome. Saltbrush and greasewood grow in arid sal-y areas. A small area of wheatgrass-bluegrass represents the grassland iome. At the highest elevations, Douglas-fir and spruce-fir forests and t somewhat lower elevations ponderosa pine of the montane coniferous forest iome are found.

7. Wildlife

When describing the wildlife as part of the environment over a road area, it is desirable to describe the animals in relation to the iotic communities to which they belong. This makes it possible to see, generally, where certain animals species, life forms, types, etc., "fit" into the environment concerned and how certain actions affecting one element of a community might affect other elements.

Animals found in the various coal regions of the Rocky Mountain Coal Province, are, in general, characteristic of the montane coniferous forest and forest edge and the cold desert portion of the desert biome. The wood-land-bushland biome or community occurs principally as an ecotone between the cold desert and coniferous forest biomes throughout the coal province. Although there are some distinctive animals, the woodland community is an ecotone with respect to animal species composition also, (Kendeigh, 1961). The coal-bearing formations lie in the intermountain basins and along the flanks of the mountain ranges which were formed after deposition of the coal. Basins or groups of basins make up the different coal regions. In

neral, cold desert communities lie on the lower elevation basin floors, odland-bushland communities are found on the lower slopes and intermediate ateaus and the coniferous forest communities are present on the higher ateaus and along the mountain flanks. The woodland-bushland communities e greatly diminished in the Green River Region and regions to the north ile sagebrush-grassland communities are diminished in regions to the uth. There is considerable variation in animal species composition north south even though some species are common throughout the province. Aquatic bitats are somewhat limited in the coal regions of this province, but are ighly important to various wildlife species in the generally arid environ-ent.

Terrestrial Wildlife

Throughout the montane coniferous forest areas animal life is character-zed by marked seasonal cycles. Invertebrates and many vertebrates are dor-ant during the coldest months; large numbers of migrating birds arrive n the spring and leave in the fall. Some of the larger species such as eer and elk migrate to the lower elevations during winter. Others, such s the blue grouse and snowshoe hare, remain active, adapted to walking n the snow and burrowing into it for protection. The northern flying squirrel and red squirrel harvest and store food for winter use. Pocket gophers and mountain phenacomys are active under the snow. Predators such as the goshawk, marten, and mountain weasel stalk the forest year-long.

Some boreal coniferous animals are found overlying the montane coniferous forest species in the province's northern coal regions. The Shiras moose is found in the conifer-aspen type and along the willow bottoms of the

iparian woodlands primarily in the Green River and Ham's Fork Coal Regions. anada lynx occur in forest areas of these same regions. Some species are onsidered characteristic of both the montane and boreal coniferous forests. hese include the snowshoe rabbit, red squirrel, porcupine, deer, mouse, ater shrew, black bear, ruffed grouse, goshawk, great horned owl, and others.

The woodland-bushland communities, i.e., juniper, pinon-juniper, moun-ain mahogany-oak, attract species from the adjacent montane coniferous orest. Since the trees are sometimes scattered and interspersed with grass r shrubs, grassland or desert species may penetrate into the community. The ule deer, mountain lion, and coyote commonly occur in the woodlands during he fall, winter, and spring, although most of these species spend summers n the higher mountains. The bobcat, rock squirrel, cliff chipmunks, desert nd bushy-tailed woodrats, and pinon mouse show preference for rough country, ocky hillsides, and cliffs within the woodland-bushland communities. Birds such as the pinon jay, band-tailed pigeon, and scrub jay are characteristic. Invertebrate populations are low and consist largely of spiders, ants, ter-mites, and jumping plant lice, (Kendeigh, 1961). Rattlesnakes, lizards, and horned toads invade from the desert, but are not particularly character-istic.

The cold desert communities of the Green River, Big Horn River and Wind River Coal Regions are largely sagebrush-grasslands. Saltbrush-grease-wood associations are present in most regions, but become most prominent in the Uinta Coal Region. The pronghorn antelope and the sage grouse are abundant only in the sagebrush-grass ranges of the province, (Sundstrum, 1973, Scott et al, 1971). This is not surprising since both species are

ighly dependent upon the sagebrushes for food and cover, especially during he winter. Using figures presented by Sundstrum, as much as 20 percent f the World's pronghorn populations may be found in the Green River Coal egion. A major portion of the total sage grouse population is also ound in the Green River Region. The low, stock form and the arrangement n clumps with intervening open ground make sagebrush favored living quarers for many kinds of animals. It provides shelter from wind, pursuing redators, and the sun in addition to food and nesting sites, (Shelford, 963). The white-tailed jack rabbit, mountain cottontail, desert cottonail, ordis kangaroo rat, northern grasshopper mouse, sagebrush vole and various pocket mice are characteristic small mammals of the province's cold desert communities. The black-tailed jack rabbit becomes more common than the white-tailed jack rabbit in the southern part of the province. The sage thrasher, sage sparrow, Brewer's sparrow, and ferruginous hawk are characteristic birds. Lizards are most numerous in the southern coal regions, especially in the San Juan Region. The sagebrush lizard is found throughout the province. Invertebrates are most numerous in the sagebrush and greasewood communities and least abundant in the shadscale, (Kendeigh, 1961). Spiders, ants, and tenebrionid beetles are the most conspicuous ground invertebrates. Harvester ants build conspicuous mounds throughout the sagebrush communities.

Some of the species of higher public interest and/or value are wide ranging, often utilizing most types of plant communities found in this coal province. The mule deer are found in all the coal regions. Numbers are usually restricted by the limitations of winter range. Because of these constraints, deer populations are actually controlled by certain are of range that comprise only small percentages of the total land area. The critical areas must support not only the present deer herds, but also the herds which will be needed to maintain most of the big game hunting for future generations. Deer winter range typically comprises the lower slopes of the mountains and adjoining valley fringes between the deep snow at higher elevations and the edge of farm and ranchlands in the valley. Migration of up to 50 miles and more between summer and winter ranges takes place annually in some areas. The vegetative types which characterize this winter habitat are the pinon-juniper and mountain mahogany-oak at higher elevations and sagebrush type at lower elevations. Deer herds in the northern part of the Green River Coal Region commonly winter almost entirely on sagebrush winter ranges. The White River and Piceance Creek drainages in the Uinta Coal Region supports one of the largest and most productive mule deer herds in the United States.

Elk also occupy extensive areas and are found in all coal regions of the province, but are most prominent in the eastern portion of the Uinta Coal Region, the northern portion of the San Juan River Region, the northern portion of the Green River Region, and the eastern portion of the Big Horn Basin Coal Region. Like mule deer, they are restricted by the limitations of available winter habitat. Typically, elk winter in the conifer-aspen forests and in the woodland-bushland communities of this coal province but in some areas, notably in the Green River Region, elk winter in the sagebrush-grasslands. In these situations, they are highly intolerant of human activity. A notable example of elk inhabiting the cold desert com-nity is found in Wyoming's Sands elk herd. As many as several hundred k live year-around in a remote sand dune-sagebrush-saltbrush habitat far om the nearest trees and mountains. This herd is in the Green River al Region.

Two subspecies of bighorn sheep occur in this coal province. Those und in the Green River region and the northern part of the San Juan gion are Rocky Mountain bighorns while those found in the Southwestern ah region are desert bighorn, (Scott, et al). The Rocky Mountain bighorn an animal of the coniferous forest alpine openings, while the desert ghorn occurs in the cold desert community in this province. Turkeys ve been reintroduced to much former native range especially in the South-stern Utah and San Juan Regions. They inhabit the coniferous forest and roken woodland areas. Ring-necked pheasants, some bob-white quail, and huckar partridge have been successfully introduced in the Bighorn Basin egion. Pheasants occur to some extent in most agricultural areas. Chukars ave been established in most coal regions.

The exotic Barbary sheep was introduced at one site within the San Juan oal Region, but reportedly has not done well, (New Mexico Department of ame and Fish, 1967).

Conspicuous terrestrial animals found within the Rocky Mountain Coal rovince are summarized below according to biotic communities:

Coniferous Forest and Forest-Edge Communities

Water shrew

Snowshoe rabbit

Red squirrel

Northern flying squirrel

Deer mouse

Porcupine

Black bear

Wapiti (elk)

Mule deer

Bobcat

Mountain lion

Canada lynx

Shiras moose

Wolverine

Marten

Least chipmunk

Yellow-bellied marmot

Golden-mantled ground squirrel

Bushy-tailed wood rat

Goshawk

Pigeon hawk

Golden eagle

Great horned owl

Saw-whet owl

Pygmy owl

Flamulated owl

Ruffed grouse

Blue grouse

Yellow-bellied sapsucker

Hairy woodpecker

Williamson's sapsucker

White-headed woodpecker

Gray jay

Red-breasted nuthatch

Steller's jay

Clark's nutcracker

Common raven

Mountain chickadee

Mountain bluebird

Varied thrush

Western tanager

Cassin's finch

Gray-headed junco

Audubon's warbler

Woodland-Bushland Communities

Rock squirrel

Cliff chipmunk

Desert woodrat

Band-tailed pigeon

Acorn woodpecker

Lewis woodpecker

Pinon mouse

Bobcat

Bushy-tailed woodrat

Ringtail

Ash-throated flycatcher

Gray flycatcher

Scrub jay

Pinon jay

Plain titmouse

Common bushtit

Blue-gray gnatcatcher

Western bluebird

Black-throated gray warbler

Cold Desert Communities

Black-tailed jack rabbit

White-tailed jack rabbit (northern)

Desert cottontail

Nuttall's cottontail

Desert woodrat

Least chipmunk

Great Basin pocket mouse

Ordi's kangaroo rat

Northern grasshopper mouse

Sagebrush vole

Pronghorn antelope

Coyote

Kit fox

Western spotted skunk

Desert bighorn sheep

Leopard lizard

Sagebrush lizard

Side-blotched lizard

Short-horned lizard

Bullsnake

Plateau whiptail

Racer

Western rattlesnake

Red-tailed hawk

Gambel's quail

Sage grouse

Mourning dove

Great-horned owl

Loggerhead shrike

Black-throated sparrow

Sage thrasher

Sage sparrow

Brewer's sparrow

Aquatic Wildlife

As described here, aquatic wildlife includes invertebrates, fishes, birds, mammals, reptiles, and amphibians associated with the stream, lake, and pond-marsh biotic communities.

Aquatic wildlife habitat in the Rocky Mountain Coal Province, as a single geographic entity, historically included a wide representation of the three freshwater biotic communities. However, when considered in term of the actual geographic location of the individual coal regions within the province and in view of man's alteration of natural surface hydrologic patterns, stream and man-made lakes are the major aquatic habitats to be considered.

Streams range from clear, cold rivulets and brooks cascading down the mountain slopes to broad silt-laden rivers flowing through narrow valleys or deep canyons. There is very little warm water in the province. In the southern regions, at lower elevations, either cold water or warm water aquatic species may be found. The principal habitats in a stream are falls, riffles, or rapids, sand-bottom pools, and mud-bottom pools. Mud-bottom pools form in backwaters and behind dams and are essentially young stages of ponds. The typical stream animals are found in the riffles and sand-bottom pools. The most characteristic and abundant stream animals are the caddisfly larvae, mayfly naiads, stonefly naiads, fly larvae, crayfish, snails, freshwater clams, and fish.

Streams of the Yellowstone, Big Horn River Coal regions support fish species typical of the colder headwaters of the Missouri River drainage. Characteristic fish species include the mountain whitefish, Yellowstone cutthroat trout, lake chub, flathead chub, longnose dace, plains minnow, silvery minnow, fathead minnow, white sucker, longnose sucker, mountain sucker, burbot, and sauger. Common introduced species include rainbow trout, brown trout, brook trout, and carp, (Baxter, 1970, and Brown, 1971).

The Green River, Uinta, Southwestern Utah, and San Juan River Coal gions are primarily within the Colorado River drainage. The cutthroat out and the mountain whitefish are the only native game fishes of the per Colorado River drainage. These natives have been supplemented, and the case of the native Colorado River cutthroat, largely replaced by merous introduced species. Rainbow trout are the most numerous newcomers d are stocked in tremendous numbers each year, (Scott, et al, 1971). her game fish which have been introduced are brown trout, Yellowstone tthroat trout, brook trout, and arctic grayling in the coldest waters d channel catfish, black fullhead and yellow perch in the warmer waters. aracteristic non-game fishes are the carp, Utah chub, roundtail, bony-ail, humpback chub, leatherside chub, redside shiner, Colorado squawfish, peckled dace, fathead minnow, flannelmouth sucker, mountain sucker, blue-ead sucker, humpback sucker, and the mottled sculpin, (Baxter, 1970, cott, et al, 1971, Singler and Miller, 1963).

Amphibians such as tiger salamanders, the Great Basin spadefoot toad, he boreal western toad, chorus frogs, and leopard frogs are found along treams in all the coal regions of the province. Others such as the western padefoot toad, Woodhouses' toads, the red-spotted toad and the bullfrog are found only in some of the southern regions, (Stebbins, 1966).

A variety of mammals and birds are closely associated with and at least partially dependent upon stream communities. Bald eagles, kingfishers, and great blue herons harvest fish. Water ouzels dive for aquatic insects. Muskrats, beavers, mink, raccoons, water shrews, river otters, and others are links in the food chains of the streams ecosystem.

The Rocky Mountain Coal Province lacks extensive wetlands so waterfowl numbers are comparatively small. The available habitat consists largely o streams and stream bottonlands, canals, reservoirs, and seeps created by irrigation practices. Food supplies are limited, except in areas of agricultural development. Waterfowl tend to concentrate in areas of irrigatio development such as in portions of the Green River and Yampa River valleys in the Green River Coal Region, and in the San Juan River valley in the San Juan River Coal Region. Waterfowl are present in greatest concentrations during irrigation. In the summer only the breeding species are foun dispersed over the nesting areas. Nesting occurs at waters associated wit agricultural lands, river side-channels and oxbows, beaver ponds and to a lesser extent reservoirs and natural lakes. The Great Basin Canada goose, mallards, pintails, teal, and Barrow's goldeneye are typical nesting speci.

There are relatively few natural lakes remaining in the coal regions of this province. The majority of those once in existence have been modif d for storage of irrigation water. The acreage of man-made reservoirs far exceeds that of natural lakes. Man-made lakes are usually less productive than natural lakes, but creation of large impoundments such as Yellowtail Reservoir, Boysen Reservoir, Flaming Gorge Reservoir, Lake Powell and Nava Reservoir, coupled with fish stocking programs, has greatly expanded the fisheries of the province. Various combinations of trouts and introduced warmwater fish species such as the walleye, large-mouthed bass, small-mout d bass, black crappie and others may be found in these waters. These lakes also provide immense resting areas for migrating waterfowl.

Pond-marsh biotic communities are quite limited in extent in this coal province, but are significant locally. Stock ponds and the river sidehannels, oxbows and irrigation seeps mentioned above often support typical pond-marsh animal associations, but probably the most widespread example of this biotic community throughout the province is the beaver pond. Beaver ponds are found in thousands of small streams throughout the province. Their margins are usually marshy and they support rooted vegetation around the edges. A variety of frogs, toads, snakes, and air-breathing aquatic insects occur here. Sandpipers, killdeer, and snipe search the pond edges, while in the evenings, swallows, and bats take insects emerging from the water. Mallards, teal, and Barrow's goldeneye, commonly nest around beaver ponds. Typical fish inhabitants are brook, rainbow, and cutthroat trout, sculpins, and suckers. The beaver is the most conspicuous aquatic mammal found here. Muskrat and mink are often present, as are raccoon and sometimes otter.

Threatened Species

Those wildlife species determined by the Secretary of the Interior to be threatened with extinction and named on a list published in the Federal Register are officially "endangered species." The species categorized as "threatened" in the Bureau of Sport Fisheries and Wildlife's 1973 publication, Threatened Wildlife of the United States, include all vertebrate species whose existence is considered threatened whether they are officially listed as "endangered" or not.

In the Rocky Mountain Coal Province, one mammal, two birds, and three species of fish are presently on the official endangered species list. The black-footed ferret has been reported on the basis of several observations within the province, but these have not been confirmed. Ferrets are closely associated with prairie dog towns as prairie dogs are their major food source.

One bird considered endangered is the American peregrine falcon. This bird has been extirpated as a breeding species in the eastern United States and is generally decreasing in the West. In the Upper Colorado River area the peregrine falcon is uncommon. Very few nesting peregrine falcons are known to occur in this province probably less than a half-dozen pairs. Nest are usually found in coniferous forests or along major rivers. Extreme care should be taken to prevent disturbing them. The southern bald eagle, also endangered, probably occurs in the San Juan River coal region as a winter resident or migrant.

Two of the endangered fish, the humpback chub, and the Colorado squawfish, are native to the Colorado River drainage. Both are adapted to a swift water environment. Present indications are that reservoir construction is an inhibiting factor. The natural habitat is obliterated in the impoundment areas, while reproductive requirements are affected by lowered temperature in the tailwater areas. Both are quite rare in the natural stream segments remaining.

A recent addition to the endangered list is the Kendall warm springs dace, which is found only in a warm spring-fed tributary to the Green River in the Bridger National Forest in Wyoming. It is within the Green River Coal Region.

In addition to the endangered species, there are several other species considered threatened within the province.

The spotted bat is evidently America's rarest mammal. It ranges from

Mexico and the southwestern states as far north as Yellowstone County, Montana. Until recently, it was thought to be limited to ponderosa and pinon pine habitat. However, it is now known to be a permanent resident of treeless canyonlands in west Texas. The bat has been recorded from the Bryce Canyon area and may occur in favorable habitat in any part of the province.

The threatened Utah prairie dog is found in parts of the Southwestern Utah coal region. Most of its range is in the Great Basin of Utah, but a number of colonies located near the Wayne-Piute Counties boundary are in this coal region.

The spotted owl occurs in the San Juan River coal region and possibly in the southeastern part of the Uinta region. This extremely sedentary bird is threatened by removal by old growth timber and disturbance of limited areas of mountain canyon habitat by recreation and construction activities.

Another of the falcons found in this province is considered threatened. This is the prairie falcon, a bird of the canyons, deserts, and open country. It has disappeared from many localities within its overall range in recent years, and will appear on the endangered list if this trend is not halted.

The arctic grayling, native of the Missouri River drainage, has been introduced into a number of lakes and the Green River in the Green River coal region. Grayling naturally prefer clear, cold streams with gravelly bottoms and deep holes.

Not officially included, but a candidate for the endangered list is the Colorado River cutthroat. This native of the headwater streams of the

Colorado River continues to exist as a pure or relatively pure form in a few remaining areas. Isolated cutthroat populations have been recently found in remnant numbers in remote tributary reaches within Colorado, Utah, and Wyoming. The most extensive populations found to-date occur in short stretches of several small creeks in the Green River coal region. In some localities, these populations are threatened by habitat deterioration resulting from watershed erosion. Hybridization with rainbow trout and other types of cutthroat trout is eliminating the subspecies. Management efforts are being directed toward watershed improvement and continuance of barriers that isolate the local populations. This species is presently categorized as "status undetermined."

Some species, while not endangered throughout their range, have remnant populations in danger of being eliminated in local areas. This has prompted state development of "rare and endangered" species lists. As an example, Wyoming's list of rare or endangered species which occur in this coal province include species such as the shovelnose sturgeon and sturgeon chub of the Big Horn River drainage, the Colorado River cutthroat and leatherside chub of the Green River drainage. Others are the osprey, trumpeter swan, burrowing owl, midget faded rattlesnake, Green Basin smooth green snake, wolverine, river otter, and ringtail.

8. Land Uses

The Rocky Mountain Coal Province features some of the most rugged topography in the United States. For this reason, the major portion of the province today is covered by natural vegetation. The most extensive land use of the area is for grazing by livestock and wildlife.

Timber production is of significance and outdoor recreation is an ext use which is rapidly gaining economic significance, surpassed only by grazing. Data from comprehensive river basin studies on the Colorado River, (Table 33), provides an idea of the relative significance of tl various land uses. The upper Colorado Region is somewhat representati of the Rocky Mountain Coal Province. It includes grazing on 84 percer the area; cropland cultivation on three percent; timber production 13 cent; urban, transportation, and utilities one percent; outdoor recr ation 65 percent; and formally designated wilderness two percent. The ner in which land uses were calculated demonstrates multiple use.

Table 33- Land Use Data for the Colorado River Basin, 1965

Land Use	Upper Colorado Region 1/ (1,000 Acres)	(%)	Little Colorado Subregion 2/ (1,000 Acres)	(%)
Grazing	60,442	84	16,604	96
Cropland	2,225	3	44	--
Irrigated	(1,622)	(2)	(28)	--
Dry Farm	(603)	(1)	(16)	--
Timber Production	9,419	13	1,419	1
Urban & Transportation	929	1	82	--
Designated Wilderness	1,414	2	0	--
Outdoor Recreation	47,543	65	15,128	88
Military	114	--	21	--
Exclusive Fish & Wildlife	229	--	16	--
Intensive Mineral Production	37	--	7	--
Total Land Area	72,234		17,252	

1/ Defined as the Colorado River Drainage and all tributaries above Lee Ferry, Arizona.

2/ Little Colorado Drainage above confluence with Colorado.

Note: Land uses acreages are not inclusive and demonstrate some mulitpl

Source: Comprehensive Framework River Basin Studies, Appendix IX, Land Resources and Use, Upper and Lower Colorado Regions.

a. Agricultural

Grazing of sheep and cattle and cultivated crop production are the most extensive land uses in the Rocky Mountain Coal Province. It is estimated that 85 to 90 percent of the area is utilized for agricultural production. This area is also used for wildlife habitat, extensive outdoor recreation, and mineral production.

Range lands vary considerably in productivity, but as an average the native vegetation produces an estimated .1 animal unit month (AUM) of forage per acre, (Data from Upper Colorado Region). The range livestock industry is oriented to production of feeder livestock from cow-calf and ewe-lamb type operations. A major portion of the grazing lands are in Federal ownership administered by the Bureau of Land Management and the Forest Service.

Croplands are scattered throughout the province, but make up a small percent of land use. It is estimated that three percent is cropland, with the majority being irrigated. Some dry land farming takes place under favorable soil and moisture conditions. Livestock feeds are the major crops. This enables producers to balance operations with the available range forage and adverse weather conditions. Major crops include hay, (alfalfa and native), improved pasture, and feed grains. Other crops include food grains, orchard fruits, sugar beets, potatoes, dry beans, and various truck crops.

b. Timber Production

Coniferous forest occurs in the Rocky Mountain Coal Province primarily between elevations of 5,000 to 11,000 feet. Pinon-

juniper woodland is the most extensive forest type, but is of minor importance for wood production except for fuel wood in Colorado. The important timber species include ponderosa pine, Douglas-fir, white fir, lodgepole pine, Englemann spruce, and limber pine. Based on river basins study data, it is estimated that 10 percent of the province is valuable for timber production. The majority of the area is under Forest Service administration with some ownership by States, private individuals, and other Federal agencies.

The forest lands are valuable for other uses including watershed protection, wildlife habitat, outdoor recreation, and domestic livestock grazing.

c. Watershed

The Rocky Mountain Coal Province is headwaters for the major river systems in the west and midwest. Much of the high mountain area produces runoff in excess of ten inches annually. The quantity and quality of the water is highly dependent upon watershed conditions. Data from the upper Colorado comprehensive river basin study indicates that 40 percent of that area is affected by accelerated erosion. Conditions over the province are estimated to be something less than this amount.

Agricultural-related uses are presently the most significant depletion of surface water. In the upper Colorado Region, water depletion by use in 1965 was: irrigation - 62 percent, municipal and industrial - one percent, minerals and parks - 1.6 percent, recreation and wildlife - .4 percent, and livestock water - one percent. The remainder of depletion is accountable to evaporations from storage facilities. Surface water use

in the province is comparable to the above data although depletion for power production is known to have accelerated considerably since 1965.

d. Mineral Industry

At present, mineral production utilizes only a small percent of the province. Using upper Colorado Region as an example, mineral use was less than 1/10 of 1 percent in 1965. Use, however, is intensive in many cases with significant impact on other uses and on the environment. Mining activities of the past have been abandoned loading facilities, waste dumps, tailings, ponds, and extensive road systems.

A great variety of minerals are produced with the following being of significance: Coal, oil, gas, uranium, iron ore, copper, silver, gold, lead, zine, molybdenum, potash, trona, and phosphates. Mining and primary processing in a major employer in many areas, contributing significantly to local economies. This province also includes the major oil shale deposits in the United States and vast reserves of bituminous sandstone.

e. Urban and Transportation Uses

Urban uses including residential, commercial, and industrial along with all types of transportation systems, (highways, roads, railroads, airports, power lines, communication lines, pipelines), utilize relatively extensive areas. In the upper Colorado Region, which has no major urbanized areas, this use amounted to more than one percent. The Rocky Mountain Coal Province with major urbanized areas along the eastern mountain front in Colorado, the Wasatch front in Utah, and the Albuquerque area in New Mexico make more extensive use of land. It is estimated that two percent of the province is utilized for these purposes.

Higher uses such as these preclude mineral development in most cases. It is possible however that under certain economic conditions, that improvements can be removed and replaced in order to obtain valuable mineral reserves.

f. Wild Horse and Burro Habitat

The Rocky Mountain Coal Province includes extensive areas used by wild horses. Some of the more significant areas include the Red Desert and Big Horn Basin in Wyoming; Book Cliff - Piceance area and Yampa River in Colorado, Book Cliffs in Utah, and Pryor Mountains in Montana. The Pryor Mountain wild horse range, (32,000 acres) is the only formally designated wild horses area within the province. Overall, wild-horses utilize extensive acreages and involve many areas which have coal resources. Coal resources are found in the Big Horn Basin, Red Desert, Book Cliff, Piceance Creek, and Yampa River areas.

Wild burros are not a big factor in the province. Some isolated areas have small burro populations.

g. Mountain Subdivisions

Many factors which make the Rocky Mountain area so inviting to the recreationist and tourist has created an added land use -- mountain recreational and rural residential community developments. Subdividing is taking on major proportions in some locales, particularly in Colorado. Patented, mining claims and homesteaded lands are main categories being subdivided. These are intermingled with Federal lands administered by the Forest Service and Bureau of Land Management.

In the Colorado mountain valleys, over 380 rural subdivisions involving

285,000 acres are located adjacent to Federal lands. Coal lands within the San Juan River and southwestern Uinta Coal Regions are specifically affected by these developments. Under mining patents and the homestead laws, coal is reserved to the United States.

h. Recreational - Educational

Factors of relatively low population, remoteness, and breathtaking scenery combine to make opportunities almost unlimited for the recreationist.

Some outstanding national forests, national parks, and national reserve lands are located in this province, the most famous being Yellowstone National Park. Others such as Bryce and Zion National Parks, and the Grand Canyon add to the recreational appeal.

Camping and picnicking facilities are provided by numerous Federal- and state-operated installations.

The Rocky Mountain Coal Province offers considerable opportunities for the tourist to review historical events.

A history rich in mining activities has left reminders of the past in old installations and ghost towns. Numerous forts have been restored as have pioneer sites and old camps.

Some of the best hunting and fishing in the country is available. Drainages support several varieties of trout, while hunting opportunities include deer, elk, moose, sheep, goats, bear, and pronghorn antelope.

Other activities available to the recreationist include winter sports, rock hounding, horseback riding, and boating.

9. Population Patterns and Considerations

a. Social

The Rocky Mountain area is socially characterized by it primarily rural patterns in which political, social and economic views are generally conservative, with a markedly slower rate of social chang than in urbanized areas. Rural localities are notable for their lower rate of acceptance of new social norms and modes.

Sparse distribution of population can be related to the topography and climate of the province. High elevation and sharp relief of the la limits settlement to lower, flatter areas near reliable water supplies.

Technology has changed this pattern only in small part from the days of earliest pioneer settlement, and many of the social values are rooted in the pioneer experience. Related to these environmental extremes of climate, topography and pioneer ethic are predominant social attitudes of self-reliance and personal independence exhibited by the residents. Traditionally, American pioneer social values and mores are understood as a basically rural heritage, well illustrated in this province. Their attachment to the land, ties of family unity, and communit solidarity are, in social viewpoint, keystones of their image. These same strengths are primary contributors to their insularity and appare reluctance to change.

b. Political

Salt Lake City, Utah and Denver, Colorado (though the latter is geographically in another coal province) are the political-economic-social centers for the Rocky Mountain Province and often exhibit polar extremes in Socio-political orientation. Conservative political views are generally held, in the province, expressing a rural thought pattern usually opposed to the liberalism of urbanized areas. Salt Lake City, though urban, is more conservative than Denver or Cheyenne, Wyoming, perhaps due to the socially and political conservatism of the influential Mormon community.

Denver owes much of its political outlook to the great numbers of immigrants from eastern urban centers. This largest city of the province also attracts many of its residents from the smaller neighboring towns and even neighbor states. Conversely, the city, through political and economic considerations, diffuses its influence throughout the state to the effect that people of Colorado are more liberal in political expression and thought than Utah, Wyoming, and New Mexico.

c. Economic

Economic patterns of the Rocky Mountain Coal Province are closely related to the social attitudes. In keeping with the rural orientation, livestock raising is a major influence, with agriculture usually an adjunct to the livestock industry. Exceptions occur along watercourses wherein cropland agriculture is a primary industry, but only on a localized basis.

Mining has been important to all the states in this province with copper, gold, lead, zinc, and silver mining usually capturing the public's attention. Coal has been mined historically in all the province states but only recently have these reserves received national interest.

Historically, some tension has existed between mining interests and people engaged in farming. Other minerals have local economic prominen[ce.] Iron, uranium, limestone, and gypsum are extracted in most of the subje[ct] states, but the economic-political base has remained in the raveling-rural orbit in most province states.

Similarly, forest products industries are important, but have not gained dominant positions in the economies except in Idaho. Oil and ga[s] interests have large impacts on the states' economic outlooks. Some states have extensive reserves of petroleum and exploit them heavily while other states in the province have little, but actively seek explo[-]ration for this resource.

Of ascendant economic value is recreation and tourism. The Rocky Mountains have long been a mecca for skiers, hunters, and summer visito[rs] from the lower elevation states and densely populated regions of the nation. Yellowstone, the world's first National Park, and many other National Parks, Monuments, and National Forests are located in the Rocky Mountain Coal Province. The Federal government is expanding its public recreation potential and facilities in this area, as are the states and counties. Some developed recreation units are underlain by coal deposits.

Recreational use is of growing economic importance, due to increase[d] leisure coupled with a heightened awareness of the human need for open space. All the states in this province are presently advertising their recreational values, and this use is showing significant economic growt[h] in all of them.

Major industrialization of this province has not occurred as a concommitant to population growth. Industrial expansion, in other than services to extractive industries has been limited to the larger population centers; the largest ones attracting, such service industries, seemingly exponentially, more than have the smaller cities. The expansion of major population areas as distribution, transportation, and communications centers been simultaneous to the growth of light industry in these metropolitan areas.

The growth of population in some areas of this province is usually indicated by the expansion of government services. As county populations and tax bases grow, more demands for protection, health, and community services are experienced. Coupled to the growth and shift of emphasis in State governments, has been the expansion of Federal agencies to serve the citizens. There has been a trend in the past decade to decentralize Federal administration from the nation's capital to regional centers closer to the people. This has influenced regional economies due to the presence of Federal payrolls. The need for more schools, libraries, churches, hospitals, and paving, water and sewage districts is measured by the expansion of the urban centers. Smaller cities' growth has awakened many local governments to the need for land use planning and zoning.

All sectors of enterprise are showing growth in the Rocky Mountain Coal Province. Though specific localities may show a net loss of great consequence to themselves, the province as a whole shows growth in population, goods and services, and in annual product.

d. Ethnic

Ethnic considerations within this province center mainl around its numerous scattered Indian population. Another large minorit group is the Mexican-American population, which presently is in a state of rapid acculturation and urbanization within the larger Caucasian community. Initially at least, this group should be considered as any other unit of our society within this province. Existing, discernible ethnic minority groups are factors to be considered in environmental analyses preceding individual coal developments.

Enclaves of other nationalities and ethnic/racial groups are very small or conspicuously absent in the province, or have completed the acculturative process and presently comprise part of the dominant culture.

The native American Indian groups in the province occupy extensive scattered land areas. Many of these possess coal deposits of merchantable quality and disposition. Some, such as the Navajo and Hopi tribes, have begun a program of coal leasing within their reservation boundaries and other tribal lands have been explored for coal resources. While this statement does not treat these Indian coal lands, it must be understood that coal leasing actions on Federal lands surrounding or adjacent to Indian properties affect their lives as such actions also affect non-Indians.

e. Cultural and Religious

The Church of Latter Day Saints (Mormon) and its adherents in the state of Utah and to a lesser extent in the surrounding states is an important influence of cultural and religious significance.

As a group, Mormon church members generally are conservative in political, social, moral, and business considerations. Within the state of Utah Mormons are the single most influential religious and social force. To the Indian the natural state of his environment is basic to his cultural identity.

Other elements of cultural significance occur within the province in significant array. Uncounted archeological sites, significant paleontological deposits, and many historic buildings, areas, sites, and trails of significance to the nations' history are found. The Oregon Trail, Mormon Trail, Overland Trail, Bozeman Trail, forts of the Indian wars, and routes of early explorations are a few examples of cultural resources found within the province. Some of these values are presently under Federal jurisdiction, and others under state, county local authority. Many places eligible for nomination to the National, Register of Historic Places exist on and adjacent to coal bearing lands.

10. Human-Value Resources

a. Esthetic Values

The Rocky Mountain Coal Province is primarily within the segment of the Rocky Mountain Range of the western United States. Esthetic interests of this province are exceptional. Extremely rugged land forms prevail, many reaching above 14,000 feet. Interesting and colorful rock formations provide many structural uplifts and basins. Great coniferous forests blanket the slopes, cut by major drainage patterns which feed the Great Plains to the east and deserts to the west.

Lines are dominant in this province. Strong erosion and slide patterns, textural changes between rock and vegetative types, deep valleys cut by major drainages and irregular skylines contribute to a variety of linear categories.

Altitude and latitude both contribute significantly to color composition, since generally speaking, timberline rises in the southern Rockies. In higher altitudes the herbs and grasses are contrasted with great expanses of bare rock. On the lower slopes vegetative types predominate as major timber stands provide a canopy of green occasionally broken by rock outcrops or slides. Several major lakes, deep and intensely blue, fill intervening basins within the province.

Textural contrasts are extensive. In some areas great rock faces protrude from timbered slopes. Grassy meadows give way to towering stands of timber. Shimmering lakes and rushing streams are significant in the textural element.

All landscape elements are massive.

b. Historic

Historic sites, structures, and objects are tangible aspects of rich historic resources. They are physical links with the past and landmarks of the American experience. Their preservation and are vital to comprehension of America's past and how that past has shap the present and can influence the future. Most of the better known historic sites are included in the national park system or are on or eligi for listing in the National Register of Historic Places. Many other historic sites and structures are administered by state and local agenc A large number of these historical resources are situated on or adjacen to Federally administered coal deposits.

This coal province includes hundreds of historic sites, trails, districts, and structures on and adjacent ot Federal lands, that are of national, state, and local significance. Included are resources relate to:

1. Early exploration by Spanish, French, British, and Americans fr 1540 to the 1850's.

2. The history of such Indian tribes as the Blackfeet, Nez Perce, Shoshone, Flathead, Crow, Arapaho, Ute, Paiute, Comanche, Navajo, Zuni, and Apache in their interaction with each other and confrontation with the white culture.

3. Military history of the region is represented by sites related t the Civil War, Mexican War, and especially the Indian Wars, in the form of battlefields, forts, and sites where important events occurred.

4. Economic, social, commercial, and settlement history, as exemplified in the mountain fur trade (first exploitation of the natural

resources of the area); the Santa Fe Trail; the mining frontier (many mines, sites, and towns on Federal land); the cattle and sheep frontier; the farmer's frontier; the history of transportation and communication (especially the transcontinental railroads); and the timber products frontier.

5. Overland migration and settlement as seen in the history of the Oregon, California, Mormon, and other historic routes and trails.

c. Geologic

The Rocky Mountain Coal Province is the richest of all in terms of human-interest values. The Rocky Mountains are the most thought of value within the province. These mountains are the youngest of all mountain ranges in the United States; their formation dates back only ten million years. The high peaks, deep canyons, tree covered slopes, and racing streams attract summer visitors to the area by the millions. The mountainous areas with the glacier-carved valleys and cirque lakes are outstanding simply as scenic values, yet what is seen is merely the result of the natural forces which continue to shape these mountains today.

Apart from the mountains of the area are the deserts which appeal to a different sort of human interest. Wide open spaces barren of much vegetation and empty of people and the works of man, scenic expanses, and wind-carved formation of sandstone stand out in the memories of all who experience them.

The Rocky Mountain Coal Province includes the Colorado plateau and the Grand Canyon of the Colorado River, which unfold stories of geologic history. The plateau contains many geologic values of interest such as the Petrified Forest and Painted Desert. North and west of the plateau lie the deserts of the Basin and Range lands. This unique area is a series of north-south oriented mountain chains which are uplifted bloc of land separated by downdropped blocks to form the valleys. This is only place in the United States where this is seen on such a large sca In this area are many enteric basins, remnants of Pleistocene lakes. such basin exists today as the Great Salt Lake.

Geothermal activity exists in the province, significantly at Yellow stone National Park, and is of high human interest value. Hot springs abound, which man finds very attractive. Volcanic activity and geotherm values often have a direct relationship. Other than volcanoes and surf lava flows the public generally doesn't see volcanic action except as the remains from which the overlying strata have been eroded. These remains are generally seen as curiosities or scenic values such as dike necks, sills, and zones of spectacularly colored or shaped rock, shaped and metamorphosed into their present condition by contact with molten lava beneath or on the surface of the earth. Shiprock in northwestern New Mexico is one such example of a volcanic neck and a dike formation. The province has many other evidences of volcanism throughout. Many su interests occur on national resource lands and in national parks and mo uments. Caves and caverns exist throughout this coal province. Timpan Cave National Monument in northern Utah is such a cavern, and others oc in the province.

The sharp relief of these recently uplifted landforms displays anot value of human and scientific interest. Throughout the entire Rocky Mountain Coal Province are places where the strata present to ready vie the undisturbed geologic relations of rock in that area. In many places representative type-sections of the rock have been made and represent, with their easy access, valuable opportunities for Americans to learn of and enjoy their nation's mineral character.

Some of these type-sections, such as the Morrison Formation, are better known for other features. Named for the small town of Morrison, Colorado, where it was first described, this formation has yielded skeletons of dinosaurs and is known to be rich in paleontologic values. Dinosaur National Monument, Florissant Fossil Beds, large fossil deposits near Rock Springs, Wyoming, and frequent vertebrate fossil discoveries in Utah show another value of the Rocky Mountain Coal Province.

Of greatest scientific value are the remaining undisturbed geological relations. Those areas of undisturbed land surface which remain are valuable as a resource in the study of surficial geology. This discipline considers today's land surface features as indicators of the geomorphic past and through study can reconstruct the geologic and erosional history of the earth. Pediments are climatic indicators, showing that powerful erosive forces have been at work in the past; study of the alluvium on the terraces reveals how long ago and what part of the parent material was eroded. Disturbance of the surface will destroy these educational resources.

d. Archeologic

The Rocky Mountain and Northern Great Plains Coal Provinces touch nine states and include parts of four different prehistoric culture areas. The Interior Plateau Culture Area (parts of five states) is best known for its historic tribes. Archeologically this seems to have been a transition area between the Plains and the Northwest Coast Culture Areas. At the time of European contact the inhabitants had adopted mor of the plains culture characteristics than of the other cultural influences. The Interior Culture Area extends from western Montana to the Cascade Range on the west. Spanning such a large area, the cultural affinities of the culture subareas change to resemble more closely the proximate, dominant culture.

The Old Cordilleran Tradition was the progenitor of the plateau peo 9,000 B.C. or earlier. These hunters and gatherers gave rise to the culture of the Great Basin peoples further south. Later, as the enviro ment changed, destroying the bases of the Old Cordilleran Tradition, th Great Basin dwellers, having already adjusted to these changes, spread their influence and culture northward into the interior plateau area. Subsequently, the rise of the Northwest Coast Culture spread its values eastward into this area with the effect that the people adopted a river life while in the eastern part of the interior plateau we recognize the dominance of the plains culture.

The Desert Tradition of the Great Basin Culture Area had it's beginnings in the Old Cordilleran Tradition from which it separated approximately 8,000 B.C. This ancient way of life, built around seed-collecting, seed-grinding, and small-game hunting, at various times occupied most of arid North America and persisted in purest form down to historic and even modern times. The various branches of this culture spread even to Mesoamerica and to today's Four Corners states where it developed into the component units of the Southwest Culture.

From its Great Basin Desert Tradition beginnings we recognize the existance of the Cochise culture in southern Arizona and New Mexico by 5,000 B.C. Along the Colorado River and in western Arizona another Desert Tradition group developed about this same time or earlier, the Pinto Basin people. Simultaneous to these developments was the evolution from the Desert Tradition of the San Jose culture in New Mexico and later, into the Four Corners area. These Archaic period cultures developed into distinctly different manifestations by the time of the Christian era and at contact had ceased to exist or had merged to become the Indian groups of today.

During the period of 1000-1500 A.D., the Southwest Culture Area was intruded into by Athapascans who, by reoccupying areas abandoned earlier or by pressuring the puebloid peoples out, became the residents of the Four Corners, eastern Arizona-western New Mexico and eastern plains of New Mexico. The Paiutes and other Shoshonean speakers of the Great Basin area and the Utes also moved into parts of the southwest not previously in their range.

The archeology of the Northern Great Plains Coal Province includes the western portion of the Plains Culture Area. The earliest dwellers in this area were the Paleo-Indians of the Big Game Hunting Tradition. These people, the makers of projectile point called Eden, Scottsbluff, Folsom, and Clovis hunted the large mammals of the Pleistocene and post-Pleistocene western plains. At about 4000 B.C. the environment had changed gradually to the point that it was too dry and too warm to support this prior form of life and the succeeding peoples formed the Plains Archaic Culture.

The Big Game Hunting Tradition at one time extended into Mexico and southeastern Arizona. With the northward recession of the Pleistocene climate and its associated fauna, the big game hunters also retreated northward and were replaced by an expansion of the Desert Tradition. I the Northwestern and Central Plains sub-areas the Big Game Hunters seem to have changed their way of living and became the Plains Archaic who hunted the smaller animals and gathered much of their food from vegetal sources. Later cultural developments on the plains included the introduction of pottery and agriculture with its associated sedentarism and growth of villages and social systems. These elements of culture affect the occupants of the two cultural sub-areas only marginally, the people remaining essentially in the Plains Archaic level of development until the time of contact. At that time, with the introduction of the horse and ffrearms they left their wandering, hunting-gathering, and minimally horticultural way of living and reverted to a totally hunting culture.

The prehistoric residents of the Rocky Mountain Coal Province were quite different from one another. Certain things were basic to their ways of life which remain today. Their houses were often of different materials which depended upon the area in which they lived. For the most part they were ephemeral surface structures of poles and brush and which were readily abandoned when time came to move to another area. Common to all cultures are the lithic sites where they obtained stone fo tools and left the chips and other debris of tool manufacture. Campsites generally have little cultural depth. Since succeeding camps would be made within the same area to exploit the wood, water, and shelter resources, over a long period of time considerable depth can be deposited within a small area which can yield information much in the fashion of a deeply stratified, long inhabited site. So, there is no quantitative value that can be established for a single campsite in the barren Great Basin area in comparison to large pueblo ruins of many rooms; each must be considered within the context of the entire surroundings. Each Culture Area will have unique and valuable cultural remnants which will have to be considered on an individual basis at the time of initiation of the individual projects. An area of three-story pueblo ruins will not be sacrificed to minerals development but the more subtle archeologic remains must also be safeguarded.

Rock outlines, called intaglios, of the Southern Great Basin area, prehistoric trails, animal trap and kill sites, and stone circles and "Medicine Wheels" of the plains are fragile, irreplaceable examples of Indian heritage. In the southwest are agricultural sites, fields, farmplots and terraces, water diversion structures, field house structures, irrigation systems, and cave sites which go back to the dawn of agriculture in this part of North America. All prehistoric values are subject to total and final destruction by any form of land surface disturbance.

C. Northern Great Plains Province

1. Geology

Most of the Nation's Federal coal lies within the Northern Great Plains Coal Province, (Trumball, 1960) and (Campbell, 1929), in Fort Union and Powder River regions located in North and South Dakota, Montana, and Wyoming. This coal province lies wholly within Fenneman' Interior Plains major physiographic division and encompasses the north part of this Great Plains physiographic province, (Fenneman, 1931). Th area is mostly characterized by little surface relief, gently rolling some areas of badlands, and dissected plateaus, and isolated mountains Altitudes range from about 5,500 feet along the western margin of the province to about 1,500 to 2,000 feet along the eastern margin in South Dakota. The average slope is approximately ten feet per mile.

Rocks of the province are mostly sedimentary, ranging in age from Paleozoic to Tertiary, and rests nearly horizontal, except along the fl of the Rocky Mountains where they turn up sharply. The sedimentary roc consist of several thousand feet of sandstone, shale, limestone, conglo erate, and beds of lignite and coal. Many of these sedimentary units are quite thick and extensive. Some were deposited on the floors of an cient seas that extended across the continent and others were deposited in delta or tidal areas along the margins of the seas or inland in broa depositional basins. Coals formed in tidal swamps and marshes along th marine shores and also in swamps, lakes, and on the flood plains of maj drainage systems of inland basins. These basins developed after the co tinents were uplifted and the seas moved out.


Assiniboine Region
Judith Basin Region
Fort Union Region
NORTH DAKOTA
MONTANA
Powder River Region
SOUTH DAKOTA
WYOMING
NEBRASKA
Denver Region
COLORADO
Raton Mesa Region
High-Volatile Bituminous Coal
Low Grade Bituminous Coal
Subbituminous Coal
Lignite
NORTHERN GREAT PLAINS PROVINCE

Figure 28-A

a. North-Central Region

The north-central region of Trumball (1960) includes all the coal-bearing lands of the north-central part of Montana. This region was separated into the Assiniboine and Judith Basin regions by Campbell, (1929).

The Judith basin portion of this region includes the Great Falls and Lewistown fields. In this area, coal beds as thick as eight feet are contained in sandstone and shale beds of the Kootenai Formation of Early Cretaceous age, (Combo, Brown, Pulver, and Taylor, 1949). The coal beds are discontinuous and occur in a zone 60 to 90 feet above the base of the 500-foot-thick formation. The coal is high volatile bituminous B and C in rank, but contains 1.7 to 4 percent sulfur, somewhat higher than coals of the regions in the West.

The Assiniboine area of this region surrounds the Bearpaw Mountains and includes 10,500 miles of nearly flat-lying, coal-bearing rocks of the Upper Cretaceous Judith River and Eagle Sandstone Formations and the Paleocene Fort Union Formation. The coal ranges from sub-bituminous A and B rank to high volatile bituminous B and C rank, but in most places, the beds are discontinuous and too thin to be of commercial importance other than as a local source of fuel.

Coal-bearing rocks also crop out in the Blackfoot-Valier area west of the Assiniboine region along a belt extending from Cascade County in west-central Montana to the Canadian border. Coal beds two to 3.5 feet thick of Upper Cretaceous and Paleocene age are contained in rocks of the Two Medicine and St. Mary River Formations, but generally they are

too thin and sporadic to be of commercial interest.

Two other Montana coal areas in the northern part of the province are the Bull Mountain and Garfield County coal fields. The coal-bearing rocks are in the same formations as in the nearby Fort Union and Powder River regions, but the coal beds are generally thinner and less extensive.

b. Fort Union Region

The largest region in the Northern Great Plains Coal Province is the Fort Union region encompassing the western half of North Dakota and parts of South Dakota and Montana. This region contains an estimated 440 billion tons of lignite, by far the largest coal resource in the entire United States, (Averitt, 1963, 1969, 1973), (Brown, 1972), (Berryhill, Brown, Brown, and Taylor, 1950), and (Landis, 1973).

The region occupies a very broad, shallow basin with Tertiary rocks dipping slightly toward the center. In the South Dakota part of the basin, some gentle smaller flexures are superimposed on the major depression. Dips are less than one degree and nowhere are there structural disturbances of sufficient magnitude to cause serious mining problems. Faults are rare in this region.

Most of the coal is contained in the Lebo (Ludlow in North Dakota). Tongue River and Sentinel Butte (in North Dakota), are members of the Fort Union Formation of Paleocene Age. A few thin beds are also contained near the base of the overlying Wasatch Formation and in the underlying Paleocene Tullock and Late Cretaceous Hell Creek Formations. The coal beds are discontinuous and vary greatly in thickness. More than a hundred coal beds have been identified by the North Dakota State Geological Survey

but in any one section no more than three beds of commercial thickness have been found. The Fort Union Formation ranges from 425 to 775 feet thick in South Dakota to 1,500 feet thick in Montana. The coal throughout most of the Fort Union region is lignite in rank. However, westward from the Montana-North Dakota State Line, the rank of the coal increases to sub-bituminous C near Miles City and sub-bituminous B further to the west. The Fort Union region merges with the Powder River region along this vague northwest trending boundary roughly defined by the rock change from lignite to sub-bituminous.

c. Powder River Region

The Powder River region is the southern extension of the Fort Union region, and it continues from southern Montana into northeastern Wyoming. The region encompasses an area of about 20,000 square miles and contains nearly 240 billion tons of sub-bituminous coal, (Glass, 1972), and (Berryhill, et al, 1950).

The Powder River basin is a broad gentle structural trough lying between the Big Horn mountains to the west, the Black Hills uplift to the east, and the Laramie mountains and Hartville uplift to the south.

The basin is asymmetrical with rocks dipping five degrees or less along the eastern side and considerably steeper along the western and southwestern sides. Most of the coal-bearing rocks crop out away from the more steeply dipping edges of the basin and are characterized by nearly flat or gentle dips beneath a gently rolling or dissected plain. Red-weathering "clinker" beds of burned coal along the outcrop are more resistant to erosion than the enclosing strata and form prominent distinctive caps and ledges throughout the region.

The Fort Union Formation consists of 1,700 to 3,200 feet of sands shale, and coal, and is divided into the Tullock member at the bottom overlain by the Lebo Shale member, and the Tongue River member, the thickest unit, at the top. The Wasatch Formation ranges from 1,050 t 3,500 feet thick and consists of sandstone, shale, and coal with beds conglomerate at the base along the western margin.

Coal of commercial interest is contained in the Tongue River memb of the Fort Union Formation of Paleocene age and also in the overlyin Wasatch Formation of Eocene age. Some thin impure coals are also rep in the underlying Lance Formation of Upper Cretaceous age, but they a little commercial value.

In general, the coal beds are thickest in the northern parts of t region and most persistent across the gently dipping northern and eas sides of the Powder River basin. Some of the important coal beds in region are the Badger and School seams at Glenrock, the Monarch seam Sheridan, and Healy bed near Lake DeSmet, the Felix and Anderson beds the Spotted-Horse field and the famous Wyedale seam of "D" bed near G lette. Regional correlations of these and other coal beds are being vised, but it remains certain that the Wyodak or "D" bed persists as a thick and continuous bed over several thousand square miles with re erable resources of several billion tons.

The Black Hills portion of this region extends from the Cambria c field near Newcastle, Wyoming, around the west and north sides of the Black Hills uplift into South Dakota. This area is a dissected plate tilted slightly away from the Black Hills uplift. The plateau is underlain by the massive Dakota Sandstone of Early Cretaceous age which is 150 to 300 feet thick and locally coal-bearing. The coal is high volatile bituminous C and, though locally as thick as ten feet, it occurs in discontinuous pods and lenses and has little commercial value. About ten million tons of good coking coal were produced in the past from the Cambria field, (Berryhill, et al, 1950).

d. Denver Region

The Denver region extends from the Colorado-Wyoming State Line southward across east-central Colorado as far as Colorado Springs. Physiographically, this area falls within the Colorado Piedmont section of the Great Plains. The region includes 8,000 square miles of gently rolling plains underlain by coal-bearing rocks of the Laramie Formation of Upper Cretaceous age. It occupies a north-south tending asymmetrical basin characterized by gentle dips on the east flank and steeply upturned beds along the Rocky Mountain front to the west. The coal beds occur at depths probably less than 1,000 feet throughout the region. The coal seams occur in the lower 300 feet of the Laramie Formation. They are mostly sub-bituminous B to C in rank and as thick as 17 feet, but most are thinner, lenticular, and discontinuous.

In parts of the region, coal beds also are contained in younger overlying strata of the Denver-Arapahoe Formations and Dawson-Arkose Formations of the Paleocene age, but these coals are very lenticular, generally quite dirty, and of lower rank, bordering on lignite, (Hornbaker & Holt, 1973).

e. Raton Mesa Region

The Raton Mesa Coal region occupies a large part of the Raton basin, a broad structural trough that trends in a north-south direction from northern New Mexico into southern Colorado. The basin is an asymmetrical syncline characterized by gently dipping rocks on the eastern flank and gently dipping to overturned rocks along the flanks of the Sangre De Cristo Mountains to the west. The area contains many igneous dikes, and rills of intermediate composition that alter and destroy coal beds they intrude.

Coal occurs throughout the sandstones and shales of the Vermejo Formation of Upper Cretaceous age and the conglomerate, sandstone, and shales of the Raton Formations of Upper Cretaceous and Paleocene age. The coal is high volatile bituminous A to B in rank and will coke throughout most of the region, except in the Walsenburg field in the northern part.

The coal-bearing rocks are as thick as 2,400 feet and contain coal beds mostly two to five feet thick, but ranging as thick as 15 feet in the New Mexico portion of the region. Much of the coal crops out at the surface on hillsides, and along hogbacks. Some stripping coal reserves are reported, but some of the major beds of the Vermejo Formation are buried by overburden as thick as 1,000 to 3,000 feet, (Pillmore, 1969).

North of the Raton Mesa region, the Canon City field contains as many as 16 beds of non-coking high volatile bituminous C coal in rocks of the Vermejo Formation in a similar, but smaller scale structural setting.

2. Topography

Topography of the Northern Great Plains Coal Province is predominantly rolling hills, plains, and some areas with breaks or sharply eroded hills. Elevations range from 5,000 feet on the west, to about 00 feet above sea level along the eastern boundary of the province. The streams in general drain easterly to southeasterly. Average slope is about ten feet per mile. The main rivers of the area are the Missouri Yellowstone, and Platte. Each of these rivers has numerous tributarie especially the Missouri River. There are several isolated, small moun- tainous areas such as the Black Hills in South Dakota and the Bearpaw, Little Rockies, Judith, Bull, Big Snowy and Little Belt Mountains in M- tana. Some other significant topographic features of this province in- clude the Sand Hill area of west-central Nebraska, the badlands of sou- western South Dakota, Devil's Tower in northeastern Wyoming, and glaci ed areas of Montana and North Dakota, and the Little Missouri Badlands of western North Dakota. The Missouri River in northern Montana has cut to the soft shale, perhaps 500 feet below the tops of the rims. This are is known as the Missouri breaks.

3. Climate

The Northern Great Plains Coal Province has a continental climate. The average annual precipitation varies between eight and 24 inches. By far, the largest portion of the area receives between 10 a 16 inches. The eastern portion of the area in the Dakotas and Nebrask along with the mountainous areas, receives more than 16 inches. The p- cipitation is heaviest along the eastern boundary and lightest in the north-central area. The precipitation is heaviest in April to Septemb when the monthly average may exceed two inches. The summer rains are usually out of the south from the Gulf of Mexico. They usually come i the form of thunderstorms. The prevailing wind pattern is out of the west or northwest. The western portion of the area is noted for its wind. The area normally receives less than one inch of precipitation per month in the winter. This is in the form of snow. The frequent high winds cause the snow to drift. The drifted snow can be a major problem for livestock and travel.

Temperatures range from 50 degrees below zero to 110 degrees above zero. Mean daily temperatures range from 10 degrees in January to 70 degrees in July in the northern portion. Along the southeastern boundary, the mean daily temperatures range from 20 degrees in January to 80 degrees in July. The freeze-free days range from 90 in the north to 140 in the southeast. The average annual snowfall varies from 20 inches to 60 inches. The January humidity of the area averages between 60 and 75 percent. The summertime humidity averages between 40 and 65 percent.

4. Hydrology

Northern Great Plains Province

All streams in the northern Great Plains Coal Province are in the Northern Missouri River Basin. The average annual runoff to streams in the province ranges from less than one inch in some of the structural basins to over ten inches in the eastern part of the Big Horn Mountains. Most of the larger streams draining the area are perennial, while most of the smaller tributaries are intermittent. The Missouri River and its major tributaries obtain most of their water outside the province. The Rocky Mountains to the west of the province is the major source of runoff to these large streams. The province is vulnerable to droughts of up to several years duration.

The total dissolved solids in surface waters in the province range from less than 100 mg/l in the more mountainous headwater areas to more than 1,800 mg/l on many tributary streams. The amount of dissolved solids in a watercourse is affected by the type of soil and rock in the region, the length of time the water has been in the watercourse, and the extent to which the flows are affected by other water sources. Although the specific chemical composition is an important consideration in determining whether water can be used for specific purposes, the total amount of dissolved solids in the water generally is the controlling factor as to whether a water supply is chemically suitable for most general uses.

The average suspended-sediment concentrations in streams in the province ranges from less than 200 ppm in the mountainous parts of the province to more than 30,000 ppm during peak flows on tributaries within the basin. The suspended-sediment in the stream is comprised of particulates such as sand and silt. The ability of streams to carry suspended-sediment increases with stream velocity. Suspended-sediment tends to be greater in areas where soils is not held in place by dense vegetative cover.

Groundwater in this province occurs in alluvium, glacial drift, and bedrock aquifers. Alluvium in the region generally is a good aquifer. This flood plain alluvium is capable of yielding moderate amounts of groundwater to wells (a few hundred gpm) and as much as several thousand gpm to wells at a few places. The quality of water in the alluvium generally is acceptable for most uses. In the northern part of this province, glacial drift mantles the consolidated sedimentary rocks. Glacial drift is de[illegible]ital material deposited by glacial ice and glacial melt water, and may range in thickness from 0 to more than 200 feet within the province. Only locally does the glacial drift yield more than moderate amounts of water to wells. Glacial outwash, which is glacial drift that has been sorted and redeposited by streams, yields moderate to large amounts of water at some places. This water generally is of acceptable quality although in some areas, it may contain over 1,000 milligrams per liter (mg/l) of dissolved solids.

The principal and most widespread bedrock aquifers in the province are beds of sandstone and limestones. Yields of most sandstone aquifers are low to moderate, while the highly variable limestone aquifers may yield up to 1,000 gpm to wells. In general, where the aquifers are highly permeable good quality water is obtained even to depths of 1,000 feet or more. However, where the aquifers have low permeability, highly mineralized water is obtained even at shallow depths. Some shallow coal beds in the province are aquifers and can supply enough water for domestic use.

Many large areas in this province, including areas underlain by coal, have no nearby perennial surface water supplies, and the groundwater supplies are limited or of poor quality.

a. North-Central Region

The Missouri River is the main stream draining the region. The Judith River, Teton River, Milk River, and Marias River are the main tributaries of the Missouri River in this region. The quantity of surface water available in this region is highly variable especially on the smaller tributaries. Many of the tributaries draining areas underlain by coal are dry most of the year. The quality of surface water is generally good on the larger streams in the area. Most of the surface water is a calciur bicarbonate type. The streams in this region generally have high sedir concentrations, especially during periods of peak flow. Many of the sr er intermittent tributaries have sediment concentrations of over 30,00(gpm during peak flows.

The availability of groundwater in the region is highly variable as to quantity and quality. In the northern part of the area, glacial dr covers much of the surface. Yields from the glacial drift are general poor, except in scattered areas of glacial outwash. Alluvial deposits yield small to moderate amounts of generally good quality water in man parts of the region. In the unglaciated part of the region, bedrock aquifers are believed to contain good quality water. Little informati is available on the groundwater in bedrock aquifers underlying areas covered with glacial drift, but they are believed to contain poor qual water.

b. Fort Union Region

Most of the Fort Union Region is drained by the Missouri R and its tributaries. The surface water originating in most of the are has relatively high concentrations of dissolved solids and is a sodium carbonate type. The sediment yield of tributary streams is high as th shales and sandstones in the area are easily eroded.

The best source of groundwater in the region is from alluvium. We tapping the alluvium in the preglacial valley of the Missouri River yi over 1,000 gpm at many locations. The water is generally of acceptabl quality, but locally it may be highly mineralized.

Groundwater from the glacial drift in the northern part of the region is generally of poor quality. The shallow bedrock aquifers in the region yield limited quantities of acceptable quality groundwater.

Other water-bearing rocks are present at depth, but the water is thought to be brackish.

c. Powder River Region

The major streams draining the Powder River Region are the Powder River, Belle Fourche River, Cheyenne River, and North Platte Rivers. The quality of water available from these streams varies considerably. During maximum runoff periods, the dissolved solids content of the water is generally low and suitable for most uses. However, during low flow periods, the dissolved solids content of the waters can increase to over 2,000 mg/l. Some of the tributary streams in this region contribute very high dissolved solids contents to the major drainages following intense thundershowers.

Sediment concentrations in streams of the region varies from moderate to high. The Powder River breaks area, a broad band of badlands along the Powder River, is subject to extensive sheet and gully erosion and contiributes much sediment to the stream.

Groundwater supplies from alluvial deposits along the major streams in the area yielding medium to large supplies of water to wells. The water is generally of acceptable quality for most uses. Pumpage from the alluvial aquifers can deplete streamflow during dry periods and effect downstream water rights. However, dewatering alluvial aquifers permits

increased storage of flood runoff in these aquifers. Many of the alluvial aquifers along intermittent tributary streams may yield medium quantities of poor to highly saline water. Bedrock aquifers in the region generally yield small quantities of acceptable quality water, especially around the edges of the basin. As the center of the basin is approached, the aquifers generally yield more mineralized water. The potential of the bedrock aquifers in the region has not been fully evaluated. It is believed that in parts of the region, some of the limestones may yield large quantities of good quality water.

d. Denver Basin Region

The Denver Basin Region is drained by the South Platte River and its tributaries. The headwaters of the South Platte lie outside the Denver Basin Region, and consist of several tributary streams draining the Rocky Mountains. In the mountainous headwater areas, the water is generally of good quality, with dissolved solids contents of less than 100 mg/l common on most tributaries and the main stream. Most of the tributaries draining the Denver Basin itself are intermittent and contribute only a small percentage of the total flow. These tributaries also have high dissolved solids contents, with values of 1000 mg/l or more common. In the headwater areas, the streams generally are a calcium bicarbonate type, while by the time the South Platte River leaves the Denver Basin, it contains an average of over 1,000 mg/l dissolved solids and the major ions present area: sodium, calcium, sulfate, and bicarbonate.

Sediment concentrations are generally low in the mountainous headwater areas during low to medium flows. However, during high flows, high sediment concentration are common, especially on tributaries disturbed by mining operations. Within the Denver Basin, most tributaries have higl sediment yields during peak runoff periods.

Groundwater aquifers in the region are obtained from river alluviu and bedrock aquifers in the northern part of the Denver artesian basin The groundwater supplies in the alluvium are used predominantly for ir- gation. Wells along the main stream yield from 400 to 2,000 gpm and average about 900 gpm; wells in the tributary valleys yield 50 to 1,8 gpm and average about 800 gpm.

The groundwater in the river alluvium deposits along the main stre tends to deteriorate in quality downstream. The average dissolved sol content near Denver is about 1,300 mg/l; at the state line, it is abo 1,800 mg/l. The water is usable for irrigation, but some of it has a high "salinity hazard."

The bedrock aquifers consist of sand, sandstone, gravel, and congl ate of Late Cretaceous and Tertiary age. Generally, several horizons yield water to wells. The yields of individual aquifers ranges from 1 100 gpm. The water in most areas is under artesian pressure. In some areas, intense pumpage has lowered the artesian head more than 600 fee The water is generally a sodium type and is of good quality. Loca the mineralization is high because of structural conditions that imped groundwater circulation.

5. Soils

Soils within the Northern Great Plains Coal Province are s divided into coal regions. A table for each region, or for two region

Table 34 - Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Powder River Region of the Northern Great Plains Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Cabba	Montana (USDA, 1971)	ML	2-3	C	15-50	mild & short grasses	rangeland
Limitations - Shallow to shale, low fertility, moderate to severe erosion hazard, cold soil temperatures.							
Elso	Montana (USDA, 1971)	ML	2-3	D	8-45	short grasses	rangeland
Limitations - High wind erosion hazard, low fertility, shallow to shale.							
Farland	Montana (USDA, 1971)	ML	8-10	B	2-8	hay, grain, grasses	dryland crops & range
Limitations - Slight to severe water erosion hazard, severe wind erosion hazard, high fertility.							
Haverson	Montana (USDA, 1971)	ML, or CL	9-11	B	0-4	hay, small grains	cropland
Limitations - Severe wind erosion hazard, moderate fertility.							

Table 34-(Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Hesper	Montana (USDA, 1971)	CL	10-12	C	0-15	grasses, small grains	rangeland

Limitations - Moderate erosion hazard, clayey soil.

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Hydro	Montana (USDA, 1971)	CL	10	C	0-8	grasses, small grains, hay	rangeland & dryland farming

Limitations -

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Midway-Elso	Montana (USDA, 1971)	CL or CH & ML	1-3	D	8-35	grasses	rangeland

Limitations - Erosion hazard is moderate to severe. Shale occurs about 10 inches deep. Gullied, low fertility, clayey textured.

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Midway-Elso	Montana (USDA, 1971)	CL or CH & ML	3	D	35-75	grasses	rangeland

Limitations - Erosion hazard is very severe, [illegible]
sandstone outcroppings, low fertility, clayey textured.

Table 34-(Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (Inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Ringling-Cabba	Montana (USDA, 1971)	GM or SM & ML	1-2	C	15-50	grasses	rangeland

Limitations - Slight to moderate erosion hazard, shallow to shale, low fertility, contains over 35 percent coarse fragments.

Table 35 - Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Raton Mesa and Denver Regions of the Northern Great Plains Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Bresser	Colorado (USDA, 1971)	SC or SM	6-9	B	0-20	winter wheat, alfalfa	cultivated crops
Limitations -	Wind erosion hazard is severe, water table about 10 feet deep, sandy subsoils.						
Fondis-	Colorado (USDA, 1971)	CL	9-12	C	1-9	wheat, grasses	cropland, residental
Limitations -	High fertility, moderate erosion hazard, compaction layer forms easily, clayey soil.						
Nunn	Colorado (USDA, 1971)	SM	9-12	C	0-3	small grains, alfalfa, corn	cultivated crops, residential
Limitations -	Moderate wind erosion hazard, occasional flooding, slight water erosion hazard, clayey soils.						
Weld	Colorado (USDA, 1971)	ML-CL	9-12	C	0-5	small grains, alfalfa, corn, grass	cultivated crops, range
Limitations -	Moderate wind erosion hazard, slight water erosion hazard, clayey soils.						

Table 35- (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Ascalon	Colorado (USDA, 1968)	CH	2-6	B	0-9	small grains, sared bluestem	dryland crops, rangeland
Limitations -	Lime layer occurs about 15 inches deep. Wind and water erosion hazards are moderate to severe.						
Bijou	Colorado (USDA, 1968)	SP	4-8	A	0-3	onions, small grains	cropland
Limitations -	Sand layer about 45 inches deep. Wind erosion hazard is severe.						
Dune land	Colorado (USDA, 1968)	SP	3-6	A	5-25	sparse grass	limited grazing
Limitations -	Dunes are actively blowing, very severe wind erosion hazard.						
Heldt	Colorado (USDA, 1968)	CL	4-8	C	0-3	saltgrass, blue-gramma & small grains	cropland, rangeland
Limitations -	Saline soils, some slickspots, slow permeability, high seasonal water table, high compaction hazard. Clayey soils.						

Table 35- (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Valentine	Colorado (USDA, 1968)	SP	2-6	A	1-25	sandreed, sand bluestem	rangeland
Limitations - Very severe wind erosion hazard, very sandy soil. Vegetation easily destroyed.							
Campus	Colorado (USDA, 1969)	ML	2-4	B	0-5	winter grains	dryland farming
Limitations - Pan exists at about 15 inches, severe erosion hazard.							
Richfield	Colorado (USDA, 1969)	ML	4-6	C	0-5	winter grains, grasses	dryland farming, rangeland
Limitations - Moderate compaction and erosion hazard.							
Slickspots	Colorado (USDA, 1969)	CL	-	D	0-1	saltgrass, alkali sacaton, switch grass	pasture
Limitations - Saline soils, water table about 50 inches deep, very severe restrictions to management.							

Table 36-Some characteristics, Uses and Limitations of Dominant Soils Occurring in the North-Central and Fort Union Regions of the Northern Great Plains Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Cherry	Montana (USDA, 1973)	CL	12	C	0-25	crops, grasses	cropland, rangeland
Limitations - Slight to moderate erosion hazard. Poor roadfill material.							
Farnuf	Montana (USDA, 1973)	ML, or CL	6	B	0-8	crops, grasses	cropland, rangeland
Limitations - Slight erosion hazard; susceptible to frost heaving.							
Lambert	Montana (USDA, 1973)	ML	12	B	2-65	crops, grasses	cropland, rangeland
Limitations - Moderate to severe erosion hazard, susceptible to frost heaving.							
Norbert	Montana (USDA, 1973)	CH	3	D	8-65	grasses, juniper	rangeland
Limitations - Clayey soil, 13 inches to shale bedrock, severe erosion hazard, severe limitations for most uses.							

Table 36 - (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Tinsley	Montana (USDA, 1973)	GW	1	A	15-65	grasses	rangeland, sand & gravel

Limitations - Gravelly, sandy, droughty soils, severe wind erosion hazard. Soil is four inches deep to sand and gravel.

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Turner	Montana (USDA, 1973)	SW, or GW	2	B	0-8	crops & grasses	cropland, rangeland

Limitations - Sand and gravel occur from 20 to 40 inches, severe wind erosion hazard.

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Williams	Montana (USDA, 1973)	CL	12	B	1-8	crops	cropland

Limitations - Slight to moderate erosion hazard.

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Badland	Montana (USDA, 1973)	--	--	-	15-100	some grasses	limited grazing

Limitations - Very severe erosion hazard, severe limitations to most uses.

Table 36 - (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Bainville	North Dakota (USDA, 1968)	CL	2	C	3-40	crops & grasses	cropland, rangeland
Limitations - Severe wind and water erosion hazard, over clayey shale, low natural fertility.							
Morton	North Dakota (USDA, 1968)	ML, or CL	9	B	0-15	crops	cropland
Limitations - Moderate erosion hazard, underlain by silty shale.							
Bowbells	Montana (USDA, 1973b)	ML, or CL	9	B	2-4	grasses, legumes, & crops	rangeland, cropland
Limitations - Slight erosion hazard, slight limitations for most uses.							
Havrelon	Montana (USDA, 1973b)	ML, or CL	9	B	0-2	small grains grasses, grass hay	cropland, rangeland
Limitations - Cold soil temperatures, calcarious, slight erosion hazard, salt tolerant vegetation is required.							

Table 36-(Continued)

Soil Name	Location	Unified Classi-fication	Available Water Capacity (inches)	Hydro-logic Group	Relief (%)	Vegetation	Major Use
Fargo	Montana (USDA, 1967)	CH	-	D	0-3	sedges & rushes	pasture

Limitations - Poorly-drained, calcarious clays, high water table, slight erosion hazard. Severe compaction hazard, soil management is very difficult.

where the soils are similar, lists some dominant soil series which occur in that particular area. Some characteristics, uses and limitations are given for each of the listed soil series. Specific items for each soil such as the unified classification of the subsoils for engineering uses and hydrologic groups are given as well as general information. Thus, the information may be used by engineers, hydrologists, and soil scientists as well as the general public to gain some knowledge of the soils. The listed soil series are not inclusive. They occur extensively in the region under which they are identified, but they must be viewed as examples. A detailed, on-site soil survey must be made before the total soil resource is known. More detailed information of the soils characteristics and limitations may be obtained from the soil survey reports listed in the selected references.

Descriptions of soil organisms for this province are the same as for the Pacific Coast Coal Province.

6. Vegetation

Plants of the Northern Great Plains Province are mostly grasses. Principal species in the northern part of the province are wheatgrasses (primarily western wheatgrass, often a sod former), needlegrasses, blue grama (another sod grass), and fescues. As a result of prior overgrazing during the growing season by grass-eating livestock (and possibly by bison before them), blue grama, sagebrushes, and rabbitbrushes have increased in these grasslands. Lower forms of plant life sometimes protect the soil in the thinned stands of grass. Fringed sage (a half-shrub), and prairie globemallow (a forb), are important non-grass plants. Plains prickly pear

is noticeable.

All the grasses, except blue grama (a warm season grower), do well because of the temperature - precipitation pattern. Seventy percent of the precipitation falls as rain during the April-October growing season. This is especially true in eastern Wyoming and Montana and western North Dakota, with 12" - 16" total precipitation.

The northern coal regions in the Northern Great Plains Province also includes small areas of the cold desert biome dominated by sagebrush. In addition, some areas are dominated by the ponderosa pine portion of the montane coniferous forest biome. Under the pine either grasses or shrubs may predominate or they may be mixed. Cottonwood, willow, and elms of the deciduous forest biome dominate the bottoms along the rivers and their tributaries.

Further south, the Denver coal region is mostly covered by blue grama and buffalo grass, quite possibly as a result of historic overgrazing by grass-eaters in this hotter more southern climate. Yucca, probably increased by over-grazing, is present. Western wheatgrass, needle and thread (or needlegrass), fringed sage, and prairie globemallow are present here, too. Four-wing saltbrush found along the drainages, and inland saltgrass indicate soil alkalinity or salinity. Sand sage and prairie sand reed, a grass, are in sandy areas. Plains prickly pear is present.

In the Raton Mesa region are pine, inland Douglas-fir, and spruce-fir types of the montane coniferous forest. Pinon-juniper stands of the woodland-bushland biome are present. Short grass plains similar to those of the Denver coal region occur, (Kuchler, 1966).

7. Wildlife

The Northern Great Plains Coal Province is located within the short grass plains of the grassland biome and it has a grassland fauna similar to that described by Kendeigh in 1961. This province is bordered closely on the west by the montane coniferous forest biome. The ecotone between the two biomes along the western part of the province is inhabited locally by animal species characteristic of the montane coniferous forest and of the forest edge. A distinct plant community -- riparian woodland -- of willows, cottonwoods, aspen, boxelder and other broad-leafed deciduous trees occur along streams, bodies of water, and elsewhere. The animals associated with this plant community are characteristic of the deciduous forest-edge (Kendeigh, 1961).

The wildlife of this coal province then, is a composite of the native, terrestrial animal associations, the aquatic animals of the stream, lake and pond-marsh communities, and the introduced species present.

Terrestrial Wildlife

The high annual turnover of net primary production in the grassland communities provides a food-base for a large variety of animals. Grazing animals, burrowing animals, swift running animals and ground nesting birds are characteristic of the grasslands. Insect life is abundant, varied, and heavily utilized as food by many secondary consumers. Large herbivores, such as bison and antelope were present in great number during pre-settlement times. Today, bison have been replaced by domestic livestock as the primary grazing ungulates. Grazing horses, cattle and sheep often live in competition with native herbivores. Practices used in livestock production have sometimes disrupted the natural function of the grassland e- system to the detriment of various wildlife species. Examples are pr- ator and rodent control programs and sagebrush eradication in antelop or sage grouse winter areas. Antelope are still fairly numerous in t grasslands of this coal province. Investigations have shown that the are highly dependent upon the brush and forb components of the grassl d for survival, (Sundstrum, Hepworth, and Diem, 1973). Drought and seve winter storms periodically occur and the population of some wild anim s can fluctuate widely from year to year.

In the ecotone area between the montane coniferous forest and the grassland biome, animal species characteristics of the coniferous for t and of the forest edge will often be found living in close proximity grassland animals. Some of these animals such as the mule deer and e occur on extensions of scattered islands of coniferous forest and rel ed subtypes within the grassland. Examples of these areas are noted in e Powder River Breaks of Wyoming, the Bull Mountains of Montana, the Li le Missouri River Breaks in North Dakota and several others. The wildli composition of these non-grassland habitats is a reflection of the fo , cover, and living space available. These habitats may be marginal fo some species in particular areas. The Powder River Breaks herd elk i Wyoming is a good example. This small herd survives in an area with w trees and little escape cover other than topography. It is suspected hat they are able to survive here primarily because the breaks provide re ativ isolation from civilization at the present time, (Bureau of Land Mana emen Casper District, 1973).

The deciduous forest-edge biociation extends into the short grass plains along the major stream drainages supporting the riparian woodland community. As the interior of the continent grew arid in prehistoric times, many species of deciduous trees together with their associated animals were able to persist along the stream. These "tongues" of forest greatly extend the forest-edge into the grasslands. Some species are common to the deciduous forest-edge over most of its range and others are found only in the western portion of this biociation, (Kendeigh, 1961). The presence of the riparian woodland within the shortgrass plains greatly increases the variety of ecological niches available for animals. Animals requiring heavy escape cover, shade, browse, tree nesting sites, etc., are able to survive within the grasslands.

Specific mention should be made of the importance of the sagebrushes to some wildlife species within the Northern Great Plains Coal Province. Sagebrush is prominent in the vegetation composition in parts of the grassland especially in the Powder River Region of this province. Sage grouse are limited almost entirely to areas of abundant sage growth. They use sagebrush for food, nesting, resting, and brooding. Certain sagebrush areas are highly important as nesting and wintering areas. Sage grouse will sometimes use farm lands adjacent to their native habitat. However, they are basically dependent on the sagebrush and cannot survive in areas that lack that vegetation (Fish and Wildlife Service, 1952). Pronghorn antelope are heavily dependent upon the sagebrushes, especially Wyoming big sagebrush and silver sagebrush, (Sundstrum, et al, 1973). Brewer's sparrow, a common resident of the sagebrush grassland, appears to be quite dependent

upon cover provided by sagebrush for nesting. Studies in Montana showed significant reduction in nesting pairs of Brewer's sparrows with sagebrush eradication, (Best, 1972).

Some man-introduced species have become well established in parts of this coal province. Chuckar partridge have adapted well to areas of rough breaks. Hungarian partridge have done well in some portions of the Fort Union region of the province. The ring-necked pheasant is plentiful in cropland areas where good winter cover is intermixed. Wild turkeys have been established in some of the broken woodland areas of the Powder River and Fort Union Regions where they never occurred historically.

Conspicuous terrestrial animals found within the Northern Great Plains Coal Province include the following representatives of different biotic communities:

Masked shrew

White-tailed jackrabbit (northwest)

Black-tailed jackrabbit (southeast)

Desert cottontail

Black-tail prairie dog

Ground squirrels

Northern pocket gopher

Plains pocket gopher (south)

Meadow vole

Coyote

Swift fox

Long-tailed weasel

Black-footed ferret

Badger

Prairie spotted shunk

Pronghorn antelope

Prairie rattlesnake

Eastern short-horned lizard

Ferruginous hawk

Prairie chickens

Sharp-tailed grouse

Mountain plover

Burrowing owl

Horned lark

Western meadowlark

Lark bunting

Savanah sparrow

Grasshopper sparrow

Vesper sparrow

McCown's longspur

Montane Coniferous Forest and Forest Edge

Yellow-bellied marmot

Golden-mantled ground squirrel

Least chipmunk

Red squirrel

Bushy-tailed wood rat

Boreal redback vole

Bobcat

Mule deer

Wapita (elk)

Porcupine

Golden eagle

Western flycatcher

Clark's nutcracker

Mountain chickadee

Mountain bluebird

Pugmy nuthatch

Deciduous Forest Edge Community (Riparian Woodland)

Red fox

White-tailed deer

Fox squirrel

Eastern cottontail

Striped skunk

Raccoon

Blue racer

Milk snake

Red-spotted garter snake

Turkey vulture

Sharp-skinned hawk

Cooper's hawk

Red-tailed hawk

Swainson's hawk

Mourninig dove

Common nighthawk

Red-shafted flicker

Violet-green swallow

Common crow

Black-billed magpie

Loggerhead shrike

Brewer's blackbird

<u>Aquatic Wildlife</u>

Aquatic wildlife includes a variety of invertebrates, fishes, bird mammals, reptiles, and amphibians associated with the stream, lake, an pond-marsh biotic communities.

Stream riffles and sand-bottom pools are characterized by caddisfl vae, mayfly naiads, stonefly naiads, crayfish, and snails. Fish chara istics of streams in this coal province include the plain minnow, long dace, flathead chub, goldeye, fathead ninnow, river carpsucker, black head, channel catfish, stonecat, plains topminnow, plains killfish, an white sucker, (Baxter and Simon, 1970, Brown, 1972, Costello, 1969, Fi and Wildlife Service, 1952). Rainbow trout and brown trout are found suitably larger streams. The shovelnose, pallid sturgeons, and the pa fish survive in the Missouri River and some tributaries, but the shove fish is considered a threatened species over parts of its range, (Baxt et al, 1970). Other stream-associated wildlife include the tiger sala manders, plains spadefoot toad, great plains toad, leopard frog, and s ping turtle. The belted kingfisher feeds on stream fish and nests in jacent banks. Muskrats make burrows in the stream banks and feed on stream side vegetation. Mink patrol the streams for muskrat and fish. Beaver feed on the aspen, willow, and cottonwoods along stream courses and in some localities build dams creating pools.

Lakes, defined as large, deep, thermally stratified bodies of water, are relatively few in the Northern Great Plains Province. Lake biotic communities are seen in lakes such as DeSmet in the Powder River Region, Fort Peck Reservoir bordering the Fort Union Region and Cherry Creek Reservoir in the Denver Region.

Lakes are closely knit ecosystems largely independent of the rest of the world, except for solar energy, inflowing water and mineral salts. The base of food chains is composed of detritus, bacteria, and phytoplankton (free floating or barely mobile small animal organisms), and small bottom organisms and, finally, fish and birds. Amphibians and reptiles do not commonly occur in lakes, except around the edge supporting aquatic vegetation, and here pond species occur. In this coal province, many fish found in streams mentioned above are found in the lakes. In addition, species more characteristic of the lakes include yellow perch, largemouth bass, black crappie, and carp. In deeper, cooler lakes, rainbow trout are often planted and maintained by man. There are a number of birds commonly inhabiting the lakes. They subsist mainly on fish. Common mergansers, California gulls, bald eagles, white pelicans, and osprey are among them. Swallows skimming over the water consume great numbers of emerging midge flys and other insects.

Prairie potholes, small reservoirs, and stock ponds are common through-

out most of the province. These support pond-marsh biotic communities are generally quite productive. They differ from the lakes in that they are usually smaller, more shallow, and have rooted vegetation over much of the bottom. Air-breathing aquatic insects and terrestrial forms occur in the surrounding marsh. Amphibians, reptiles, birds, and mammals are usually more numerous than in lakes. The aquatic and emergent vegetation common in the more permanent potholes and ponds support many kinds of insects, amphipods, mites, flatworms, protoza, and snails. Two predominantly terrestrial orders of insects, the Coleoptera and Hemiptera, have invaded the pond community. The diving beetles, whirligig beetles, and water striders are conspicuous examples. Terrestrial insects found in the pond-marsh vegetation are mainly those whose immature stages live submerged, such as mosquitoes and midges. Fish such as bullheads, suckers, and yellow perch are often abundant. The spadefoot toad and tiger salamanders, mentioned as members of the stream communities, are also common in the pond communities.

Probably, the most noticeable animals of the pond-marsh communities in this coal province are the waterfowl and shore birds. Much of the Fort Union Coal Region is within the famous duck producing area known as the prairie pothole region. Potholes may average 30 per square mile, (Department of the Interior, 1964). The number, variety and quality of potholes available and the many kinds of plants and small animal life associated with them make the region a waterfowl producing giant. In the drier portions of the coal province, man-made stock ponds and small reservoirs support pond-marsh communities and also produce large numbers of waterfowl (Department of the Interior, 1964). Mallards, blue-winged teal, pintails, shovelers, gadwalls, American widgeons, and ruddy ducks, are common breeding speci

Coots, avocets, killdeer, snipes, sandpipers, and grebes are characteri tic water and shore birds. Many other waterfowl and water birds use th ponds and potholes during migration.

The muskrat is the most characteristic mammal of the pond-marsh com- nity. Mink, a primary predator of the muskrat, are usually common wher muskrats are plentiful. Red fox, raccoons, and skunks are frequent use of the pond-marsh communities.

Threatened Species

Those wildlife species determined by the Secretary of the Interior t be threatened with extinction and named on a list published in the Feder Register are officially "endangered species." The species categorized a "threatened" in the Bureau of Sport Fisheries and Wildlife's 1973 public- tion, Threatened Wildlife of the United States, includes all vertebrate species whose existence is considered threatened whether they are offi- cially listed as "endangered" or not.

The black-footed ferret and American peregrin falcon are found withi portions of the Northern Great Plains Coal Province. They are officiall endangered species. Ferrets are closely associated with prairie dog tow as prairie dogs are their major food source. They are most apt to be fo in the Fort Union, Powder River, and Denver Coal Regions, but may occur isolated populations throughout the province. Very few nesting peregrin falcons are known to occur in this province, probably less than a half- dozen pairs. Nests are usually found in coniferous forests or along maj rivers. Extreme care is required to preserve them. The southern bald ea also "endangered," probably occurs in the Raton Mesa Coal Region as a winter resident or migrant.

Other species considered threatened which are found in this coal province include the Tule white-fronted goose, probably a migrant user of the prairie potholes; the prairie falcon, commonly a rimrock nester in the plains areas; the northern greater prairie chicken found in the grasslands of the Fort Union and Denver Coal Regions; and possibly the rare spotted bat.

Some species, while not endangered throughout their range, have remnant populations in danger of being eliminated in local areas. This has prompted state development of "rare and endangered" species lists. Wyoming's list includes such species as the shovelnose sturgeon, goldeye, sturgeon chub, kit fox, western burrowing owl, upland plover, and western smooth green snake which occur within this coal province. Other States have, or are developing, similar lists.

8. Land Uses

The Northern Great Plains Coal Province is primarily a vast expanse of rolling grasslands dissected by various major river systems. Much of the area remains in native vegetation. Extensive-type land uses dominate. Information from Missouri River Basin Investigations provide an idea of current land uses, (Table). Lands administered by the Bureau of Land Management are in four subbasins including the Yellowstone River, Upper Missouri, Western Dakota tributaties, and Platte-Niobrara. Pasture and range utilized by livestock and wildlife constitute the most extensive uses involving from 61 percent to 74 percent of the subbasins. Croplands,

Table 37 - Land Uses in the Missouri River Basin, 1972

	Subbasins							
	Yellowstone River		Upper Missouri		Western Dakota Tributaries		Platte-Niobrara	
	(1,000 Acres)	(%)	(1,000 Acres)	(%)	(1,000 Acres)	(%)	(1,000 Acres)	(%)
Pasture and Range	33,628	74	33,252	61	35,253	71	39,671	62
Forest and Woodland	6,100	14	7,200	14	2,500	5	5,200	8
Cropland	3,400	8	10,700	20	9,300	19	15,600	25
Recreation	1,400	3	500	1	300	-	400	-
Urban and Transportation	200	-	1,200	2	900	2	1,200	2
Fish and Wildlife	50	-	100	-	100	-	200	-
Mineral Industry	10	-	3	-	3	-	3	-
Military	10	-	7	-	300	-	100	-
Other Agriculture	100	-	300	-	200	-	600	1
Water	300	-	700	-	500	1	700	1
Total	45,198		52,962		49,356		63,674	

primarily dryland, are also significant, utlizing from 8 percent to 25 percent. Forests and woodlands cover from 5 percent to 14 percent of the subbasins. Other uses in order of magnitude are: recreation (up to three percent of the subbasins), urban and transportation (two percent), fish and wildlife, military, mineral industry, and other.

a. Agriculture

Agriculture land uses including grazing of sheep and cattle and crop production are the most extensive uses involving 85 - 90 percent of the Northern Great Plains Coal Province. Grazing occurs on up to 74 percent of the subbasins. Rangelands are highly productive in comparison to many other Federally managed lands. Their average productivity is 6.5 acres per animal unit month (AUM). Cattle operations are dominant and oriented toward cow-calf or cow-calf-yearling production programs. Rangelands managed by BLM and the Forest Service, as well as private holdings, are extensively grazed.

Croplands are distributed throughout the province. Dryland farming is the most common method, but some farmers irrigate lands along the valleys where water is available. Livestock feeds and human food crops are both important. Major crops include, wheat, barley, oats, and hay with some production of sugar beets, corn, and dry beans. In terms of value, producton is split about evenly between livestock and crop production.

b. Timber Production

Forest and woodland vegetation covers from 5 percent to 14 percent of the land area within the various river subbasins. Timber and woodland types include pinon-juniper, ponderosa pine, Douglas-fir, Engel-

mann, spruce, and lodgepole pine. National resource lands, (surface ownership), have forest and woodland types on five percent of the area. Pinon-juniper is the dominant type on national resource lands. Productivity of the forest and woodland area for wood products is moderate. The area provides habitat of vital importance to wildlife populations. Other significant uses include: watershed protection, outdoor recreation, and domestic livestock grazing.

c. Watershed

The Northern Great Plains Coal Province is primarily within the Missouri River Basin. The Plains area provides runoff from zero to five inches annually. The condition of this watershed is of vital importance to water quality.

Studies of national resource lands in the Missouri River basin indicate relatively stable watershed conditions. Studies indicate that 64 percent is classified as having from no erosion to slight erosion; 29 percent slight to moderate erosion, and seven percent moderate to severe erosion.

The Missouri Basin has 1,345,000 acre-feet of surface water depletion. Agriculture-related uses and loss to evaporation from storage facilities are the most significant sources of water depletion. BLM studies indicate that livestock and watershed improvement activities deplete 45,000 acre-feet or an estimated 3.3 percent of total depletion in the basin.

d. Mineral Industry

Mineral production in the province is an insignificant use of land in terms of percentage. There are, however, localized situations where use and impacts are significant. Major land disturbing activities

are associated with mining of coal and bentonite, gravel and other building materials. Other mineral commodities of significance include oil, gas, and gold. The extensive reserves of coal indicate that the mineral industry will be of greater significance in the future.

e. Urban and Transportation

The Great Plains Coal Province is sparsely populated, but does make relatively significant use of land for urban and transportation uses. Data from Missouri River Basin studies indicate that up to two percent of the subbasins are used for these purposes.

Major urbanized areas with the bulk of residential, commercial, and industrial uses include Great Falls and Billings, Montana. Highways, railroads, pipelines, and powerlines form a transportation network.

f. Wild Horse and Burro Habitat

Wild horse and burro populations are not extensive in the Northern Great Plains Coal Province. Some isolated occurrences exist in Wyoming and Montana, but populations are scattered and limited in comparison to the situation in the Rocky Mountain area.

g. Recreational

Facilities in an organized sense are far less numerous when the recreationist travels east from the Rocky Mountains into the Northern Great Plains.

Extended remote areas of rolling countryside provide a degree of seclusion and to some this is a very satisfying recreational experience. Federal and state facilities, however, are more sparse and the recreationist must build his interest around other available activities or be satis-

fied with a less formal camping and picnicking exposure.

Numerous historical features are found in this province, mostly notably the Lewis and Clark Trail and the Bozeman Trail. Fort Rock, Crow, and Cheyenne Indian Reservations are also significant to the tourist.

Most drainages support a substantial trout population for the fishing enthusiast. Pronghorn antelope hunting is particularly favorable throughout the Northern Great Plains.

9. Population Patterns and Considerations

The Northern Great Plains Coal Province is thinly occupied, (less than ten persons per square mile), and almost entirely rural in social orientation. Social attitudes and mores are basically conservative, and marked by relatively slow rates of change from those traditionally held in rural America. New social norms and patterns are slow to be accepted, and there is a considerable reluctance to see radical social change. Ranching, dry farming, and irrigated agricultural land use has resulted in a sparse population. Towns are centers for commercial, governmental, and other services. They are widely separated along major transportation routes. Townspeople generally share many of the social attitudes of their country neighbors. Older, traditional pioneer social characteristics are prized, such as strong family ties and community social conformity, with somewhat paradoxical emphasis on individual self-sufficiency and personal initiative bordering on "rugged individualism".

The people of the province place high value on attachment to the land and its traditional uses. The more radical changes in social norms and acceptable standards of mid-20th century America have not significantly impacted the social fabric of the province. Pioneer social values ar standards are much valued, and radical alteration of social patterns not acceptable to most of the inhabitants of this coal province.

As a people, they are accustomed to wide horizons, vast expanses of space, and may require a broad, horizontally oriented environment personal psychic well-being. They are adjusted to wide variations in temperature and radical weather changes and extremes. They are large dependent on land and climate for their livelihood, and take fierce pr in wresting their living from a land and climate that is at times viol hostile and at other times lavishly bountiful. They are plainsmen, wi the inherited social values of the 19th Century cattlemen and the tena dry-land homesteader.

Political

The people of the province are generally politically conservative. They are accustomed to making their own political decisions in local g ernment and are in the main prone to be active participants in the political areas affecting their economic and social values. Denver is th largest urban center affecting the political climate of the province, which feels a cohesiveness of self-interest transcending state politica boundaries. Eastern Montana plainsmen are much more politically in harmony with their fellows in the western Dakotas and northeastern Wyoming then they are with mining-dominated western Montana. Many of these peop are violently opposed to plans for extensive strip-mining and coal-electrical power generation being developed in their region. Much evidence c their opposition to coal development is seen in regional newspapers and such publications as Montana Outdoors. They do not wish to see radical change in their existing social, economic, and political way of life.

Economic

Economic patterns and attitudes are closely related to and interact with the prevailing social and political views. Ranching, small grain agriculture, and irrigated farming along the river valleys are the primary elements of the economy. Industrial plants exist only in supportive roles, such as the processing of sugar beets, and they are not themselves major elements. Towns are trade centers and transportation centers. Some coal has been mined in the past, but national interest in the coals of this province is of recent date. Oil and gas production in the Williston basin has had a marked impact on the economy of the Fort Union Region. Recreation and tourism have been important and growing in economic importance, but not to the extent, the mountain areas have experienced.

Ethnic

The Northern Plains Indians are the largest single ethnic group in the Northern Great Plains Coal Province. Acutally, these Indians represent a variety of Indian tribes: Crow, Gros Ventre, Mandan, Arickara, Sioux, Chippewa-bee, Blackfeet, and Northern Cheyenne. They speak different languages and exhibit other physical differences, but all are native Americans. The Blackfeet, Ft. Belknap, Crow, Northern Cheyenne, Ft. Berthold, Pine Ridge, Rosebud, Ft. Peck, and Northern Cheyenne reservations are all underlain with coal as are the lands adjacent to these reservations. Some of these people are cooperating in coal leasing (Crows, 1972), but others, (Northern Cheyenne, 1973), are violently opposed to coal development that they view as a direct threat to their ethnic integrity. Few Indians have been completely assimilated into the white culture in this coal province, and there has been discrimination against Indians based on ethnic and cultural attributes.

Cultural and Religious

People of this coal province are generally conservative in cultural and religious matters. The Indian inhabitants of the province are also culturally conservative, especially in ways that are involved with land use and occupation. Basically, man is part of the natural environment in the Indian view, and derives much of his identity from interaction with the natural world about him. To the Indian, man is not set apart from the natural world, but rather is a component part of that world and should be in harmony with it. Opposition to coal development by the Northern Cheyenne in June, 1973, is partly based on fears that the familiar natural world they feel a part of will be despoiled and irrevocably altered by massive strip-mining of their reservation and the adjacent lands they feel a psychic attachment to.

Archeological and historic sites of national, regional, state and local significance are located in this province on or adjacent to coal bearing lands. Sites and structures relative to the history of the early fur trade, exploration, settlement, and the Indian Wars are profusely scattered over the entire province. Some historical resource sites are protected as units of national, state, and local park systems; other are as unprotected, and of these many are situated in areas where Federal coal is located. Inventory of historical and archeological resources is in progress by all Federal agencies, and many will ultimately be included on the list of National Historic Places maintained by the National Park Service. Historic sites, forts, and battlefields are a major tourist attraction in this coal province.

10 Human-Value Resources

a. Esthetic Values

Land forms within the Northern Great Plains Coal Province have a great similarity throughout. It is characterized by rounded, moulded slopes stretching as far as the eye can see, broken only by an occasional uplift or a drainage.

Line patterns are insignificant, occurring primarily in man-made features such as roads, power lines, or fences. In cultivated portions of the province, strong linear patterns are produced by rows of crops or the edges of cultivated fields.

In undisturbed grasslands, color and textural patterns are similar. Some variations exist, however, where native stands of grass have been converted to grain or cultivated pasture.

Lack of overall contrasts provide little in the way of a dominant element in the general sense, yet a pastoral scene with grazing livestock may produce a rather tranquil and pleasing mood. In addition, a viewer may be in a spot in which local elements produce a number of contrasts, especially near a drainage or topographical break.

b. Historic

The Northern Great Plains Coal Province, like the Rocky Mountain and other provinces, abounds in historic sites, ruins, trails,

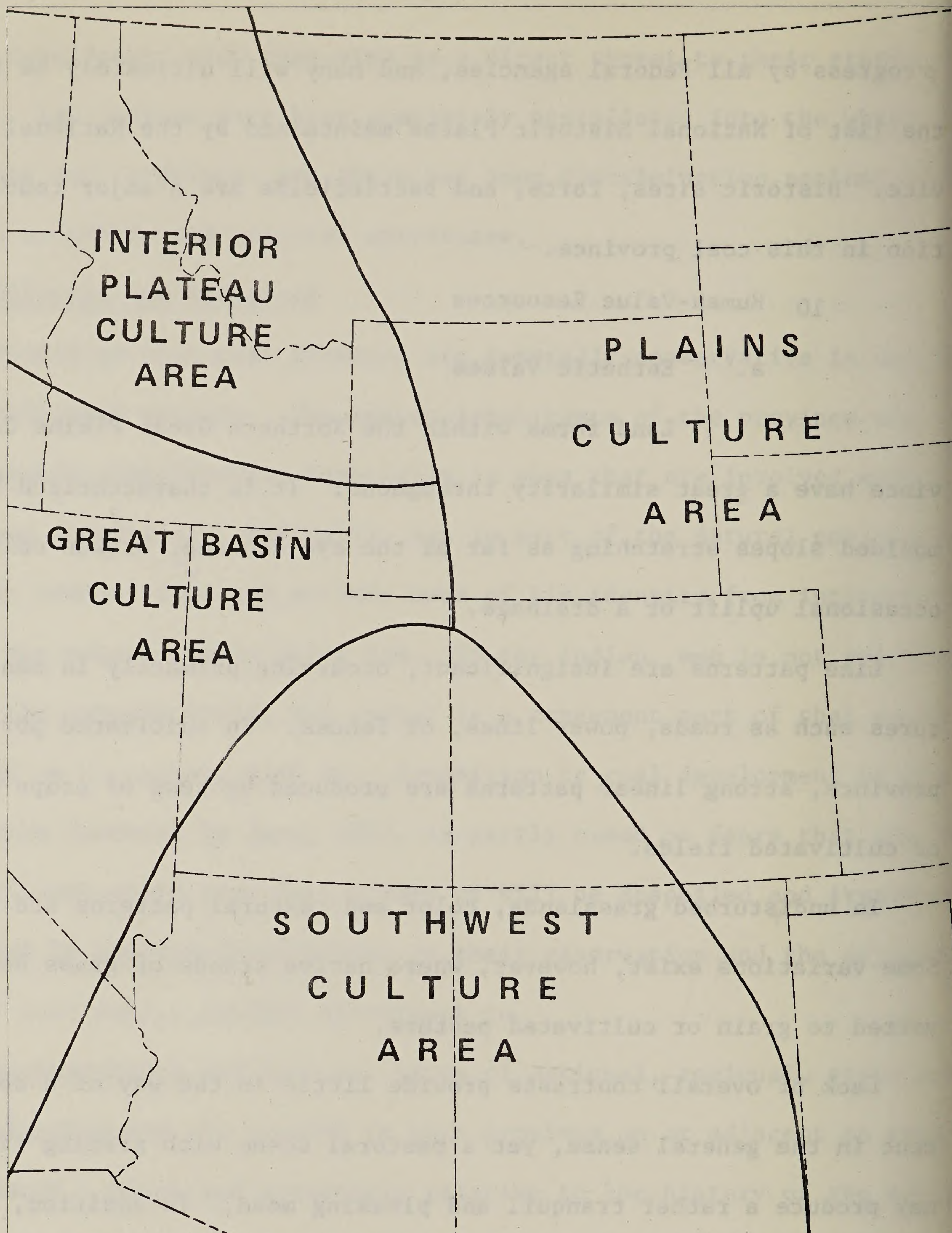

INTERIOR PLATEAU CULTURE AREA
PLAINS CULTURE AREA
GREAT BASIN CULTURE AREA
SOUTHWEST CULTURE AREA

Figure 33

structures, and objects that are physical links with and evidence of historical heritage. Preservation, research, and development of these historical cultural resources are vital to comprehension of the American past and present, and may serve as indicators and guidelines for the future. Nationally, significant identifiable historic resources, such as Fort Union Trading Post, Theodore Roosevelt National Memorial Park, and Custer Battlefield National Monument are units of the national park system and administered and protected under Federal statutes and regulations. Other historic and cultural resources are included in state and county park systems. A great many smaller and less significant or well-known historic resources are scattered over the province on Federally administered lands. Inventory of these resources is currently underway by all Federal agencies, but is far from complete. Some historic sites, such as the Battle of the Rosebud, (June 17, 1876), and the Battle of Wolf Mountain, (January 9, 1877), may be affected by surface coal mining operations. In addition to Indian War battle sites, many historic military posts, early ranching sites, fur trading posts, Indian village sites, transportation and communication historic sites, and others exist in considerable profusion in this coal province. Included are historic cultural resources related to:

1. Early exploration by the Lewis and Clark and other expeditions.

2. The history of such Indian tribes as the Blackfeet, Crow, Assiniboine, Sioux (many branches), Gros Ventre, Mandan, Arickara, Cheyenne, Arapaho, and Pawnee in their interactions with each other and confrontation with the white cultures.

3. Military history is represented in the Powder River War of 55, the Sioux Wars of 1862-1864, 1866-1868, and 1876-1881; and many sm ler campaigns and expeditions still traceable on the land.

4. The economic, social, and developmental history of the provi e includes the history of the fur trade of the plains, ranching develc en exploitation of the buffalo, the farming frontier, transportation an communication development, and the early settlement of towns and com ni

c. Geologic

The Northern Great Plains Coal Province is charact iz by rolling plains, tablelands, and areas of high hills. This is the ea of the Upper Missouri River drainage. The most outstanding geologic ea tures of human interest are the many dome mountains. An example is e Black Hills, an area 50 by 100 miles, formed by the intrusion of mol n rock beneath the overlying sedimentary strata. This underground pres ure forced the surface up in the form of a dome. This uplifting activit has been related to the creation of the Rocky Mountains. The Black Hills long axis runs parallel to the Rocky Mountains indicating that the hc i- zontal pressures which formed the Rockies were important in shaping t Black Hills dome. The intruding magma sometimes ruptured the coverin strata, lifting them irregularly, as in the Mocassin Mountains in Mon na These overlying strata are sedimentary and this is important for many other human interest features of this province. The sedimentary lime on contain many spectacular caverns, as at Jewel Cave National Monument, nd are the parent material for the carvings at Mount Rushmore. The nort rn and eastern borders of the province were glaciated during the Pleisto ne

Age and show some features such as kettles, moraines, drumlins, and eskers of possible human interest.

This province, particularly in eastern Wyoming, is rich in paleontological values which are stratigraphically found above the coal-bearing layers. It was this area in which the progenitor of today's modern horse was discovered and here in the geologic past, it flourished along with many other significant vertebrates. In some coal formations of the province, the time of the animals and of coal formation was concurrent. All vertebrate fossils are protected by the Antiquities Act of 1906.

d. Archeologic

As has been previously described for the Rocky Mountain Coal Province, the earliest dwellers of the plains are believed to have been the Paleo-Indians of the Big Game Hunting Tradition. The aforementioned province description included cultural information for two of the cultural sub-areas in this province, the Northwestern and Central Plains sub-areas. The Northern Great Plains Coal Province contains elements of two other culture sub-areas, the Northeastern and the Middle Missouri sub-areas.

Approximately 4000 B.C. is the time given for the change from the Big Game Hunting economy to the Plains Archaic which was a hunting-gathering, nomadic way of life. At about 4000 B.C. began a period of drier, warmer conditions which lasted about 1,000 years. During this time, accelerated erosion and arroyo cutting occurred and the times were so harsh that few or no humans lived in the western plains. At about 3000 B.C., archeological records indicate that the climate had ameliorated to the point of being able to support a hunting-gathering existence.

The northeastern and possibly the eastern portion of the Middle Missouri sub-areas yield sites in the 4000 - 3000 B.C. era so it can be concluded that as harsh an environment did not pertain there. Plains Archaic sites are likely to be camps, caves, and bison kills. Some locations show refuse depth that indicates fairly steady, if seasonally intermittent occupation.

The subsequent stage of cultural development, the Plains Village Tradition, is recorded in the northwestern part of the Central Plains and Northwestern Plains Cultural sub-areas only in attenuated and modified forms. Pottery entered the Northeastern and Middle Missouri sub-areas after 1 A.D. accompanied by the advent of agriculture. These and other additions entered from the eastern woodlands area and the continued contact with the people to the east and southeast later brought the Plains Village Traditions' array of values.

Early in the Plains Village period, post 1000 A.D., the people lived in rectangular houses in settlements of 50 to 100 persons. The gardens (they were largely an agricultural people), would be located on the river bottoms and the houses on a bluff or ridge above. Houses of this period were of earth and timbers (earth lodges), rectangular in shape, and in the eastern part of the sub-area tended to be semi-subterranean while in the west, usually surface structures. Middle Missouri houses were larger and usually there were more houses in a village. They were usually fortified sites, also. Later, through drought, aggression, or both, many areas were abandoned and the people moved south to form very large village sites which were extensively fortified. Others moved to the north and northwest.

With the advent of the horse, many Plains Village Tradition people reverted to a mainly hunting style while others, as did the ones which remained mostly agricultural, acted as go-between traders for European goods to other Indian groups. The Arikara, Mandan, and Hidatsa, and less, the Pawnee, remained agriculturalists well into the European contact era.

Most of the Federal coal in the Interior Coal Province is in the southern part of the Western region, mostly in Oklahoma. In this region, and in western Arkansas as well, mountain building forces of the Ouachita disturbance further devolatized the coal beds and raised their rank to low volatile bituminous and, locally, semi-anthracite, (Campbell, 1929). The coal is mostly of coking quality and is contained in rocks of the Hartshorne Sandstone and the McAlester Shale. The most important beds are the Lower Harshorne 2.5 to 6 feet in thickness that lies near the middle of the Hartshorne Sandstone, and the Upper Hartshorne, 1.75 to 5.5 feet thick, and the McAlester coal. 1.75 to four feet thick, that occur in the McAlester Shale.

The coal-bearing rocks are folded into a series of eastward-and-northeastward-trending broad, flat synclines and tightly folded anticlines, (Averitt, 1966).

Coal has been mined extensively in areas of moderate to low-dip (20 degrees or less), but areas of steeply-dipping coal beds have been mined only locally. A report by Trumball (1957) described the coal resources of Oklahoma and included a detailed classification of the resources.

2. Topography

The Interior Coal Province has a generally flat to rolling topography of gentle relief. There are some eroded mountains in eastern Oklahoma and western Arkansas known as the Ouachita and Boston Mountains. The maximum elevation is 2,800 feet above sea level. There are numerous scenic rolling hills such as the Ozarks in Missouri and Arkansa plus steep bluffs along many of the rivers and broken hills in sout Illinois, Indiana, and western Kentucky. The elevation of most of area is less than 700 feet.

3. Climate

The climate of the Interior Coal Province is character by hot humid summers and cold humid winters. The annual precipitat ranges from a low of 24 inches along the western and southwestern bo dary to more than 56 inches in the Ouachita Mountains of western Ark sas. The majority of the area receives between 32 and 48 inches of cipitation per year. March, April, May, and June are the months wit the highest precipitation. Parts of the area receive over four inch per month during this time. The rains come during the growing seaso Fall rains in the Interior Coal Province may average over two inches per month. The humidity averages between 60 and 70 percent most of the year with some portions having a higher average in the fall and winter.

Temperatures in the southern portion average above 40° F in January, and above 80° F in July. In the northern portion, the temperatures in January average above 20° F and above 70° F in July. The m annual freeze-free days range from 150 in the north to 210 in the sou west. The winds are typically out of the west and northwest in the wi ter and out of the south the rest of the year. This area is subject many tornadoes every year.

4. Hydrology

Most of this region has abundant supplies of surface water. However, pollution of surface waters is widespread, and most large users must treat surface waters before use. Sediment loads in most streams are generally low during low flow periods, but can be high during peak flows.

The dry weather flow of streams draining areas underlain by coal is generally very low in this province. The water is generally a calcium sulfate type water in these areas, and where coal has been mined, drainage is common.

Ground-water supplies are highly variable. Large supplies of good quality ground water can be obtained from alluvial aquifers, and in some places from glacial drift. In areas underlain by coal generally have low yields of poor quality water, while outside there areas large supplies of good quality can often be obtained.

5. Soils

Some dominant soils within the Interior Coal Province are listed in Table 38 . Some characteristics, uses and limitations are given for each of the listed soil series. Specific items for each soil such as the unified classification of the subsoils for engineering uses and hydrologic groups are given as well as general information. Thus, the information may be used by engineers, hydrologists, and soil scientists as well as the general public to gain some knowledge of the soils. The listed soil series are not inclusive. They occur extensively, but

Table 38 - Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Interior Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Crete	Nebraska (USDA, 1969)	CH	9-12	--	0-5	row crops, hay & pasture, short & reed grasses	range, farming
Limitations -	Moderate erosion hazard, high in fertility, high shrink potential.						
Tillman	Texas (USDA, 1964)	CL CH	9-12	--	1-3	short grasses, small grains	range, cultivated crops
Limitations -	High natural fertility, droughty, slight erosion hazard.						
Badland	Texas (USDA, 1964)	--	--	D	2-12 20-75	some short grass	--
Limitations -	This land supports little vegetation. It is thoroughly dissected by large gullies and has bald ridges and knobs, severe erosion hazard.						
Post	Oklahoma (USDA, 1967)	ML or CL	6-9	C	nearly level	small grains, hay orchards, pasture	farming
Limitations -	Floodplain, calcareous substratum, thick surface layer.						
Richfield	Kansas (USDA, 1965)	CL or CH	9-12	C	0-3	small grains, native grasses	dry farming range
Limitations -	Table land, well drained, susceptible to wind and water erosion, natural fertility is high.						
Miami	Illinois	ML	9-12	B	2-35	crops, pasture forest	farming

they must be viewed as examples. A detailed, on-site soil survey must be made before the total soil resource is known. More detailed information of the soils characteristics and limitations may be obtained from the soil survey reports listed in the selected references.

Descriptions of soil organisms in the Pacific Coast Coal Province also pertain here.

6. Vegetation

In the Eastern Coal Province, Federal coal leases lie in the northern temperate portion of the grassland biome and in the deciduous forest biome. Oak trees and big bluestem grass occur in the western part of the area. Further east, blue stems, panic grasses, and Indian grass is interspersed between stands of oak and hickory. At the east end of the area, pine is mixed with oaks and hickories.

7. Wildlife

Federal coal in the Interior Coal Province is primarily in eastern Oklahoma. The fauma of this area consists primarily of the deciduous forest edge species (Shelford, 1963). Oak-hickory forest, tall-grass prairie, and the intermixed ecotone make up the major habitat types of the Federal coal lands. Populations of mammalian species are relatively low in the oak-hickory type. White-tail deer, raccoon, red fox, gray fox, eastern gray squirrel, fox squirrel, brush mouse, eastern woodrat, eastern cottontail, striped skunk, and opossum are common mammals.

Representative birds are the tufted titmouse, red-eyed vireo, wood

thrush, ovenbird, wild turkey, and bobwhite quail. The greater prairie chicken may be found in savannah types.

Waters of the area are generally highly productive. The Arkansas drainage reportedly contains 110 species of fish. Fishes are mostly warm-water species such as buffalo fishes, suckers, carp, catfishes, bullheads, yellow perch, bluegill, sunfishes, and crappies.

Amphibians and reptiles found in the Federal coal areas are the box turtle, spiny soft-shelled turtle, cricket frog, colloared lizard, six lined racerunner, ringnecked snake, rough green snake, kingsnake, gartersnake, and ground snake (Stebbins, 1966).

8. Land Uses

Over 75 percent of the land area is used for some type of agriculture. Cropland comprises about 50 to 75 percent, pasture about 5 to 15 percent, and woodland about 15 to 30 percent of the agricultural area.

Coal is plentiful in the province and some oil and gas exists. Some silver, lead, zinc, and iron occur within the province.

Water use is dominated by industrial demands, including major portions for fuel-electric power generators. Flooding may be expected once in every two to five years in parts of the area.

9. Population Patterns and Considerations

Southeastern Oklahoma Federal coal lands are located in a sparsely populated area in what was once the Choctaw and Chickasaw Nations. Many inhabitants are part-time coal miners and farmers. The people could be classified as socially, economically, and politically conservative. Some people are Indian or part Indian, but were long ago assimilated into the American culture.

10. Human-Value Resources

a. Esthetic Values Where Federal Coal Occurs

Federal coal is located primarily in eastern Oklahoma within the Western Region of the Interior Coal Province.

Gently rolling land forms are characteristic of the Osage plains where the principal coal deposits occur. Occasionally, uplifts provi interest and contrast within the area.

There are no heavily forested areas, consequently textural and color contrasts occur among scattered tree groupings and exposed soil or rock.

Agricultural activity and the influence of man add linear configurations to the landscape.

b. Historic

Much evidence of mid and late 19th century life sty is still present in Oklahoma, including structures and uses common to farming and rural life. Old roads and trails are still present, as a the small towns that have been there a century or more.

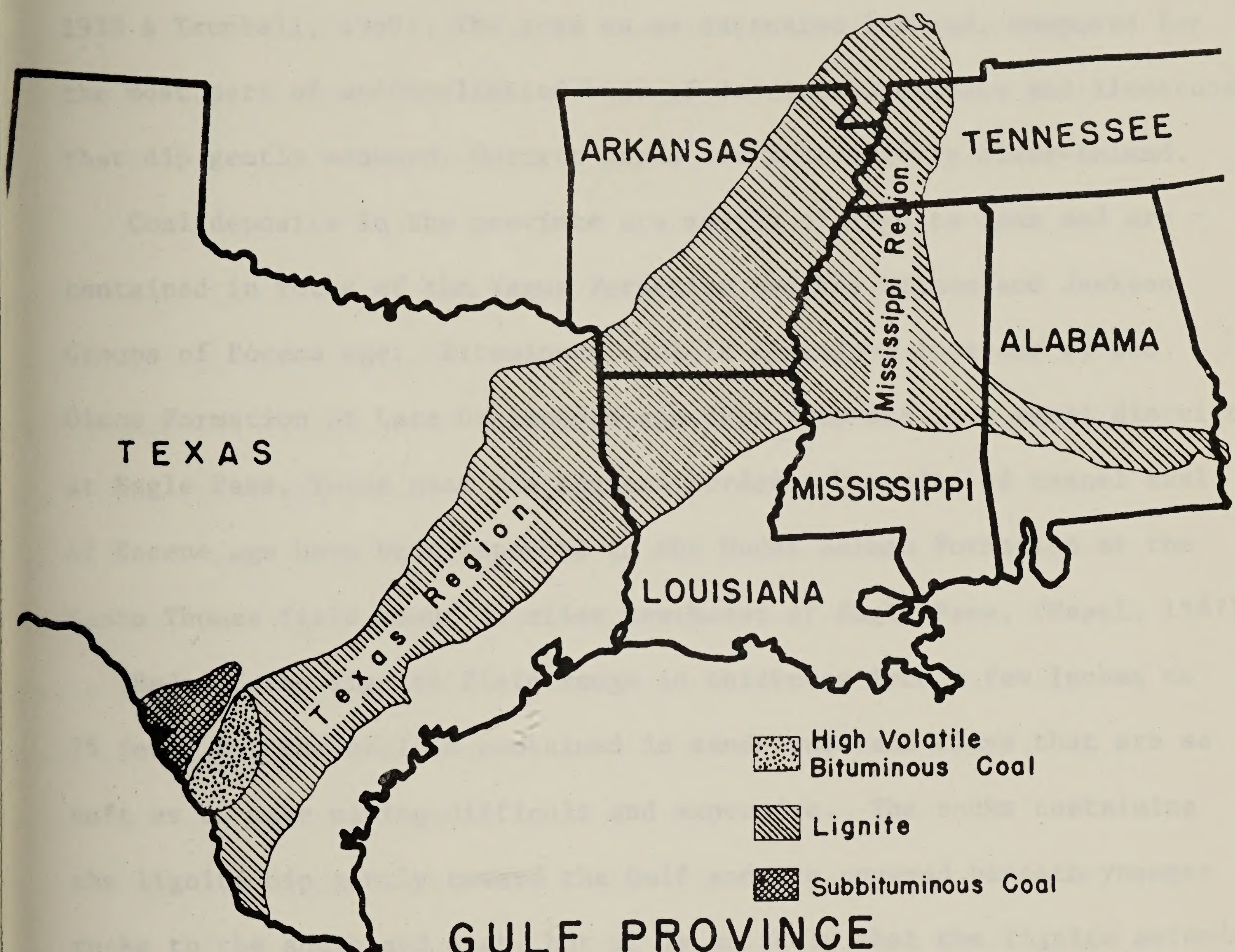
c. Geologic

The Federal coal lands of this province lie in Oklah and Arkansas. At the southern end of the Great Plains, this area is r ling, moderately hilly in the western portion and more hilly in the ea tern part. The human interest geological features of this area are the remnants of the Ouachita uplift, now tree covered and laced with many picturesque valleys and streams. Some caves, caverns, and hot springs exist in the area.

d. Archeologic

In the portion of the Interior Coal Province in which the Federal coal exists, the Big Game Hunting Tradition was the earliest phase of human life. This was followed by an Archaic tradition at a time earlier than that area to the North. This tradition was later heavily influenced by the Eastern Archaic and by the Desert Tradition from the West. This area apparently was on the fringe of most of the neighboring culture areas and in later Archaic times was closer to the Edwards Plateau Tradition of present-day northern Texas. Later, the heavily agricultural influence of the Caddo (a subtradition of the temple mound-building Mississippian Culture), brought newer concepts of government, religion, and material culture. As a part of the Southern Plains Subarea, the people shared in the Plains Village Tradition characteristics of large communities, some fortified sites, and an agriculture based economy. At historic contact times, the area had elements of the surrounding cultures in its population; the Commanche to the west, Wichita in the north, Tonkawa to the south, and the Caddo-Mississippian Tradition in the east.

Archeological remains include agricultural areas on the river bottoms with village sites on the bluffs or ridges above, camp sites, and tool chipping sites. Cave sites are valuable and significant.



ARKANSAS
TENNESSEE
Mississippi Region
ALABAMA
TEXAS
MISSISSIPPI
Texas Region
LOUISIANA
High Volatile Bituminous Coal
Lignite
Subbituminous Coal
GULF PROVINCE

Figure 28-C

E. Gulf Coal Province

1. Geology

The Coastal Plain Physiographic Province encompasses the Texas and Mississippi coal regions of the Gulf Coal Province, (Fenneman, 1938 & Trumball, 1960). The area is an extensive lowland, composed for the most part of unconsolidated beds of detrital sediments and limestones that dip gently seaward. Outcrop bands are successively older inland.

Coal deposits in the province are mostly of lignite rank and are contained in rocks of the Yegua Formation and the Wilcox and Jackson Groups of Eocene age. Bituminous coal is contained in rocks of the Olmos Formation of Late Cretaceous age that crop out in a small district at Eagle Pass, Texas near the Mexican border. Deposits of cannel coal of Eocene age have been reported in the Mount Selman Formation at the Santo Thomas field about 50 miles southeast of Eagle Pass, (Mapel, 1967).

Beds of the lignite field range in thickness from a few inches to 25 feet, but the coal is contained in sandstones and clays that are so soft as to make mining difficult and expensive. The rocks containing the lignite dip gently toward the Gulf and are covered beneath younger rocks to the south and east, but it is unlikely that the lignite extends very far in this direction because the beds were formed in relatively narrow belts marginal to the migrating shoreline. The lignite is locally used in large volumes as an industrial fuel for power generation and in turn for aluminum ore reduction (Keystone, 1972).

2. Topography

The topography of the Gulf Coal Province is that of coastal plains, minimal relief, and a significant area of coastal flats. T Mississippi River has meandered over a large portion of the middle this province leaving a large nearly-level alluvial plain. There a no mountains in the province. Approximately 80 percent of the area gently sloping to nearly level and the elevation is less than 300 f There are large numbers of marshes and swamps.

3. Climate, Air

The climate of the Gulf Coal Province has moderate win with very hot, high-humidity summers. Precipitation varies from 20 inches in southwest Texas to more than 65 inches in southern Louisi per year. Most of the area receives 50 inches per year, nearly all the form of rain. Most of the area receives more than four inches month except in August, September, and October when the average is slightly lower. The coastal parts of Louisiana, Alabama, Mississip and Florida may receive more than eight inches of rain on the avera

The temperature of the northern portion averages 40° in Januar and 50° in the southern portion. The temperatures average above 8(for the whole area in July. The northern portion averages more thai 210 freeze-free days per year and more than 270 freeze-free days pe year near the coast. The Mississippi River delta has more than 300 days without freezing temperatures per year. The winds are varied i the winter, typically out of the south in the spring and summer anc usually from the northeast in the fall. Hurricanes may be an occasi threat in late summer.

4. Hydrology

The Gulf Coast Hydrology Province is well-endowed with both surface and ground-water supplies. Surface streams generally are perennial and have good quality throughout the year. Except for the southeastern part of Texas, droughts are uncommon. Sediment content of surface waters is generally low, except during high flows.

The area contains abundant supplies of good quality ground water. Yields of over 1,000 GPM can be obtained from alluvial wells or bedrock wells over much of the area. Many high capacity wells over 1,000 feet deep yield water with less than 500 mg/l dissolved solids. The major ions in the potable ground waters are calcium, sodium, and bicarbonate.

5. Soils

Some dominant soils within the Gulf Province are listed in Table 39. Some characteristics, uses and limitations are given for each of the listed soil series. Specific items for each soil such as the unified classification of the subsoils for engineering uses and hydrologic groups are given as well as general information. Thus, the information may be used for engineers, hydrologists, and soil scientists as well as the general public to gain some knowledge of the soils. The listed soil series are not inclusive. They occur extensively, but they must be viewed as example. A detailed, on-site soil survey must be made before the total soil resource is known. More detailed information of the soils characteristics and limitations may be obtained from the soil survey reports listed in the selected references.

Table 39 - Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Gulf Coal Provinces

Soil Name	Location	Unified Classified cation	Available Water Capacity (inches)	Hydro-logic Group	Relief (%)	Vegetation	Major Use
Reeves	Texas (USDA, 1969)	CL	3-6	C	level to undulating	desert shrub salt tolerant grasses	range
Limitations - Salinity, high corrosion potential, calcareous outwash, gypsum in the subsoil.							
Brewster	Texas (USDA, 1969)	GC or GM	0-3	D	gently undulating to steep	short grasses, mid grasses, desert shrub	range, recreation wildlife
Limitations - Bedrock within 20 inches, stoniness.							
Goliad	Texas (USDA, 1973)	CL	3-6	C	level to undulating	short & mid grasses	range crops wildlife
Limitations - High shrink swell potential, severe building foundations problems, high corrosion potential, shallow to moderate depths to caliche.							
Ector	Texas (USDA, 1969)	CL	0-3	D	nearly Level	short & mid grasses	range crops, wildlife recreation
Limitations - Bedrock or cemented caliche within 80-inch depth, stoniness moderate shrink-swell potential, severe erosion hazard.							
Victoria	Texas (USDA, 1965b)	CH	9-12	D	nearly level	cotton, sorghum onions	cultivated crops
Limitations - Very high shrink-swell potential, cracks when dry, ponding occurs in depressions, calcareous clays.							

Table 39 - (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Orelia	Texas (USDA, 1965b)	CL	3-6	D	nearly level	cotton, grain sorphum	cultivated crops
Limitations - Wind blows sandy soils with a hardpan in the subsoil, hardpan slows surface drainage, calcareous substratum.							
Oil Waste Land	Texas (USDA, 1965b)	--	--	--			
Limitations - This land has been damaged by oil, salt water, mud, or other by-products of oil fields to such extent that its productivity has been seriously reduced or destroyed. For more than 25 years, some of this land has been covered by sterile mud, slush, salt water and oil to a depth of 1 to 4 feet and it is still bare of vegetation, some areas have been reclaimed.							
Olivier	Louisiana (USDA, 1965a)	CL	3-6	B	nearly level	pine & hardwood forest	pasture, urban use, wood crops
Limitations - Somewhat poorly drained, slowly permeable soils, severe erosion hazard.							
Sharkey	Louisiana (USDA, 1965a)	CH	9-12	D	nearly level	mixed hardwood forest, perennial grasses & legumes	cultivated crops, wood crops, pasture and hay
Limitations - Floodplain, difficult to work because of moisture content, cracks when dry, some areas subject to flooding.							

6. Vegetation

The only Federal lease in Alabama lies in the drier oak hickory-pine portion of the deciduous forest biome, which lies in the southern end of the Appalachian coal region.

A lease in southeastern Kentucky lies in one of the most varied portions of the deciduous forest biome represented by such species as maple, buckeye, beech, yellow-poplar, oak, basswood, and shortleaf pine.

A Federal coal lease lies near the Ohio-West Virginia boundary in an area of hardwood forest.

7. Wildlife

Coal-bearing lands of the Gulf Coal Province are found mostly within the oak-hickory and oak-hickory-pine communities of the deciduous forest biome. Some southern grassland and mesquite savannah habitats are also found in the coal regions. Characterisitics of the wildlife fauna in these areas are quite similar to those described for the Federal coal lands of the Interior Coal Province.

Some of the conspicuous wildlife species occurring in the Texas reigon of the Gulf Coal Province which are not typical of the lands underlain by Federal coal in the Interior Province are as follows:

Mammals	Birds	Amphibians and Reptiles
Mexican free-tail bat	Roadrunner	Texas toad
Mexican ground squirrel	Scaled quail	Texas blind snake
Peccary	Attwaters prairie chicken	Western diamondback rattlesnake
Ringtail		
Hognose skunk		
Red wolf		

8. Land Uses

Most of the land is devoted to agriculture or forestry. Coal is scattered in the northern portion of the province while oil and gas are located throughout. Some silver, zinc, lead, and iron minerals are located in the province.

Water use is dominated by industrial processes. Flooding may be expected once in every five to ten years in parts of the area.

9. Population Patterns

Population patterns in this province are very complicated; ranging from sparsely occupied rural areas to highly industrialized centers such as New Orleans. Any Federal coal leasing in this province resulting in mining will require a case by-case study to assess human environment and impacts likely to derive from Federal coal operations.

Ethnic and cultural/religious factors in this province include the presence of sizeable French-Creole, and black populations.

10. Human-Value Resources

a. Esthetic

In the Gulf Coal Province, coal occurs in an arc from eastern Texas to western Tennessee and central Alabama. This area is characterized by pine-hardwood forests interspersed with farms. Topography is gentle, with streams and winding roads traversing the varied landscape.

Esthetic interest centers mainly in the variety of the terrain, vegetative cover, and human influences, which are typical of the South.

b. Historic

A very wide spectrum of historic sites and cultura resources is present in this province. East Texas, Arkansas, and Louisiana contain many such sites related to early Spanish and Fren exploration and settlement, Texas settlement and independence, and Civil War. Alabama and western Florida also contain historic land sources related to early Spanish, French, British, and American act ties, the War of 1812, and the Civil War. Fort Smith National Monu Arkansas Post, and Chalmette Battlefield are examples of historic r sources. San Jacinto State Park in Texas preserves the site of tha climactic battle in the Texas War for Independence, and areas along Rio Grande River include camp and battle sites of the Mexican War.

c. Geologic

The Gulf Coast Province is geologically a low, fla plain. Farther inland, the land becomes differentially hilly with broad valleys between hill systems. Rivers and streams comprise the most obvious geological features. These waterways' sedimentary and erosive qualities are responsible for the formation of the picturesc Oxbow Lakes which become bayous with their luxuriant vegetation. Th Mississippi River debouches into the sea in this province forming ar extensive bird's-foot delta.

The underlying rock of most of this area is sedimentary. This resulted in many small caves and caverns through solution by the per lation of surface water downward. The area of southwest-central Tex in particular has large caves with human interest value. Many large springs and artesian features also attract human interest. Along the coast there exist many Cenotes with their characteristic pools of water fed by an underground water source.

d. Archeologic

The Gulf Coast Coal Province is marginal to the area of the Big Game Hunting Tradition, though it supported considerable Archaic exploitation throughout its range. From the west, the influence was primarily from the Desert Tradition, and in the east, the Woodland Tradition. Some areas, such as the Gulf Coast area, had an essentially Archaic style human exploitation at contact times.

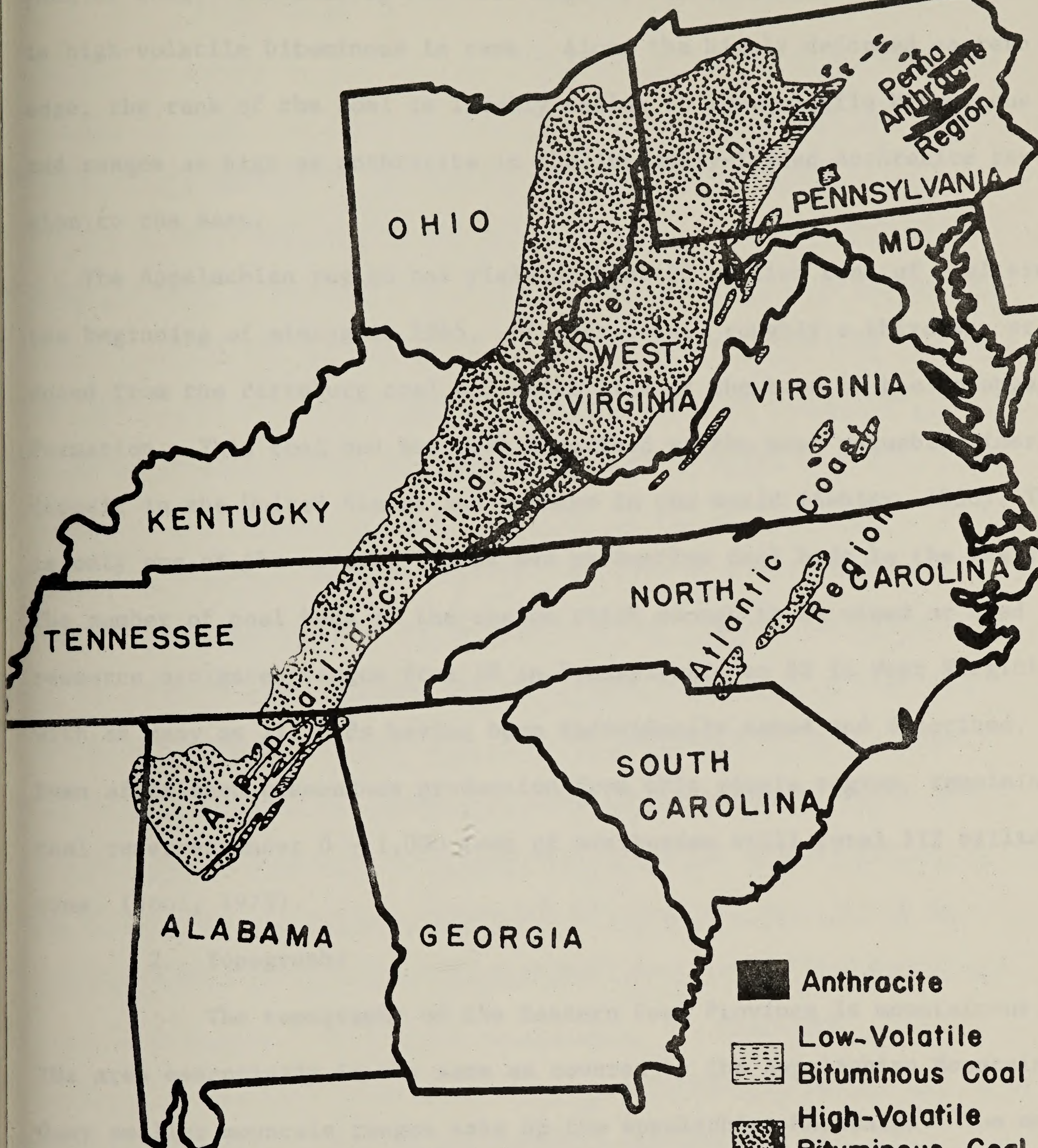
On the lower Mississippi and along it's tributaries later Meso-American influences gave birth to the Mississippian Tradition with its characteristic Temple Mounds, large concentration of population, and a dominantly agricultural subsistence. While this was in the process of developing, the Woodland variant culture to the east was declining, to be replaced by Mississippian influence. Historic and proto-historic tribes in the province were the Karankawa, Atakapa, Tonkawa, Caddo, Quapaw, Tunica Choctaw, Apalachee, Natchez, and Chitimacha. Archeologic remains will be areas of mounds in flat areas, campsites, and habitational sites on ridges and bluffs.

F. Eastern Coal Province

1. Geology

The Valley and Ridge and the Appalachian Plateau physiographic provinces encompass nearly the entire area underlain by coal-bearing rocks of the Eastern Coal Province, (Fenneman, 1938 and Trumball, 1960). The rocks in these provinces form a series of sandstones, shales, limestones, conglomerates, and beds of coal that comprise the Appalachian basin. In the Valley and Ridge province along the eastern side of the basin, these rocks have been greatly disturbed by folding and faulting. On the western side in the Appalachian Plateau province, the rocks are mostly nearly flat or dip gently to the west.

The Appalachian coal region extends uninterrupted about 800 miles from northern Pennsylvania to western Alabama and across parts of Pennsylvania and Ohio at its widest part, (Arndt, Averitt, Dowd, Frendzel, and Gullo, 1968). The region is defined by outcrops of coal-bearing rocks of the Pennsylvanian, Monogahela, Conemaugh, Allegheny, and Pottsville Formations (used locally as group names). Along the eastern margin, these rocks are folded into several hundred small subsidiary anticlines and synclines, and locally some of these structures are separated from the main part of the region. On the east edge, beds dip very steeply locally, but moderate dips of about 20 degrees are more characteristic. To the west, the beds dip less steeply until near the western edge, they are nearly flat. The Pennsylvanian Anthracite region is characterized by steeply-dipping folded beds and faults, and overturned beds are common. These variations in structure are accomplished by parallel variations i



EASTERN PROVINCE

Figure 28-D

rank of coal. The coal on the west edge of the Appalachian coal basins is high-volatile bituminous in rank. Along the highly deformed eastern edge, the rank of the coal is locally medium to low-volatile bituminous and ranges as high as anthracite in the intensely-folded Anthracite region to the east.

The Appalachian region has yielded about 23 billion tons of coal since the beginning of mining in 1965. Of that total, roughly a third was produced from the Pittsburg coal bed which lies at the base of the Monongalela Formation. This coal bed has been described as the most valuable mineral deposit in the United States and perhaps in the world (Ashley, 1938). This is only one of the several famous and productive coal beds in the region. The number of coal beds in the region thick enough to be mined or used in resource estimates ranges from 19 in Pennsylvania to 62 in West Virginia with as many as 117 beds having been individually named and described. Even after such tremendous production from this single region, remaining coal reserves under 0 - 1,000 feet of overburden still total 112 billion tons, (Joul, 1973).

2. Topography

The topography of the Eastern Coal Province is mountainous. The area essentially is the same as covered by the Appalachian Mountains. Many smaller mountain ranges make up the Appalachian Mountains. The mountains are oriented northeasterly and southwesterly with numerous ridges, gaps, and escarpments paralleling the mountain structure. Folds, faults, and steeply dipping formations are common. Few of the peaks exceed 5,000 feet, but the roughness of the area is caused by numerous drainages. The mountains are very old geologically. Generally, the ridges and valleys are narrow with few broad valleys.

3. Climate

The Eastern Coal Province has hot humid summers and moderat to cold humid winters. The precipitation ranges from about 32 inches i the far north to more than 60 inches in the southeast. Most of the are receives between 40 and 50 inches of precipitation per year. The fall a winter have the least precipitation whereas the spring and summer have t most. There is adequate moisture during the growing season without irri- tion.

The temperatures in the north average between 20 degrees and 30 degrees in January, and usually above 70 degrees in July, except for some of the higher mountains. In the south, the temperatures average about 40 degre in January, up to 80 degrees in July. The northern mountainous areas ha a mean annual freeze-free period of 120 days. In the south, this freeze free period exceeds 210 days. The winds are typically out of the west in the winter, the southwest in the spring and summer, and vary in the fall. Occasional hurricanes cross this area in the late summer or early fall.

4. Hydrology

Eastern Province

The Eastern Coal Province has abundant surface water supplies Most of the area has readily accessible surface water supplies. However, industrial and municipal pollution of surface waters is widespread, and two-thirds of the nations acid mine drainage problems occur in the provin The quality of surface waters is complex. Most of the unpolluted streams have good quality water, but municipal and industrial pollutants produce complex chemistry in many streams so affected. The sediment content of streams is highly variable in this area, with many disturbed areas contributing large amounts of sediment to streams during storm events.

Groundwater supplies in the province can be obtained from river alluvium and bedrock aquifers. Medium to large supplies (100 - 1,000 gpm) groundwater can be obtained from alluvial wells. Generally, the water is of good quality. Bedrock aquifers of sandstone and limestone generally yield small supplies of good quality water. In areas that have undergone extensive coal mining, groundwater supplies may be polluted.

5. Soils

Some dominant soils within the Eastern Coal Province are listed in Table 40 . Some characteristics, uses and limitations are given for each of the listed soil series. Specific items for each soil such as the unified classification of the subsoils for engineering uses and hydrologic groups are given as well as general information. Thus, the information may be used by engineers, hydrologists, and soil scientists as well as the general public to gain some knowledge of the soils. The listed soil series are not inclusive. They occur extensively, but they must be viewed as examples. A detailed, on-site soil survey must be made before the total soil resource is known. More detailed information of the soils characteristics and limitations may be obtained from the soil survey reports listed in the selected references.

Descriptions of soil organisms in the Pacific Coast Coal Province also pertain here.

Table 40- Some Characteristics, Uses and Limitations of Dominant Soils Occurring in the Eastern Coal Province

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Miami #3	Ohio (USDA, 1962)	ML	9-12	B	gentle to steep	crops, pasture and forest	farming
Limitations - Erosion hazard is moderate to severe; compaction hazard is severe.							
Mardin #2	New York (USDA, 1970b)	ML or SM	3-6	D	sloping to steep	crops, pasture, and forest	farming
Limitations - Fragipan at 18 to 22 inches, subject to sloughing and seepage above pan, high water table.							
Appling #5	North Carolina (USDA, 1970c)	ML & CL	3-6	B	gently to strongly sloping	crops, pasture and forest	farming & forestry
Limitations - Well-drained, natural fertility low, shink-swell pot, severe erosion hazard.							
Wegram #5	North Carolina (USDA, 1970c)	CL & SC	3-6	A	nearly level to sloping	crops, pasture and forest	farming & forestry
Limitations - Somewhat excessively drained, low natural fertility, low stability.							

Table 40- (Continued)

Soil Name	Location	Unified Classification	Available Water Capacity (inches)	Hydrologic Group	Relief (%)	Vegetation	Major Use
Madison #6	Georgia (USDA, 1971)	CL, MH	3-6	B	gentle to moderately steep	pine and deciduous forest	farming and forestry
Limitations - Moderate to high shrink-swell potential, gravelly surface soil, natural fertility is low, erosion hazard is moderate.							
Tallapoosa #6	Georgia (USDA, 1971)	ML, CL, SM	3-6	C	gently to moderately steep	deciduous forests	forestry
Limitations - Shallow, well-drained, natural fertility is low, rocky subsoil, severe erosion hazard.							
Chester	Pennsylvania (USDA, 1970a)	ML, CL	9-12	B	gently to steeply sloping	grain, pasture, and deciduous forests	farming & forestry
Limitations - Well-drained, very stony profile, severe erosion hazard.							
Lewisberry #7	Pennsylvania (USDA, 1970a)	SM, GM	6-9	B	gently to steeply sloping	grain, pasture and deciduous forests	farming & forestry
Limitations - Well-drained, gravelly to very stony profile, servere erosion hazard.							

6. Vegetation

The Eastern Coal Province is within the deciduous forest b[ome]

primarily along the Appalachian Mountains. There is considerable rang[e] in vegetative types within the province. Oaks, hickories, cherries, a[nd] maples are prevalent hardwood species, intermingled with shortleaf, lo[b]lolly, Virginia, and northern balsam fir, and some other conifers.

Natural understories include a wide variety of shrubs, forbs, and grasses. Farmlands support a wide variety of crops including corn, sm[al]l grains, cotton, tobacco, and pasture.

Federal coal is so widely dispersed and of such limited acreage th[at] specific vegetative descriptions will be necessary to relate ground co[ve]r to Federal coal occurrence.

7. Wildlife

The limited Federal coal reserves of the Eastern Coal Prov[in]ce are found in regions where major plant associations are maple-beech-bi[rc]h and oak-hickory forests, with a variety of wetland habitats included. [T]hes[e] habitats naturally support wildlife species characteristic of the deci[du]ous forest biome. The Federal coal reserves and existing leases are in sma[l]l and scattered tracts within these broad communities. Local influences [m]ay have caused significant deviations from the expected species compositi[on] o[f] a particular Federal tract. A more detailed and specific description o[f] t[he] wildlife community would be made on specific tracts should leasing acti[o]n be taken.

Nuts and fleshy fruits produced in the deciduous forest provide a l[ar]ge variety of food for wildlife. Animals such as the gray squirrel and ea[st]er[n] chipmunk often vary greatly in number from year to year, depending upon the abundance of nuts and seeds. Important mammals in the coal province include white-tail deer, eastern mole, black bear, gray fox, red fox, bobcat, raccoon, gray and fox squirrels, New England cottontail, short-tail shrew, opossum, southern flying squirrel, and white-footed mouse, (Kendeigh, 1961, Burt et al, 1964). In the southern, oak-hickory part of the province, populations of mammalian species tend to be low.

Breeding birds in the maple-beech-birch association include the very, solitary vireo, black-throated blue warbler, blackburnian warbler, rose-breasted gosbeak, and wild turkey (Shelford, 1963). Typical snakes in this association were the eastern garter snake, red-bellied snake, milk snake, and eastern ringneck snake.

In the oak-hickory association, wild turkeys utilize the fruits of all the common deciduous forest trees, shrubs, and vines, with acorns being favored. A variety of typical deciduous forest birds are present. Copperheads, coral snakes, rough green snakes, rat snakes, coachwhips, and speckled kingsnakes are reported forest snakes. The slimy salamander is the only salamander found regularly in the oak-hickory forest, (Shelford, 1963).

8. Land Uses

Most of the land in the Eastern Coal Province is devoted to cropland, pasture, and forestry.

Coal, oil, and gas are found within the province. Iron, zinc, and copper deposits are among the important minerals in the province. Water use is dominated by industrial demands. Floods can be expected once in every five to ten years in parts of the area.

9. Population Patterns and Considerations

The Eastern Coal Province is a very large area with many ferent population variables. Federal coal occurs only in small parts the Appalachian region; this description covers only the areas affect

a. Social

Where Federal coal occurs in the Appalachian region people generally are socially conservative, courteous to strangers, a without ready acceptance of newcomers. Lack of contact with other ar and populations has resulted in these people's slow acceptance of cha Their isolation is a factor in this expressed reluctance. This same lation has resulted in the development in them of their attitudes of pendence and self-sufficiency. Isolation has resulted in intermarria and the resulting kinship ties have usually served to bind the commun together more closely.

b. Political

The areas' expressed conservatism, isolation, and hi have resulted in a unique, insular outlook. Originally settled by la latecomers to the New World, the land was fought for and cleared for culture by these early frontiersmen. These pioneers farmed the hollo and valleys and developed an ethic of self-reliance and a recognition the values and responsibility of personal liberties evident today in t political outlook. This area provided men such as Davy Crockett to t early 19th Century expansion movement and the area has remained devel oriented. The tide of progress and expansion passed to the West, le these Appalachian hillfolk still in the time and thinking of the cent before. Later, coal in their area was commercially developed, and the subsistance farmers accepted it, as a benefit to their way of life which had been bypassed by later national development. The people incongruously were still following the frontier attitudes and percepts while surrounded by an industrial society. The result was a retreat within themselves and an insularity which is conservative in political expression.

c. Economic

European settlement of this coal province was based on a hunting subsistance farming style of life which persists today. The area is the nation's leading producer of coal and most of the coal for export is Appalachian. The superposition of a highly industrially oriented coal extraction economy on a previously rural situation has left the inhabitants with a need for the material comforts that coal mining can bring them while they continue in the "Mountainfolk" ways. The two are often mutually exclusive and the coal extraction efforts usually succeed, leaving the local peoples with the negative values of a debased environment while they have shared few of the benefits. The province's inhabitants do not all want the mines, yet they feel they cannot do without them. Those who don't participate in coal mining frequently receive none of the ancillary economic benefits, leaving them, as one man said, "Too proud to take welfare and too poor to do without it."

d. Ethnic, Cultural and Religious

The residents of the Eastern Coal Province constitute a distinct ethnic entity. They have been isolated from the development of the nation and they have remained more as their forebears were than the rest of the nation is today. Other than materially and superficially, the which have molded the nation have passed these people by leaving th with their distinct music forms, philosophies, religious expression patterns, values systems, and general outlook on life.

10. Human-Value Resources

a. Esthetic Values Where Federal Coal Occurs

Gently rolling hills with some mountainous areas a the eastern seaboard are characteristics of the land forms within th province.

There are great color contrasts between seasons, which greatly c butes to the interest within this province. Various green shades pr inant when in full leaf changing to brilliant shades of fall colors. winter, the structural components of individual trees are apparent u consumed by new growth in spring.

b. Historic

Many vestiges of pioneer mountain life still remai this province; log cabins and farm structures, mills, and other hist buildings and sites. Many lifestyles and attitudes have changed litt in almost 200 years. Some areas contain sites related not only to ea settlement, but also Indian conflicts of long ago and the American Ci War.

c. Geologic

The Appalachian Mountains are the Nation's oldest a are consequently the most eroded. These mountains are generally low c to the more recent Rocky Mountains and are primarily of sedimentary c acter. Many of the Nation's most interesting and unique caverns exist in this area, including Mammoth Cave National Park, and speleological interest is continually growing in that area by interest from the close by urban areas. No geysers and few hot springs of great human interest value occur. Hiking is a major use, as seen by the many trails including the Appalachian Trail.

d. Archeologic

Archeologically this area lies in the Eastern Woodlands area of prehistoric use. The Big Game Hunting Tradition was in this area early, perhaps in some places earlier than in the western plains. This later became the Eastern Archaic Tradition, with the appearance of many outside influences. The Eastern Archaic was notable for the early introduction of pottery and the development of agriculture. Subsequent to this came the advanced cultures of the Woodlands Tradition. These people, the Hopewell, Adena, Copena, and their variants, were also known as the Mound Builders and were later replaced by elements of the Mississippian Tradition from the west. The Mississippians did not cover the same original territories as the Woodland Tradition, but their influences were felt by the people which lived at that time. The historic and proto-historic tribes in this province were the Chickasaw, Creek, Yucchi, Cherokee, and the Shawnee.

The early dwellers of this area gravitated to those areas which provided shelter, water, fuel, and were close to game and arable fields. While they may have utilized the hills and mountains for hunting and probably crossed them on trading and migration travels, the main habitational features are found on level land in the valleys. The area was not heavily or uniformly populated and the sites will not usually be in same place as the deposits of coal, but can be heavily impacted by development and mining nonetheless.

IMPACTS ON THE ENVIRONMENT FROM THE FEDERAL COAL LEASING PROGRAM

The discussion of the actions relative to Federal coal leasing is de- led in Part I. The action consists of a number of operations including loration, development, production, coal beneficiation, and site rehabi- ation. Numerous separate actions are involved within the various oper- ons of the coal program. Detail of the impact of these actions on com- ents of the environment are included in this section of the report. ondary impacts are important aspects of the coal program and will be ered to an extent in this report.

The Federal coal program begins with issuance of prospecting permits areas of unknown coal resources or by competitive leasing in areas where ues are known. Some impacts to the environment occur before issuance of rospecting permit or lease. Companies or individuals interested in a ticular coal area, normally conduct air and field reconnaissance before inite interest in a deposit can be established. Impacts from low-level reconnaissance flights are minor. Some noise pollution and limited turbance of wildlife and domestic livestock can be expected.

Issuance of a Federal coal lease has not always resulted in a measureable act on the environment. A large number of leases exist today which have er become active coal mining operations. Greater dependence on coal for rgy will increase demand, and, will result in many existing leases be- ing operative. In the future, a higher percent of new leases can be ected to result in active operations within a reasonable planning and elopment period.

The Federal government has potentially leaseable coal resources within ıll coal provinces of the United States, except the Gulf Coal Province. 'he major provinces with leaseable coal resources are the Northern Great 'lains, Rocky Mountains, and Pacific Coast which includes Alaska. The reatest number of existing leases are in the Rocky Mountain Province. The ocation with respect to potential markets and abundance of the coal re-ource in the Northern Great Plains province indicate that it will receive he greatest interest in the future for leasing. Primary interest on Fed-ral coal lands in the Pacific Coast Province will be in Alaska where the ajor deposits occur.

The majority of impacts from actions relative to the Federal coal program re common to all provinces. This portion of Section III is therefore, major input of this report. Impacts that are clearly unique to specific :ovinces will be discussed separately under the heading "Unique to certain :ovinces."

A. Impacts Common to all Coal Provinces

1. Off-Road Vehicle Travel

Several aspects of coal development including field reconnais-ınce, exploration, and development, can involve travel over terrain with-ıt road construction. Several types of specialized equipment for ORV trav-. are available. Impacts from the various types of wheeled or track ve-.cles are similar.

Immediate impacts of ORV travel are to the surface where low-growing getation is injured or destroyed. All ORV travel will impact vegetation. il and moisture conditions influence the ability of vegetation to recover

in the short run. ORV travel compacts soils and reduces percolation rates. Compaction impedes water infiltration permeability, gas exchange, and root growth (Lull, 1959; Steinbrenner and Gessel, 1955). Consequently, water is more apt to flow overland causing rill and gully erosion. Natural productivity of the site is lessened due to the restricted root growth. This, in turn, causes a loss in vegetal cover which also exposes more of the area to erosion.

Repeated travel over the same route or travel during wet weather can create ruts which concentrates surface water and leads to gully erosion. Factors adversely impacting watershed conditions lead to increased sediment loads and greater deposition in reservoirs and canal systems.

The operation of off-road vehicles can have seriously harmful impacts upon some wildlife species. Any concentrated ORV travel and long-term disturbance in some areas could impact on wintering big game, breeding animals or birds, and nesting raptors. Animals of the remote open plains and tundras are most susceptible to harmful disturbance. Experience in Alaska has shown aircraft harassment to cause abortion, desertion of young and other serious impacts on many species of large herbivores (U.S.D.I., 1972). Wintering animals can be driven from traditional winter ranges into areas of deep snow, or forced into heavy exertion at a time when all their energy and reserves are necessary for survival. Prairie chickens, sagegrouse, and other grouse species annually carry out courtship and breeding activities on traditional strutting or booming grounds. Excessive harassment of grouse in these areas can result in disruption of the breeding and nesting sequence and result in reduced nesting success.

Nests, young birds of ground and shrub nesting species and other small nimals are often directly destroyed by surface vehicles travelling cross-ountry.

ORV travel will cause limited disruption to extensive land use like razing and recreation. Unless protected, natural areas and areas having rimitive and wilderness values could be damaged by man and his machines. he natural esthetic values of scenic landscape will be adversely impacted.

Surface disturbance from ORV travel could cause direct damage to ar-heological features. The increased presence of man will lead to further ctivities of illegal artifact collection.

Historic trails could be damaged or obliterated by ORV use for coal xploration. The Oregon trail in Wyoming will be particularly vulnerable. istoric structures and ruins could also be lost.

2. Road Construction

In difficult terrain, road construction is a necessary part f the exploration phase of coal development. Access must be gained to ring in drilling and other equipment for evaluation of the coal resources. oad standards are very low with primary intent being only to gain access. ost roads are of a temporary nature with the disturbed surface being re-abilitated after exploration is completed.

Road and trail construction involves the grading (cutting and filling) f surface material (usually topsoil). Bulldozers are commonly used. The peration removes vegetation, including trees, creates cut banks and casts side deposits of soil and other disturbed material. In areas where small treams or gullies are not bridged, graded loose material is pushed into the drainage. Flood runoff commonly washes out the gully plug resulting in increased sediment production. Soil and vegetative disturbance exposes more area to the erosive forces of rain and wind. The road serves to concentrate runoff water and increase the erosion hazard.

Road construction initiates conditions condusive to erosion, soil compaction, landslides and influences soil organisms. Road and trail construction usually involves the removal of topsoil. If cast aside, this life sustaining material is often the source of stream sediment. Trails are often the forerunners of gullies due to compaction and concentrated surface flow of water.

Because populations of bacteria are highest in the surfaece soil, actions which remove or destroy the topsoil have adverse affects. Actinomycetes, fungi, lichens, and algae are vital to healthy soil. Many multi-celled soil dwelling animals depend upon plant debris and organic matter for thier food source. Removal of surface soil or destruction of the organic soil fraction will reduce these populations and adversely affect certain vertebrates.

Certain soil areas within the Coal Provinces are more seriously affected by disturbance than others. The most fragile soil area are badlands and rough-broken land. Badland areas have poor vegetal cover and steep slopes. Access across steep or rocky slopes requires more soil disturbance than across more gentle topography. More cuts and fills are required when constructing roads across steep terrain. Road cuts and fill slopes are exposed to erosive forces. Some shale areas weather into montmorillonitic clays which are easily eroded. Some shales are high in sodium salts which compound all the erosion and stability hazards (Sandoval, Bond, Power, and Willis, 1973).

Wildlife populations are adversely impacted by destruction of habitat and introduction of human activities into their habitat. Certain species such as elk, are more sensitive than others, but all wildlife populations are sensitive during certain times of the year, especially during critical periods of nesting, wintering, and breeding. These impacts vary considerably in severity depending upon the intensity of the exploration, the sensitivity and adaptability characteristics of the wildlife species involved and the stability of the biotic communities disturbed. The harmful impacts of roads are more severe than those associated with ORV travel due to the greater potential for causing long-term habitat loss or impairment.

Road construction results in loss of grazing crop, and timber production areas when roads are built across lands devoted to these uses. Impacts on agricultural areas tend to be of short-term than in timber areas.

Disturbance of the surface can result in loss of human interest values. Archeological and historical values maybe destroyed by surface disturbing activities. Additional roads will increase illegal artifact collecting activities. Items of geologic interest could be lost.

Road construction impacts on the basic character of landscape by removing vegetation and disturbing the soil thus changing the color, texture, and lines of the environment. In areas of open space, roads introduce strong lines into the landscape that are visible for many miles. Cut and fill areas are highly visible and a scar on the landscape that lasts for long periods of time under most conditions.

Travel on unpaved roads except during wet weather creats dust which ighly visible and impacts on the esthetics of the area. Extensive el under these conditions is adverse to the surrounding vegetation and ie existing land uses in the area.

3. Exploratory Drilling

Exploratory drilling is usually accomplished by use of a truck-ed drill. Systems utilizing two-inch drill pipe are sufficient to ob- the needed data on coal, soil, rock, and water. Exploration holes rilled either randomly or on a grid. The grid is determined by the t of data needed for development. Commonly, coal exploration drilling ne on mile or half-mile centers. More closely spaced holes are drilled evelopment of a mining plan.

ie drill site itself requires only enough level ground for the truck cupy and a place to turn around. In rough topography, some leveling drill site may therefore be needed. Compressed air is usually used excess water is encountered. Groundwater often necessitates wet ng and the need for slurry or mud pits. Depth of drilling is lly less than 1,000 feet. Only a small amount of cutting material ught to the surface by the drilling operation. Under normal opera- except where holes are left open for water wells, drill holes are d after evaluation.

ill holes can cause around water leakage between aquifers or to the e with resulting waste of water resources. Leakage between aquifers sult in: (1) contamination of good quality water due to leakage of uality water into the aquifer; (2) mixing of aquifers which may re-

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Preparation of the drill site where necessary results in the remova of vegetation, compaction of soils, and creation of unprotected cut bank. These factors encourage wind and rain erosion. Surface disturbing activities will in general degrade water quality.

The drilling operation increases and prolongs the disruptive factors evident to wildlife in the coal exploration phase. Toxic substances be used in the drilling operation, sediments or cuttings produced by drilli , could cause contamination of soil to vegetation adversely impacting wildlife habitat or water holes. Unplugged drill holes could be a hazard to humans, livestock, and wildlife.

Drilling can have beneficial impacts on wildlife. In arid areas, artesian wells with good quality can be of benefit to wildlife if allowed to continue flowing.

Drill site preparation impacts on other land uses because of the required surface disturbance. The major impacts will be on lands used for grazing, crop production, timber production, watershed production, and recreation.

Drilling programs usually result in little increased human activity and new business in the area. The new population is of a very temporary nature. In small town situations, the outsiders bring a degree of socia isruption to the community. The impacts are temporary and of a minor ature in larger communities.

The drilling program could adversely impact esthetic values by scaring cenic landscapes to create noise pollution. The surface disturbance can esult in loss of human interest values by endangering archeological, and istoric resources. Increased activities by man will result in further roblems of protecting these values.

4. Exploratory Excavations

In some situations where coal deposists are near the surface, r when bulk coal samples are needed, pits are excavated in the exploraion process. Heavy equipment is used to excavate the overburden and xpose the coal. This procedure results in considerable disturbance of he surface area. Vegetation is removed and soil material rearranged by he excavation process. Livestock forage to wildlife habitat will be lost y the operation. Erosion to downstream sedimentation can be expected. f pits are not covered promptly, they pose hazards to domestic animals, arge wildlife species and to recreationists. Excavated area are paricularly displeasing to esthetics. Usually, the overburden is replaced short time after the necessary sample or other information has been athered.

5. Development

a. Underground Mines

After issuance of a coal lease, development of the mine an begin. This generally involves more intensive exploration with impacts s previously outlined, development of a detailed mining plan which has

can create impassable barriers for fish. Unless road culverts are installed with consideration for adequate fish passage, some species could be adversely impacted. Channel changes may also develop velocities that fish cannot negotiate.

When active mine development begins, the immediate vicinity around the mine entrance becomes dedicated to coal production. This is primarily a change from extensive type land uses and open space to intensive use. Surrounding areas are generally in natural or primitive condition and will be adversely impacted. Mountain fishing streams that occur in many areas below potential underground mine developments could be adversely impacted.

Population impacts during the development phase are relatively significant due to the fact that development is likely to overlap facility construction. Workers will likely be primarily from outside the area and many will only be temporary residents. Influxes of these people will produce temporary overloading of school and all public services. Some workers from the development phase are likely to become permanent employees and carry on to the production phase. A portion of the group can therefore be considered quite stable as they establish themselves in the community after a reasonable time.

b. Surface Mines

Surface mine development normally begins with more intensive exploration, development of a mining plan, and the initial stripping operation. In block mining procedures, the initial strip material is stockpiled in an area where it will become the final fill material when the mine life is exhausted. Contour stripping begins at the outcrop or

no adverse impacts, and development of the necessary permanent mine components. These features include construction of permanent access roads, shaft slopes or drifts, and preparation for the surface plant. Development occurs underground, but this produces considerable coal and rock that must be disposed of or stored in the immediate vicinity. The rock material is used as fill for leveling areas near the mine entrance and for construction of roads. Any excess must be disposed in the waste area. Considerable surface disturbance can occur as the underground mine is being developed. In some cases it is necessary to relocate the surface drainage in the area.

Surface disturbing activities and depositing of fill material will result in loss of vegetation along with rearrangement and compaction of the soils. Soil organisms will be lost or adversely impacted. Unstable fill deposits will be created that are subject to erosion and failure. Overall, disturbance of the surface will contribute increased sediment loads to streams and drainages.

Development of the mine will adversely impact on wildlife by displacing animals and destroying their habitat.

Many big game wintering areas are located in the areas where mine-mouth operations are likely to develop. The extensive removal of vegetation and the soil disturbance accompanying construction may accelerate erosion causing sedimentation of aquatic habitats within the drainage. This can reduce the food production and spawning beds necessary for the survival of many fish species.

Road culverts and small stream channel changes during road construction

ge of the commercial quality coal. Overburden is moved away from the al opposite the direction mining is to proceed. Large equipment to be ed in the stripping is moved or assembled at the mine site in the devel- ment state.

In situations where the strip mines are planned in or near surface ainage channels, some stream diversion may be necessary. This operation volves a good deal of surface disturbance in the natural flood plan. If properly planned, the stream may attempt to return to its original urse. This causes excessive stream bank erosion and addition of sedi- nts to the stream. Should the stream channel return to areas of waste al or carbonaceous shale, surface water could be contaminated, thus wering the water quality in the downstream area.

The stripping operation removes revegetation in the stripped area and y result in covering of the existing vegetation with the initial strip terial. Stripping of the soil results in destruction of the soil aracteristics and mixing of the soil with the parent rock material. Re- val of the natural soil results in loss of important physical, chemical, d biotic content. The soil structure is pulverized decreasing its per- ability and causing compaction which increases the erosion potential (schmeier, 1971).

Stripping topsoil when it is in a wet condition, increases the magni- le of the compaction damage.

Populations of bacteria are highest in the surface soil. Actions ch dislocate the topsoil will adversely affect these populations. erotrophic microorganisms depend upon organic matter for food. These

organisms cannot live when the supply of organic material is interrupted. Stripping the soil of vegetal cover stops the supply.

Stripping activities destroy some wildlife species, eliminate wildlife habitat and creates barriers to their normal movement. The activities of man tends to displace certain species of wildlife that have difficulty in adjusting to his presence.

Stream channels diverted around mine areas can be obstacles to migration and death traps for small animals if left steep-sided. Stream diversion may also seriously reduce the streams potential for producing fish and other aquatic wildlife. The variety of habitats found in natural streams, i.e., riffles, meanders, pools, under cut banks, etc., are lost or reduced in channelized streams.

Initiation of mine development results in dramatic changes from existing uses which are likely to be grazing, crop production, watershed and extensive recreation. Due to the hazards in the strip-mining area, all other land uses on a given lease tract that is being developed are many times curtailed or effectively eliminated.

Labor requirements are not significant development of a stripping operation so minimal population change can be expected. Initial workers are likely to continue with employment in the production phase.

Development of a strip-mine has significant impacts on the esthetics of an area as it is the beginning of an operation that literally moves mountains. Loss of the vegetation and the accumulation of spoil piles are very displeasing to the eye. Extreme difference in color aand texture is evident between the spoil pile and the undisturbed area. Operation of the

equipment results in considerable dust, noise, and odors.

6. Mine Facility Construction

The mine operation requires construction of a complex of facilities including coal handling and loading equipment, crusher, storage bins, mine operation buildings, and a repair and maintenance shop. Power is needed at the site and is usually brought in rather than generated on-site. Water and sanitation are needed. Coal marketing facilities are necessary which may require a railroad spur or hauling on public roads. Slurry lines are employed on occasion, but are for long distance transportation so they are considered beyond the scope of this report.

If not already provided in the mine development, it is necessary to grade and level a large area for the plant operation facilities. Surface water drainages are often altered to gain space. Site preparation causes considerable surface disturbance, removes vegetation, shapes and rearranges soil and the landscape in general. These activities encourage erosion, contribute to soil instability, and sedimentation and pollution of streams or drainage areas.

Plant facilities have severe adverse impacts upon soil organisms and soils. The living soils per se, are destroyed if they are removed, reshaped, compacted, covered with concrete, asphalt, or thick layers of gravel.

Mine Facility Construction

Impacts upon wildlife by displacement and destruction of their habitat. Areas adjacent to the facilities are adversely impacted. Certain animals such as elk, may be displaced due to their inability to tolerate the influx

of human activity.

The extensive removal of vegetation and the soil disturbance accompanying construction may accelerate erosion and cause sedimentation of aquatic habitats within the drainage thus reducing food production and spawning habitat necessary for the survival of many fish species.

Roads with deep cuts, fences, power lines, and channelized streams can obstruct normal movements and migration of wildlife or place serious hazards in their path. Fences often cause high deer and antelope mortality especially in the winter. Many animals are killed on roads, especially when they are constructed in areas of high animal concentration or across migration routes. Power lines may endanger flying and perching birds through collision with wires while flying and electrocution when perching.

Construction requires large quantities of sand and gravel. Many times the only available supply is in or adjacent to streams. Removal from a stream destroys the fishery and adversely impacts downstream fish life.

Construction of the mine operation facilities and appertinent transportation and utilities is usually a major new intrusion in an area influencing current land uses and the environment in general. All existing land uses are impacted. Coal mining areas of the past have left many relics of mine facilities. If maintained properly, however, the mine plant facility intrusion can be modified to some extent. The character of the landscape is changed by the many new shapes and forms.

Railroads are a permanent commitment of land surface to this use. Fences constructed to keep livestock out of the area serve as a barrier

o some wildlife species. In the open space areas common in the coal re-
ions, railroads area a major esthetic intrusion. Large trestles, over-
asses, cuts, or fills, are features that have unpleasing visual impact.

The construction phase requires the highest level of labor requirement. any workers are transient workers that travel regularly from one job to nother. Consequently, they reside in temporary housing or in mobile omes. Efforts are made to hire local people for the less-skilled jobs. A gnificant level of temporary population influx can be expected for large perations. Large population influxes adversely impact all public services nd schools. An accumulation of mobile homes commonly results in outlying reas. Health and sanitation problems could arise. Problems in enforcement of regulations can be expected. Local populations have some difficulty in adjusting to large influxes of people and the accompanying social roblems. Economic factors like employment and income are beneficially mpacted by the construction phase.

Intensive construction activities will destroy all archeological eatures on the construction sites. Additionally, the increase in activity by men and machinery will cause pressure on the surrounding archeological resources in the form of illegal pot hunting, artifact collecting nd unregulated recreational use of the lands.

7. Production

a. Underground Mines

Impacts from underground coal extraction occur both nderground and at the surface. Removal of the coal disrupts the groundwater hydrology and creates a phenomenon known as subsidence. Both prob-

lems reflect back to the surface and influence land uses and various components of the environment.

The underground mining operations interrupt groundwater aquifers and cause collapse of overlying formations. Water infiltration and migration to the mine area may increase. In order to continue the operation, accumulations of water must be pumped to the surface for disposal. The quality of this water varies, but even in areas of low-sulphur coal in the west, mine water may be acidic and contains concentrations of trace elements and dissolved solids. Discharge mine water may contaminate surface streams and result in deterioration of water quality.

Mining can cause drainage of aquifers that contain good quality water. This drainage can occur in aquifers below the mine workings as well as above. For example, a confined aquifer which lies below the mine workings may have a potentiometric surface above the mine workings. If the impermeable beds separating the mine workings from the underlying aquifer are fractured during mining, extensive upward drainage of the aquifer could result.

Subsidence of the groundwater is common above many abandoned and in some cases, active coal mines. The amount of subsidence depends on many variables, including the mining method employed, the amount of coal removed, the thickness of the coal bed, the composition and strength of raw material overlying the coal and the depth of the coal seam below the surface. Subsidence can contribute significantly to the groundwater hydrology problems and limit use of the surface above mined out areas for a long period of time. Subsidence or collapse may damage or destroy any existing man-made structures and stop new construction. Subsidence in some areas may cause landslides, minor earthquakes, and increase erosion.

Underground mining methods that allow for collapse of overlying beds can cause an increase groundwater infiltration especially beneath stream channels. Streams may be diverted through the mine workings to a different surface drainage system resulting in flow loss in the originating stream. The disturbed surface resulting from collapse can also lead to accelerated erosion and increase sediment laid in streams, especially in hilly areas.

Subsidence can have adverse impact on wildlife populations. Some surface holes and cracks resulting from subsidence of mined out areas will be direct hazards to certain forms of wildlife. Small animals are particularly prone to falling into openings. Burrowing animals such as prairie dogs, ground squirrels, marmots, burrowing owls, etc., could be affected. Conceivably, species such as the "threatened" Utah prairie dog or the black-footed ferret could be harmed. Changes in surface flows and runoff patterns due to subsidence can alter available moisture situations influencing plant distribution and altering wildlife habitat.

Lakes, springs, ponds, and marshes capable of supporting various aquatic species can be either created or destroyed by subsidence. Loss of existing water in arid areas would be particularly disastrous to many wildlife species. However, creation of a dependable water hole or spring could benefit wildlife significantly. Increased soil erosion from subsidence would adversely impact downstream aquatic habitats subject to sedimentation and siltation. Spawning beds could be degraded and aquatic habitat reduced in productivity.

Most mining operation produces waste material in the form of bone, cob, and shale, that is either left underground or taken to the surface for disposal. Mine dumps are located in the vicinity of the mine-mouth on a slope if available. The site is highly visible to displeasing esthetically. Disposal site at active mines are devoid of vegetation and subject to evasion. Unless material is wet, the operation creates dust. Smoke from fires on the waste piles degrades the air quality in the area.

Transportation of coal to the surface is generally by conveyor belt or rail which creates minor dust and accumulation of fine coal material that must be disposed of in the waste disposal area. The crusher operation results in considerable noise pollution and coal dust which impacts on air quality in the immediate vicinity.

Underground mining creates a hazard to the health and safety of the mine employees. In 1970, there were 220 fatalities in underground coal mining. The fatal injury frequency rate in that year was 1.0 per million man-hours, 0.89 in 1971. New and more stringent mine safety regulations are reducing the accidents in mining.

Underground mining employs significant numbers of manpower. In rural areas where the Federal coal is generally located, a coal mine payroll can contribute significantly to the local economy, and provide many new jobs. Unless the new coal mine is in an active mining district, the additional labor force will have to migrate to an area when a coal mine operation develops. Influx of large numbers of people impact significantly on existing social, ethnic, economic, and political, cultural institutions. Schools and other public services are often overloaded to the point that

quality is adversely affected. If predevelopment planning by the local government or the company is not initiated, the existing population of an area will suffer.

Disruption to esthetic qualities of the environment is somewhat localized in underground mining. The manner in which waste materials are disposed of, impacts significantly on the form, color, and texture of the environment. The operation of heavy equipment that causes dust, noise, and to some degree, odors, is not esthetically pleasing in some of the environments in which coal mines will be operated.

b. Surface Mines

Coal deposits that lie near the surface are subject to mining by open-pit methods. The operation first involves removal of the soil and rock overburden to expose the coal seam. Huge equipment, usually drag lines or scrapers, are utilized for removing the overburden material. The coal is then removed by a large shovel and trucked to the coal processing facilities. The operation proceeds in parallel trenches or in block areas depending on the mining methods utilized.

The operation completely eliminates existing vegetation, disrupts soil structure, alters current land uses, and to some extent, changes the general topography of the area. The surface is temporarily dedicated to mining use until it can be reshaped and rehabilitated. Some areas respond well to the rehabilitation process while others are marginal.

Surface mining impacts significantly on surface and subsurface hydrology. The stream channels and flood washes are rearranged to accomodate the progression of the mining operation. Spoil material which is brought to the

surface in the mine operation is subject to leaching by runoff water. The leach water can be very acidic, especially in the eastern mines, and may contain abundant trace elements. The overall disturbance of the area can result in increased erosion and sediment load in the streams or flood washes in the area. Water quality can be adversely impacted in drainages below the mining area.

The mine process interrupts groundwater movement and commonly results in accumulation of mine water in the strip area. In order to continue mining, this water must be pumped from the pit area into the drainage systems. Quality of the water is variable, but under most conditions, it is acidic and contains numerous trace elements. The results may lower the quality of water below the mine development.

Removal of soil from the area to be surface mined destroys the natural soil characteristics by pulverizing the structure, disrupting the organic matter cycle, and by compaction. The microorganism population and nutrient cycling processes are upset by movement and redistribution of the soil. The general disturbance and compaction of the soil results in conditions that are conducive to the erosion.

The surface mining of coal causes extensive direct and indirect damage to wildlife, (Spaulding and Odgen, 1968). The impacts on wildlife stem primarily from the action of removing and redistributing tremendous volumes of material on the land surface. Some of the impacts are short-term and confined to the mine site; others have far-reaching, long-term effects. The direct impact on wildlife is the destruction or displacement of all species in the areas of excavation. The more mobile wildlife forms like

game animals, birds, and predators, etc., will leave these areas. The mo: sedentary animals like invertebrates, many reptiles, burrowing rodents, burrowing owls, ferrets, badgers, etc., may be directly destroyed. If streams, lakes, ponds, or marshes are filled or excavated, fish, aquatic invertebrates, amphibians, etc., will be destroyed. Numerous lakes and ponds are created by surface mining.

Extensive and long-lasting impacts on wildlife are due to habitat impairment. The life requirements of many animal species do not permit them to adjust to disturbances created by men and machines. This is impairment of the habital component called "living space". The degree to which a species or an individual animal will tolerate man's competition for space varies. Some species will tolerate very little disturbance before moving. Instances, where a particular habitat is restricted, such as a lake, pond, or primary breeding area, the species could be eliminated. In some instances, secondary impacts are evident. Big game displaced from crucial winter range may be forced to use adjacent areas already stocked to carrying capacity. This overcrowding results in degradation of the remaining habitat, lowered carrying capacity and, potentially, greater losses to the population than the originally displaced animals.

Degradation of aquatic habitats has been a major impact from surface mining. It may be apparent many miles from the mining site to some degree. Silt and sediment pollution is common with surface mining. Research by Spaulding and Ogden in 1968 in Kentucky, indicated sediment yields increased 1,000 times their former level as a direct result of strip-mining. Approximately one acre-foot of sediment is produced annually for every 80 acres of disturbed land. The effects of silt and sediment on aquatic wildlife vary with the species and amount of pollution. These pollutants can kill fish directly, bury spawning beds for important species like trout and salmon, reduce production of aquatic organisms, reduce light transmittance, alter temperature gradients, fill in pools, and spread flows, etc. These changes destroy the habitat of some species and sometimes enhance the habitat for undesirable species.

Existing conditions are already marginal for some of the cold-water game-fish and anadramous species. Sedimentation of these waters can result in their elimination. Heaviest silt and sediment pollution to a given drainage normally comes within 5 to 25 years after mining, (Spaulding and Ogden, 1968). In some areas, unrevegetated spoil piles continue to erode even 50 to 65 years after mining.

The presence of toxic waste materials exposed as a result of surface mining can affect wildlife by eliminating habitat and by causing direct loss of certain species. Lesser concentrations can suppress productivity, growth rate, and reproduction of many aquatic species. Acids, dilute concentrations of heavy metals and extreme alkalinity can cause severe wildlife damage in some areas. The duration of toxic waste pollution can be long-term. Estimates of the time required to leach exposed acidic materials in Appalachia range from 800 to 3,000 years, (Spaulding and Ogden, 1968).

In certain situations, surface mining can have beneficial impacts on some wildlife. Where large, continuous tracts of forest, bushland, sagebrush, or grasslands are broken up during mining, increased edges and openings are created. Preferred food and cover plants can be established

in these openings to benefit a wide variety of wildlife. Creation of small lakes in the strip area can also be beneficial. These waters may become habitats for a variety of wildlife and sport fish; others as aquatic habitats, (Waller, 1967). These may require various levels of habitat enhancement and management to be of significant wildlife value. The open-pit mining operation and coal transportation facilities are fully dedicated to coal production for the life of the mine. Existing land uses such as grazing, crop and timber production, are eliminated from the mining area until rehabilitation processes have been completed. Timber production could be adversely affected for a long time period due to the lengthy production cycle. Intensive land use areas like urban and transportation systems are not normally impacted by mining operations. If mineral values are sufficient, these improvements may be removed and replaced in an adjacent area.

Surface mining operations often result in creations of a vertical highwall as high as 200 feet. Such a highwall may result at the end of a surface mining operation where stripping becomes uneconomic or when a mine reaches the property line that is the extent of their current lease or holdings. These highwalls are hazards to man, to wildlife, and to domestic livestock. It may impede normal wildlife migration routes. In Appalachia, there are over 20,000 miles of highwalls created by coal mining. In some cases, highwalls circumscribed entire mountains, (Spaulding and Ogden, 1968).

The impact and final shape of highwalls is similar to that of highway cuts. They can be designed to be esthetically pleasing, or they could be dangerous or form a barrier. The impact of the man-made slope will vary with the natural terrain and surroundings of the area.

Coal mining may impact other mineral development in the same site. There may be surface sand and gravel deposits, bentonite beds or commingled uranium. Drilling and blasting could impact an oil or gas reservoir.

Natural fires have occurred in coal beds underground. When coal seams are exposed, the potential for fire is increased. When coal is exposed to sunlight, the dark material absorbs heat. If pyrite in coal is oxidized, this will also raise the temperature of the coal. Weathered coal (smut), can also increase the ground temperatures, if it is left on the surface. The weathered, dirty or poor quality coal is usually buried in the rehabilitation of a coal mine.

Surface mining operations are considerably less hazardous to mine employees than underground operations. In 1971, 24 fatalities were recorded in the United States in open-pit operations, a rate of 0.46 per million man-hours; considerably less than underground mining (NCA, 1972).

Due to intensive mechanization, surface mines require fewer workers than underground mines on an equivalent production basis. Population influences are therefore not as significant. In low population areas, however, local populations cannot provide the needed employee so there is migration to the area because of the new jobs created by the new mine. Unless adequate advance planning has taken place on the local government or company level, the new population will cause over-crowded schools and demands to public services that cannot be met. Some social instability will be created at the local level.

The impact of surface mining on geological features of human interest

could be extreme in the strip-mine area. Geomorphic and geophysical features and outstanding scenic resources would be sacrificed by issuance of a lease and subsequent mining. Paleontological values would be endangered due to the extremely disruptive activities of blasting, ripping, excavatin etc. Most values would be destroyed before the existence of specimens could be noted.

Stripping of overburden will eliminate and destroy all archeological and historic features unless previously removed. The increase in activity will cause increased pressure on the surrounding archeological resources in the form of illegal pot hunting and artifact collecting and unregulated recreational use of the lands.

The extraction of coal by surface mining disrupts virtually all esthetic elements of the landscape. The alteration of land form impose strongly conflicting configuration. New linear patterns appear as the material is extracted. Different colors and textures are exposed as vegetative cover is removed and overburden dumped to the side. Dust, vibration, and odors are created adversely impacting on sight, sound and smell. The grand scale of the operation impacts significantly on the quality of the environment.

8. Beneficiation

The process of coal beneficiation involves the installation of additional plant facilities to upgrade coal quality by separating out the low-quality material. The process can utilize air or water for separation. Waste material is produced which is disposed of in the immediate vicinity. Under some conditions, the quantity of waste material produced, is significant.

The air separation process produces dry waste material that contains carbon, trace elements of sulphur, and other material. Unless special disposal precautions are taken, this material can become dust for the surrounding areas. All types of flora and fauna can be adversely impacted in the fallout area. The waste pile is also subject to erosion and leaching. Adjacent land and drainage areas could become polluted by contaminants produced in the beneficiation process, unless precautions are taken.

When a water separation process is employed, a slurry impoundment is utilized for storage of the fine waste material and recycling of evaporation of the water. The slurry material may contain concentrations of sulphur and other elements that could be leached into adjacent drainages or underground aquifers and lower water quality. Storage reservoirs such as this are subject to breaching or overfilling or by floods. Contaminated material would then be carried to streams and drainages adversely impacting the land and water resources.

The fine slurry material in the pond area must be wetted or covered at all times or it is subject to becoming airborne under windy conditions. For this reason, abandoned pond disposal areas must be covered and revegetated to prevent wind and water erosion.

Disposal of waste material from coal beneficiation is important to wildlife because these materials could cause chemical and sediment pollution of terrestrial and aquatic wildlife habitats. Use of the water process may cause excessive water demands that could lower water tables and dry up small lakes, ponds, or small streams if the water comes from local

sources. In arid areas all water sources may be critical to wildlife. Loss of these sources would destroy aquatic species and many terrestrial species.

Unless waste is returned underground or to the strip-pits, it could have long-term adverse impacts unless properly rehabilitated. When deposits are dumped on slopes, they tend to be very unstable. Land slides may occur and are a hazard to anything in the immediate area of the slide. Fires are a problem in the waste disposal area, contributing smoke to the atmosphere adversely impacting air quality.

9. Coal Marketing

Coal marketing may involve transporting coal for relatively short distances to mine-mouth power facilities by railroad, truck, or conveyor systems, or long-haul transportation. This report is primarily concerned with the short-distance transportation. All types of transportation systems, even cars, produce noise, air pollution as well as create safety hazards. Coal dust can be produced from the moving carriers and accumulate along the transportation route. Unless the trucks are traveling on paved or wetted road surface, dust is stirred up. Air and land pollution is esthetically displeasing and can adversely impact on surrounding vegetation, wildlife, and land uses. The movement of heavy equipment, and trains, plus noise, and human activity along roadways or railroad tracks can drive some wildlife species out of the area. Roads and railroads commonly cause high direct animal mortality and right-of-way fencing can hinder big game migration especially if the fences are net wire.

Energy for transportation is usually provided by diesel fuel used in trucks, and locomotives. The engine emissions contribute to air pollution

and produce considerable noise just like a car or truck would anywhere else. Transportation systems are a permanent commitment to this land.

10. Rehabilitation of Disturbed Areas

The disturbed area rehabilitation program involves the shaping of the spoil pile in the case of strip-mine operations, return of available topsoil, and planting of vegetation. The rehabilitation process has some land disturbing activities, but the outcome is intended to have beneficial impact on the environment. Soil and moisture conditions are the major variables influencing the success of a program.

Bulldozers and scrapers arrange the spoil to a desired slope and contour. Current concepts entrail returning the site to as near as possible to its original form. Hills and valleys are created to provide the same variety in the landscape as occurs naturally. Large scrapers return the available topsoil to the area in preparation for receiving the seeds or transplanted species. Some artificial irrigation may be necessary to enable a rapid response to the revegetation program.

Land disturbance in rehabilitation creates a situation conducive to wind and water erosion. Soil is compacted by some of the operations. Sediment levels in streams can be temporarily increased by the activities. Environmental impacts from the rehabilitation process are short-term tradeoffs that are necessary to reestablish vegetation and hopefully return a site to its former productive capacity, its original vegetative cover, and former land uses. Unsuccessful rehabilitation may cause more extensive environmental degradation than might be evident if there were no rehabilitation program. Nature sometimes cures her own wounds.

When mined land rehabilitation is not accomplished immediately after mining, natural plant and animal successions begins. Rehabilitation efforts beginning many years after some wildlife species have reestablished naturally will cause a temporary setback or loss of those secondary ecological successions.

Rehabilitation aimed at establishing an entirely different ecosystem in terms of vegetation, topography, and land use may affect wildlife. Some lands could be rehabilitated for intensive human use; others could be rehabilitated especially for wildlife or for intensive agricultural. The types of wildlife which would be able to survive in each situation would vary greatly.

B. Impacts Unique to Certain Provinces

Environmental components may vary significantly from one coal province to another causing differing impacts. Certain localized conditions exist that can best be explained examining the situation in a specific manner. This section of the report is intended to bring into focus the more important variations that are evident in coal development. Their consequences are discussed by coal province.

1. Pacific Coast Coal Province

Northern Alaska Coal Field

The Northern Alaskan field offers a unique situation due to the magnitude of the vast reserve of high quality coal, the fact it is adjacent to the sea and the magnitude of environmental, economic and technological problems with its development. The region is isolated with no developed access. Climatic conditions are extreme with permafrost extending several hundred feet deep during most of the year; but during the sum-

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The settlement and development of this region offers challenges for technology and for preserving the fragile tundra environment. Development will be many times more expensive than at lower latitudes. Perennial water sources are very limited and any land disturbing activities will contribute to water pollution. Life is known to exist in this northern region as a delicate balance. Minor disruption will cause significant problems to flora and fauna. Rehabilitation will be difficult with minimal success in the short run. Long lasting effects on erosion and stream sedimentation can be expected.

Since wildlife populations are highly significant in the tundra regions, the loss of habitat is of particular concern. The rate of tundra vegetation recovery from disturbance is very slow. On an area in western Alaska where lichens -- an important food of caribou -- were removed from the ground surface, they recovered to only two-thirds to their former abundance after 43 years, (United States Department of the Interior, 1972). Disturbance or loss of aquatic habitat can occur due to the demand for gravel used in construction. Streams are the principal gravel source in the tundra. Fauna displaced from their territory cannot be expected to find suitable new habitat unoccupied.

Disturbances due to human activity are significant in the tundra region because of the unusual aspect that larger animals have no place to hide. Air traffic for mineral exploration, cargo and passenger hauling and recreational flights is a source of harassment to animals on the tundra.

Threatened species or those whose status is undetermined, such as the polar bear, grizzly bear, and wolverine, are paricularly vulnerable to increased activity.

Harassment can also be serious from mechanized ground equipment. Disturbance to nesting waterfowl is a problem in some areas. Nest abandonment on a grand scale could be very detrimental. The coastal beach areas are especially important to waterfowl during the summer, for caribou grazing and for fox denning.

Anadramous Fish

Anadramous fish and species dependent upon brackish and saltwater estuaries, beaches, and mudflats can be severely impacted from silt, sediment and toxic material pollution. Many of these species support important commercial operations in addition to sport and recreation use.

2. Rocky Mountain Coal Province

Mountain Subdivisions

The many factors which make the Rocky Mountain area inviting to the recreationist and tourist has created an added land use -- mountain recreation and rural residential community development. Subdividing is taking on major proportions in mountain areas. Patented mining claims and homestead lands are the primary source of private lands being subdivided. These tracts are often intermingled with Federal lands administered by the Forest Service and Bureau of Land Management. In the Colorado mountains, valleys along over 380 rural subdivisions involving some 285,000 acres are located adjacent to public lands. Coal lands within the San Juan River and southeastern Uinta Coal Regions of Colorado are specifically affected by these developments. Under mineral patent and homestead laws, leasable minerals are reserved to the United States. These minerals, including coal, are therefore subject to leasing. Underground mining may cause subsidence to adversely impact an area that is developed or planned for building summer homes and resorts. Generally, the coal fields around the Uinta field are very deep underground workings with a minimal chance for subsidence.

Game Populations

A major concern in the Rocky Mountain Coal Province is coal development and its impact on game populations. The area is the major producer of moose, elk, mule deer, desert and Rocky Mountain Bighorn and sage grouse, in the lower 48 states. Antelope population is also of primary importance. Significant adverse impacts of concern include:

- destruction of crucial big game winter range
- interference with big game migrations
- destruction of sage grouse breeding and nesting complexes
- long-lasting effects of habitat loss in arid cold desert areas
- disruption and displacement of big game in winter concentrations
- deterioration or destruction of highly important desert water sources.

The large populations and winter concentrations of elk and mule deer in the Green River and Uinta regions can be disrupted seriously by coal mining operations. Underground mining, however, will not have as great an impact as surface mining. Relatively small winter habitat losses could assume very serious proportions due to existing problems of insufficient winter range, especially in the Green River and White River drainages.

This is extremely critical when considering specific geographic areas such as the Piceance Basin area of Colorado which is the winter range for the largest migration mule deer herd in the United States.

Antelope and sage grouse populations and winter ranges would be most seriously impacted by surface mining in parts of the Green River and Wind River regions.

In various locations scattered throughout most of this province, the advent of extensive highwalls, fenced roads, railroads, etc., would cause particularly heavy wildlife losses and habitat damage by interfering with major deer, antelope, and elk migrations. Migrations are more common and usually more necessary in the northern parts of the province, so, impacts there would be more severe.

Much of the coal province is rough, arid cold-desert cut by canyons. Soils are shallow and poorly developed. Due to this harsh environment, impacts on wildlife habitat has long-term implications. Restoration of lost habitat on a given site may take 20 to 30 years.

The shortage of water in the arid portion of the province magnified adverse impacts. Loss or degradation of a particular water will usually adversely impact wildlife populations over a large area. Conversely, when water sources are created by mining activities, they often prove highly beneficial to wildlife.

Wild Horses

Since much of the wild horse habitat in the Rocky Mountain Coal Province is underlain by coal, the lease and development of this resource will impact on horse populations. The direct coal development activities along with increased human population in the coal region will disrupt present distribution. Wild horses will concentrate more in areas where man's activities are restricted.

The level of development will influence significantly the intensity of impact on the wild horses. Present populations can likely sustain themselves with low-level development without adverse impact to the range resource. Higher development levels will restrict their range and lead to overgrazing. In the long-term, the range resource could deteriorate adversely impacting watershed condition. Increased erosion and sediment contribution can be expected.

Kaiparowits Plateau

The Kaiparowits Plateau in extreme Southern Utah offers a highly controversial and complex resource management question. The plateau has more than one million acres underlain by coal. Total reserve has been estimated to exceed 15 billion tons. The coal is thick bedded, high quality and low sulfur. Recovery will be by underground methods. Present leases cover nearly 125,000 acres.

Adjacent to this vast energy reserve is the Glen Canyon National Recreation area encompassing scenic Lake Powell. Annual visitation at this time exceeds one million. Projections for 1985 anticipate two million visitors. Surrounding National Resource lands have many significant scenic, natural and primitive values important to recreationists.

Two large power generating complexes have been prepared utilizing Kaiparowits Coal Development of the coal and its utilization to produce power without deterioration of the valuable recreation resources offers a challenge to technology. Water storage and terrain in the upper Escalante River area could adversely impact the scenic Escalante Canyons Natural area. Plant emissions could adversely impact other nationally significant recreation areas. National Parks and monuments within 100 miles include: Grand Canyon, Canyonlands, National bridges, Rainbow Bridge, Capital Reef, Bryce Canyon, Zion, and Cedar Breaks.

Due to the remote location and sparse population, development of the proposed power complexes at suggested levels could lead to a "new town" with maximum population projected up to 20,000. A population increase of this magnitude is 800 percent over the 1970 level in Kane County, Utah. Significant impact on all components of the environment could result from this urbanization.

Oil Shale

The Rocky Mountain Coal Province contains the most extensive deposits of oil shale and associated minerals in the United States. Coal beds underly the valuable oil shale deposits. The thicker seams and higher quality coal is located at great depths (over 4,000 feet). Under present technology the coal is not economically recoverable. The likelihood of coal mining preceding oil shale development is therefore extensively remote. Impact on the oil shale resource from coal development is not anticipated.

Exploration of the coal could, however, cause problems in localized areas. The Piceance Basin in western Colorado has a large aquifer of fresh and saline water above the valuable oil shale deposit. Drilling operations and improperly plugged holes would result in exchange of water between aquifers and possible storing of large quantities of water in the mineralize areas. Water could also move to the surface by artesian flow and cause problems in an active mining area.

The interrelationships between the oil shale and coal resources are not fully understood. It is recognized, however, that development of one cannot proceed without conservation of the other.

3. Northern Great Plains Coal Province

All of the coal regions in the Northern Great Plains Coal Province are in semi-arid areas. Consequently, any impacts on hydrology are especially harmful. Contamination or drainage of usable aquifers has severe impacts because there is seldom an alternate source of water available to users. Disturbance of the ground surface, though limited in underground mining, causes increased sediment loads in streams. This in turn reduces the quality of downstream users and the usable life of reservoirs. Where underground mining methods in hilly terrain result in collapse of the ground surface, the resulting increased sediment loads to streams can be especially severe. Most streams in this province are intermittent or have very little flow during part of the year. The size of the streams limits their ability to dilute.

Release of wastes and sediment during high flow periods can have adverse effects on important alluvial aquifers downstream from the operations. Fine silt and clay from coal tailings can plug up the surface of the flood plain reducing infiltration, and trace elements leached from the coal debris can contaminate the alluvial aquifers. The coals in this province generally contain little pyrite, and the soils and stream waters are often highly alkaline. Acid mine drainages would not be as great a problem as in other provinces. Trace element concentrations can be expected to persist in mine drainage waters.

Game and Waterfowl Populations

The Northern Great Plains Coal Province has significant game and waterfowl populations. The fringe and mountainous areas have many species common to the Rocky Mountain Province. Production is not as extensive, however, except for antelope. The large antelope herds of this province are susceptible to extensive habitat losses from surface mining, mine-mouth industrial complex construction and construction of road, railroad, pipeline and canal systems. These transport systems can be expected to cause significant losses to antelope due to interference with movements and proper use of available winter habitat.

Destruction and drainage of aquatic habitat, and disturbances of breeding and nesting waterfowl could cause losses of thousands of waterfowl annually in the Fort Union coal region. Parts of this region are in the famous "Prairie pothole" waterfowl production area where duck producing potholes may average 30 per square mile.

In the wide open expanses of grassland common in this province, the occasional islands of rough topography, open timber, and riparian woodlands have very high food and cover values for wildlife. Many species could not survive in the grasslands without these relatively limited areas. Destruction of these habitats during surface mining and related operations will result in losses among these species. In North Dakota, the woody draws area considered some of the highest quality wildlife habitat in the State (Morgan, 1973). North Dakota ranks last among the fifty states in woodland acres.

Parts of the Powder River Basin and Fort Union coal regions are within the presently known range and adjacent to the highest known concentration of the endangered black-footed ferret. Coal mining and related activities could eradicate local populations and severely reduce the existing populations.

Small elk herd such as those found in the Powder River breaks of Wyoming and the Bull Mountains of Montana will probably be driven out or reduced to a few scattered animals with extensive coal mining and related activities in these areas.

4. Interior Coal Province

Wildlife Populations

The primary impact in this province from leasing to mining of Federal coal is the potential contribution to acid mine drainage. Toxic waste materials exposed to mining operations could contribute to chemical pollution of the highly productive aquatic habitats in the Arkansas River

Drainage. Instances are known where waters emerging from underground mine are highly acid, destroying aquatic life downstream, (Hendricks, 1973).

C. Factors Affecting the Completeness of Coal Extraction

Many factors can affect the completeness of coal extraction, but a factor having great impact on the environment at one mine may have little or no impact at another. An objective of Federal coal leasing is to obtai maximum recovery of Federal coal with minimum impact on the environment. O factor can influence another, and the factors that affect the completeness of coal extraction include: mining method, depth of coal seam(s), thickness of coal seam(s), distance between coal seam(s), condition or type of roof and floor, safety, marketability, supervision, mining equipment, and productivity.

Completeness of recovery can be expressed as the percentage of the coa recovered from a particular seam within a designated area. Or it can be expressed as the percentage of coal recovered from the deposit or resource affected by mining. The first method of expression is the one in general use, and when it is used, the percentage recovery from strip-mining will average about 90 percent. Where underground methods are used, the Bureau of Mines has determined the recovery will be 57 $\pm$ 1.7 percent (95 percent confidence limits), (Lowrie, 1968). While the percentage of recovery from auger mining varies from 20 to 50 percent, the average is about 25 percent.

Expressing the percentage of recovery as the percentage of coal recovered from a particular seam within a designated area when other seam(s) are damaged or destroyed will result in an enormous figure. It is erroneous because other seam(s) damaged or destroyed are partially or completely lost. In the interest of conserving our coal reserves, percentage recovery should show any seams lost in part or in full. Then a mining plan submitted for a Federal coal lease that allows such losses, without good reason, should not be approved. Often a modification of the mining plan could reduce or eliminate such loss of coal. Three important factors on which such a determination can be based are economics, mining methods, and marketability.

Although a controversy over the definition of coal reserves exists, for this Programmatic EIS recoverable coal may be mined from seams as follows: Coal seams of 28 or more inches in thickness for the Eastern and Interior Province: and for all other provinces, those seams of bituminous coal, 42 or more inches in thickness; or those seams of sub-bituminous or lignite 60 or more inches in thickness. There will be exceptions, but such exceptions should be considered only on the individual mining plan.

Up to 90 percent of a single seam of coal has been extracted by underground mining methods from a designated mining area, but such is an exception that can happen only when conditions are ideal. On the other hand, when it is necessary to hold subsidence to a minimum for the safety of the miners and/or to protect the land surface, as little as 20 percent of a coal seam may be extracted. The depth and thickness of the seam, condition of the roof and floor, and the available mining equipment are the main factors that influence underground recovery. Regardless of these factors, if surface subsidence must be prevented or minimized, completeness of extraction will be minimal. For minimal extraction, the probable method would be room-and-pillar with small rooms and large pillars, and no pillar removal. Such could also be used to protect overlying coal seams for later removal. However, once mining is suspended in the lower seam for the purpose of mining, the upper seam(s), additional recovery from the mined area of the lower seam is often difficult if not impossible.

Degree of difficulty in multiple seam mining varies inversely as vertical distance between the seams mined. Mining may be possible in seams separated by a 40 feet interval, while at an interval of 150 feet to 200 feet, the problems may be minimal.

Supervision and productivity have relationships to each other and can affect recovery. Haphazard supervision of development and production, such as having too many openings, leaving broken coal in mined areas, or not adhering to safe mining limits, can reduce recovery.

Coal recovered within the mining area from a single seam or multiple seams by surface mining will range from about 80 to almost 100 percent. The mining area is limited by the economics of overburden removal. With few exceptions, up to 150 feet of overburden can be removed at an area stripping operation before equipment limitations are reached. Where contour stripping is used, maximum overburden thickness, attributed to equipment limitations, is generally about 100 feet. The exception for contour mining is when the head-of-hollow method can be used. Its limitations, beside economics, is the quantity of spoil that can be placed in the hollow(s). When a coal seam or multiple coal seams are of sufficient thickness to allow profitable extraction beyond the limits of stripping machinery, other methods such as the open-pit method can be used.

Supervision and productivity at surface operations, as in underground mining can affect recoverability. Uncovering coal too far in advance of its removal can cause slacking. Spoil not placed beyond the seam or allowed to slide back upon the coal requires leaving a fender of coal to protect the remaining coal. Improper cleaning of the top of the coal seam causes waste. Highwall sluffing onto coal seams can result in unrecovered fenders of coal.

Completeness of recovery in both underground and surface mining is reduced when part of the coal seam must be left in place to prevent loading equipment from sinking into the floor. In underground mining, it is reduced when part of the coal seam must remain in the roof to gain the necessary roof support.

Marketability governs whether the coal is mined or left in place; determining factors include calorific (heat content), ash, moisture, sulfur, and sometimes sodium content. Overlying coal seams are often bypassed to mine a deeper seam with either one or a combination of a high calorific value, low ash, moisture, sulfur, and/or sodium content. When this occurs and the lower seam is mined using underground mining methods, the overlying beds may be damaged by subsidence to the point they cannot be mined. When surface methods are used, the overlying seams of marginal or sub-marginal value may be discarded with the overburden.

The low percentage of recovery from auger mining is attributed mainly to the fact that no subsidence can occur while augering is being done. If it should occur, neither the auger or the coal can be removed from the hole. Therefore, to assure subsidence will not occur, a large part of the coal

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The low percentage of recovery from auger mining is attributed mainly to the fact that no subsidence can occur while augering is being done; if it should occur, neither the auger or the coal car be removed from the hole. Therefore, to assure subsidence will not occur, a large part of the coal remains between the holes and in the roof and floor for support. The amount left depends upon the condition of the roof and floor. Where the roof is hard and dense, and the floor is sound more coal can be extracted than where the roof cannot support itself across short spans and/or the floor is prone to swelling.

Because of equipment limitations, the maximum size of an auger hole is about eight feet in height and 200 feet horizontally. This reduces the recovery percentage in seams of greater thickness. Because of equipment limitations and the terrain, most of the auger mining has been done in the Eastern and Interior Provinces where thick coal seams are not as prevalent as they are in the western United States.

Safety, supervision, productivity, and marketability at auger mining operations will affect the recovery of coal, the same as where other mining methods are used.

D. <u>Coal-Fired, Mine-Mouth, Electricity-Generating Plants</u>

Secondary impacts include the potential coal-fired, mine-mouth, electricity-generating plants that could be built if coal resources are leased, and the overall social and economic impacts that can be expected from all aspects of coal development and utilization. In terms of significance, these impacts will be among the more significant resulting from development of the coal resource.

The environmental impacts from coal-fired, power-generating stations have been identified in the Southwest Energy Study and in numerous environmental impact statements on specific plant proposals. Some of the potential impacts from these type developments include:

(1) Emission of particulates that will reduce visibility under certain atmospheric conditions. Impacts could be minor or relatively intensive depending on the level of development.

(2) Emissions of concentrations of SO_2 that could be hazardous to plant and animal health.

(3) Emissions of NO_2 and other gases with undetermined impacts.

(4) Emissions of vapor from water cooling towers and ponds, creating visual pollution and impacting on esthetics.

(5) Emissions of trace mineral elements including Mercury, Lead, Cadmium, Florine, Boron, and Manganese.

(6) Consumption of vast amounts of water resources, some of which will occur in regions where supplies are limited. This action will cause widespread loss and deterioration of aquatic wildlife habitats.

(7) Change to intensive land use of significant acreages now in natural condition, affecting upon open space and other esthetic values.

(8) Construction of new power transmission lines over extreme distances to power marketing centers. New corridors will be required that will introduce power lines to new areas and adversely impact on current land uses and the landscape in general.

(9) Increased human concentration and activity in the plant area and in the general region that will cause competition between man and wildlife for food, cover, water, and living space at many levels.

(10) Thermal pollution to streams, rivers, and lakes, that will impact aquatic habitat and result in changes to species composition. Impacts will be negative and positive depending on one's point of view.

(11) Construction of new reservoirs and water conveyance facilitie that will eliminate existing land uses, but create beneficial water facilities.

(12) Disturbance of archeological and historical sites at the plant site and along transmission and transportation routes.

Impacts here are greater than those at the site. Roads and better access - more pressure and pot hunting. If a transmission route or plant site is in a valley, for instance, the impact is not an archeological/historic site on the transmission line right-of-way - it impacts the whole valley!

Impacts increase expotentially with improvement of access, sensitivit of sites, rarity of sites, recorded knowledge of culture in that area.

E. Potential Extractive Techniques

Potential extractive techniques are still in the experimental stag, and by 1973 standards it does not appear that these techniques will be the source of large amounts of coal or energy in the near future. If they are developed to a commercial scale, they will have impacts on the environment Regardless of the technique used, all will cause surface subsidence, and from what is known about them, impacts from surface subsidence should be similar to those caused by underground mining.

In addition, any of the techniques used will require construction of a surface plant. With the exception of the completely automated underground mining technique which will have a mine plant similar to any underground coal mine, all techniques will require pipelines. Such pipelines will probably run from a central plant to holes drilled into the coal seam(s). As the mining process continues, the network of pipelines and recovery holes will cover a progressively large area. Ultimately, an operation could cover several square miles. The extensive drilling program and pipelines network will necessitate roads. These roads are envisioned as main hard surface roads, with one road crossing, the mine property in each direction; laterals, probably graveled, extending from the main roads; and temporary roads, probably more like trails, extending from the lateral roads.

Impacts on the geology, topography, and hydrology will be greatest from the subsidence. Socio-economic impacts will not be as significant because the operations will not be labor intensive. Surface plant disturbance from the roads and pipelines will intensify the impact to soils, vegetation, wildlife, land uses, open spaces, esthetics interest, and human value. In four of the eight potential extractive techniques, the process will utilize gases that could pollute the air unless proper precautions are taken.

The use of the completely automated underground mining techniques or the technique of flushing solid coal to the surface could create a waste pile on the land. Its size would depend upon the quantity and type of impurities in the coal, and the amount of coal produced. The waste disposal technique and rehabilitation program will be important aspects of mitigating the impact of this type coal recovery.

F. Social and Economic Impacts

The overall social and economic impacts from coal development and utilization are dependent on the level of development that will be attained. The potential mine-mouth generating plants have been identified in various studies concerning western coal resources.

The North-Central Power Study of 1971 identified 42 potential mine-mouth plants over 1,000 MW in generating capacity. These potential developments vary in size from 1,000 to 10,000 MW each. They include 21 sites in Montana, 15 in Wyoming, 4 in North Dakota, 1 in South Dakota, and 1 in Colorado. In total, the potential plants have a combined generating capacity of 209,000 MW.

The Southwest Energy Study of 1972 identified 11 potential plants, or additions to existing generating stations. The combined generating capacity projected to year 1990 exceeded 30,000 MW. Power generation sites include 4 in Utah, 3 in New Mexico, 2 in Nevada, 1 in Arizona, and 1 in Colorado.

In addition, other potential sites have been identified in the west since the above studies were completed. Alaska is also known to have several potential plant sites. The potential coal-fired power-generating capacity must therefore be termed as exceedingly great based on evaluation of the coal and almost complete allocation of uncommitted water resources to electric power development.

To gain perspective of the social-economic implications of coal development and mine-mouth power generation, one must examine an increment of capacity and project the various implications or factors. A 1,000 MW unit is assumed for demonstration purposes. There are innumerable variables that affect a coefficient of 1,000 MW, so a range of values are provided.

1,000 MW Capacity Will Result In:

Coal Production	3.0 - 3.5	Million Tons/Yr.
Water Consumed	8,000 - 15,000	Acre Foot/Yr.
Direct Construction Employment	4,000 - 6,000	Man Years
Total Construction Employment 1/	7,000 - 13,000	Man Years
Direct Operation Employment	250 - 350	Man Years
Total Operation Employment 1/	500 - 700	Man Years
Direct Population Impact	750 - 1,100	Persons
Total Population Impact 1/	1,500 - 2,500	Persons
Direct Construction Payroll	60 - 100	Million Dollars
Total Construction Employment 1/	90 - 150	Million Dollars
Direct Operation Payroll	3 - 3.5	Million Dollars/Yr.
Total Operation Payroll 1/	5 - 5.5	Million Dollars/Yr.

1/ Direct and Induced - Data from Southwest Energy Study, North-Central Power Study, and various existing generating plants in the west.

The various counties that will receive the major direct impact from the proposed generating plants are listed in Table 41. Examining the 1970 county populations, personal income or employment, it is evident that even a 1,000 MW unit would impact significantly on many of these sparsely populated areas. In an area such as Powder River County in Montana, installation of a 2,000 MW generating station would more than double the existing population. Nearly double the present personal income and more than double the present employment. In Campbell County, Wyoming, installation of 10,000 MW, which is only a minor portion of the identified potential which result in a population increase of about 150 percent, personal income gain of more than 100 percent, and additional employment opportunities exceeding 100 percent. These examples include the total direct and induced impacts resulting from a power development. Many other examples can be drawn from these data pointing out the significance of these industrial developments in a rural region.

Table 41 - Social-Economic Data (1970) For Counties Anticipated to Receive Major Impact from Mine-Mouthed Generating Plants

State	County	Population (Numbers)	Personal Income (Million $)	Employment (Numbers)
Montana	Big Horn	10,057	22	3,163
	Carbon	7,080	18	2,393
	Custer	12,174	34	4,466
	McCone	2,875	9	1,030
	Powder River	2,862	8	1,115
	Richland	9,837	24	3,311
	Roosevelt	10,365	23	3,196
	Rosebud	6,032	13	2,238
	Sheridan	5,779	18	1,943
Wyoming	Campbell	12,957	46	4,803
	Carbon	13,354	37	4,963
	Converse	5,938	16	2,163
	Johnson	5,587	19	2,202
	Lincoln	8,640	21	2,894
	Sweetwater	18,391	52	6,982
North Dakota	Billings	1,189	2	389
	Bowman	3,901	10	1,453
	Mercer	6,175	14	2,132
	Oliver	2,378	5	779
	Slope	1,593	3	501
South Dakota	Harding	1,920	4	657
	Perkins	4,769	11	2,033
Utah	Emery	5,140	11	1,583
	Garfield	3,160	8	976
	Kane	2,420	6	801
Colorado	Delta	15,286	34	4,856
	Gunnison	7,578	19	2,589
	Mesa	54,378	145	20,125
	Moffat	6,525	18	2,503
	Routt	6,592	17	2,527
New Mexico	McKinley	43,208	74	11,277
	San Juan	52,517	116	15,159

1970 Census Data

The overall social and economic impact that could result from development of the coal resources and construction of mine-mouth generating plan are:

1. Influxes of people associated with the exploration and constructi phase will cause temporary overloading of school systems and all public services while adding limited additional tax base.
2. Rapid expansion of population will create problems to the local planning and zoning. Difficulties will result in the financing of public services to accommodate planned growth.
3. The influx of large number of outsiders that in many cases will outnumber existing populations and will adversely impact existing social and political structures.
4. Expansion of employment and personal income will alleviate local unemployment and low incomes, but will cause social problems.
5. Increased human population combined with reduction of wildlife habitat will create demand for fish and game that will exceed supply. Conflicts between man and wildlife such as elk will lead to reduction in numbers. Greater restriction of hunting and fishing seasons will be necessary and intensive management of wildlife and habitat will become essential.
6. Indian populations who are primarily accustomed to rural surroundings will to some extent become disoriented and adversely affected by the trends to urbanization.

IV MEASURES TO MITIGATE ENVIRONMENTAL IMPACTS OF FEDERAL COAL LEASING

In accordance with the terms of Federal coal prospecting permits and coal leases, exploration for coal is conducted and Federal coal is mined. Coal is used for many beneficial purposes, and its continued use (until supplanted by some more suitable form of energy) is unquestionably justified. However, the process of mining coal results in physical impacts to the environment where mining occurs, as well as to the social and economic environment in affected communities and the nation. These environmental impacts have been described in a preceding part of this statement.

There are several ways to mitigate the impacts involved with mining Federal coal. Foremost is the opportunity to plan when, where, and how much coal is to be mined in coordination with the management of other resources and in consideration of community, regional, and national needs. Another method to minimize the impacts of mining Federal coal is to incorporate requirements to achieve that objective in prospecting permits and coal leases . Adequate supervision of the permittees' and lessees' operations is another means to ensure that impacts will be minimal. A primary means of mitigating the physical impacts of coal mining is through the operational techniques employed. Each of these means of mitigating the environmental impacts incident to mining Federal coal will be discussed in the following sections.

A. Planning to Mitigate Environmental Impacts

1. Natural Resource Management Planning

All resources of Federal land, including minerals like coal, receive consideration under comprehensive multiple use planning system Federal land managing agencies, such as the Bureau of Land Management a the Forest Service, use sophisticated systems to produce land use plans that define permissible uses within a given geographic area. Land use decisions are made after many considerations, including those concerned with policies and objectives, capabilities of the resources, economic, social factors, public and interest-group views, and anticipated enviro mental impacts.

Interdisciplinary planning mitigates impacts of resource use by weighing the various uses to determine their potential compatibility an the land use constraints necessary in managing a geographic area.

Federal coal managing agencies seek the active involvement of the pu- lic, interest groups, and other agencies in developing appropriate plans for the management of all natural resources, including coal. It is by person-to-person participation in the early stages of planning that all facets of concern can best be brought into focus. Such expressions of opinion and fact, supplemented by additional research where needed, and coupled with a clear understanding of public objectives, are the basis effective resource management planning. An accurate and complete invent of all the resources in the planning area, plus a knowledge of demands them, is of course necessary.

In planning for optimum long-range natural resource uses, coal extra tion must be considered as an interim land use. An inventory of existi resources -- air, water, vegetation as ground cover and as forage and ha tat for animals, timber, wildlife (especially threatened species), open space, historic and archeological values, and minerals -- and their present and potential uses must be made. Next, the value of each resource must be compared with all the others. An informed public at local and regional levels must help decide on relative resource values and the most logical order and sequence for their development. At this step, the value of one resource may stop the development of another. Or it may only modify the development of one to reduce conflict in the development or protection of others.

Cooperatively, developed plans for the method of operation at each coal mine are essential to mitigate the physical impacts on the site. An understanding, by everyone involved, of how the area is to look following mining and what its future uses are to be will serve to forestall unnecessary impacts and simplify rehabilitation.

2. Comprehensive Regional and Community Planning

Knowledge about the resources of an area and their potential uses is helpful in planning to balance their use and minimize conflicts. However, equally important is a knowledge of the social and economic needs of the community, region, and nation.

Community or comprehensive regional planning must consider the people-- how they live, and how their way of life is and will be affected by existing and proposed resource uses. If a significant increase will result from a new resource use, adequacy of community facilities -- housing and space for new housing, schools, physical and mental health services, police and recreation -- must be inventoried. Expanded services must also be planned in advance so they can be provided as needed.

Coal production (and its use for electric power production) in an area where it has not existed before, will affect the habits, customs, li styles, and values of people. Impacts begin with the first rumor that co might be mined and ends long after the exodus of the last person involved in the industry. All mitigating measures, like the impacts, they are inte ded to ameliorate, are likely to have wide and significant social, politi cal, and economic implications. Existing social and cultural conditions and component factors on them and to develop optimum ways to mitigate the impacts. Planning, is an all important measure to mitigate the impacts o social structure when a community "booms".

A well-balanced public information effort in communities fearing soci, economic, and political impacts due to boom psychology may help to mitigat the effect of giving the people sound information on what to expect. Use of local people as exploration employees may also alleviate adverse impact and resentments. This would be especially true in regions where apprehension is great regarding looming change and the in-migration of outsiders. Conscious considerations of ethnic, religious, and cultural customs would also mitigate impacts of a new or expanding Federal coal leasing program.

Thorough understanding of existing local social, political, and econom values and conditions by those involved in exploration, development, and mining could go far toward mitigating impacts alleviating expectations of potentially radical change. Temporary needs during initial construction and development should be the first phase planned for. Coal extraction an energy conversion development siting can serve to mitigate many impacts by locating such activities near existing large communities or in areas where such activities already are understood.

Maximum employment of local people by incoming and expanded coal operations and development should be planned for, and training programs and employee recruitment oriented accordingly. In situations where local populations will be heavily impacted and perhaps outnumbered by in-migrants due to coal development, orientation programs for the newcomers could lessen impacts by helping them to understand the existing social, economical, political, cultural, ethnic, and religious fabric.

All manner of services and community recreation facilities should be planned for in advance of need. To help gain acceptance, leaders should emphasize beneficial aspects of change as well as problems.

Community financial reserves built from severance, corporate, or individual income or other taxes can mitigate the "bust" effect as non-renewable natural resources are depleted, an area economy winds down.

Federal control of the location, extent, and rate of coal mining under Federal leases can do much to modify community impacts caused by sudden shifts of operations. Advance knowledge of the uses to be made of rehabilitated areas following coal mining can help communities and individuals shape their own plans for the future.

There are huge quantities of Federal coal already committed under active Federal coal leases and tentatively committed under preference-right coal lease applications and prospecting permits, as previously summarized. For this reason, it is likely that planning efforts in the forseeable future will be in connection with limitation of operations under existing leases rather than with the location of additional leases. An exception, however, might be in recognition of the desirability of leasing an isol ted tract of Federal land that is surrounded by other lands which are b mined.

Geological Survey has the authority for approving coal mining operat plans for incorporation by the Bureau of Land Management into the terms the coal lease.

However, the Federal land managing agency -- Bureau of Land Manageme Forest Service, Bureau of Sport Fisheries and Wildlife, or other -- has responsibility for determining the appropriateness of the mining plan ir lation to other present and future resource uses. The public also is gi the opportunity to comment on proposed mining plans.

It is at this crucial stage that resource management plans must be c fully coordinated with comprehensive community and regional plans for la uses, community services, transportation systems, and utility networks. The Bureau of Land Management, as the lessor, and the lessee are obligat to lead the efforts in securing realistic and coordinated planning to ac orderly development. Assistance in planning can be expected from federa state, regional, county, and municipal planning staffs; from organizati concerned with maintaining the quality of the environment; from resourc user groups; and from other public spirited citizens who are willing to contribute their efforts toward maintaining a livable land.

Plans, however, are only the first step toward securing the added co munity services or establishing appropriate land uses. Continuing leade ship is essential to raise the finances needed -- through bond issues, t grants, or otherwise. Public officials must make timely and effective decisions. Individuals must fulfill thier community responsibility by knowing the issues and using good judgement in voting.

Enforceable plans to use suited and designated lands in expanding communities for residential, commercial, and industrial purposes must be developed early in the transition. Utilities to serve the community must be planned, financed, and constructed.

Roads, power lines, telephone lines, water and sewage systems, solid waste disposal systems, and other services to new coal mine plants must either be provided by the community or be self-contained at the plant site. Planning the location of utility rights-of-way should be done jointly by all who have interests, keeping in mind the need to minimize environmental impacts and planned future uses of the area which might be served by the utilities.

Community planning must consider the expected duration of mining in the locality, so community investments can be amortized on a timely basis. The opportunity to convert a mined area to a public recreation site providing fishing, boating, picnicking, camping, hiking, biking, and other recreational activities should be considered in long-range plans for community or regional recreational facilities. If such future use is planned, recognition of it should be given in the rehabilitation provisions of the mining plan when they are incorporated in the coal lease.

B. Requirements to Mitigate Environmental Impacts

Authorities (including laws, regulations, and policies) available to the Federal Government for managing its coal leasing program are summarized in a preceding part of this statement. Following is an analysis of the principal requirements governing the operations of holders of Federal coal prospecting permits and Federal coal leases.

1. Laws to Mitigate Environmental Impacts

Numerous Federal laws relate to the management of natural resources and bear more or less specifically on the mining of Federal coal. Some which significantly relate to minimizing environmental impacts are mentioned here.

The National Environmental Policy Act of 1969 (NEPA) required Federal agencies to protect the environment while managing natural resources. They do this by seeking public involvement in developing resource management plans, applying professional skills in making management decisions, and by requiring resource users to observe specific environmental safeguards.

The Clean Air Act of 1970 provides for national, state, regional, and local standards and criteria for air quality and pollutant tolerances. The standards apply to coal mining and energy conversion operations.

Water quality laws include the River and Harbor Act of 1899, the Federal Water Pollution Control Act, and the Water Quality Improvement Act of 1970.

The Antiquities Act of 1906, the Historic Site Act of 1935, and the Historic Preservation Act of 1966 protect cultural, historic, archeologic, and paleontologic resources on Federal lands. These laws require the identification, evaluation, and protection of historic cultural resources that might otherwise be impacted by coal mining. Review of proposed actions that might have an adverse impact on historic cultural resources is to be completed prior to implementation, by the President's Advisory Council on Historical Preservation.

Various bills have been introduced for consideration by Congress in 1973 and 1974 that are designed to improve the management of the natural resources of Federal lands and to promote environmental quality. Several call for termination or modification of many laws enacted a century ago that sponsors believe are not applicable to the present situation.

2. Regulations to Mitigate Environmental Impacts

Regulations applicable to Federal coal leasing were listed in a previous section, but those which relate specifically to mitigation of environmental impacts attributable to the mining of Federal coal are summarized here.

a. Surface Management Requirements

Regulations of the Department of the Interior in Title 43, Code of Federal Regulations, Part 23, require in connection with an application for a prospecting permit or coal mining lease that the appropriate district manager of the Bureau of Land Management shall make, or cause to be made, a technical examination of the prospective effects of the proposed exploration of surface mining operations upon the environment. The technical examinations shall take into consideration the need for the preservation and protection of other resources, including recreational, scenic, historic, and ecological values; the control of erosion, flooding, and pollution of water; the isolation of toxic materials; the prevention of air pollution; the reclamation by vegetation, replacement of soil, or by other means, of lands affected by the exploration or mining operations; the prevention of slides; the protection of fish and wildlife and their habitat; and the prevention of hazards to public health and safety.

A technical examination of an area should be made with the recognition that actual potential mining sites and mining operations vary widely with respect to topography, climate, surrounding land uses, proximity to densely used areas, and other environmental influences and that mining and reclamation requirements should provide sufficient flexibility to permit adjustment to local conditions.

Based upon the technical examination, the district manager shall formulate the general requirements which the applicant must meet for the protection of non-mineral resources during the conduct of exploration or mining operations and for the reclamation of lands or waters affected by exploration or mining operations. The general requirements shall be made known in writing to the applicant before the issuance of a permit or lease or the making of a contract, and upon acceptance thereof by the applicant, shall be incorporated in the permit, lease, or contract. If an application or offer is made under the Mineral Leasing Act for Acquired Lands and if the lands are under the jurisdiction of an agency other than the Department of the Interior, the requirements must incorporate provisions prescribed by that agency. If the application or offer is made under the Mineral Leasing Act of February 25, 1920, or the Minerals Act, and if the lands are under the jurisdiction of an agency other than the Department of the Interior, the district manager shall consult representatives of the agency administering the land and obtain their recommendations for provisions to be incorporated in the general requirements. If the district manager does not concur in the recommendations, the issues shall be referred for resolution to the Under Secretary of the Department of the Interior and the comparable officer of the agency submitting the recommendations. In the case of disagreement of the issues which are so referred, the Secretary of the Interior shall make a determination on the recommendations which shall be final and binding.

In each instance in which an application or offer is made under the Mineral Leasing Acts, the mining supervisor shall participate in the technical examination and in the formulation of the general requirements. If the lands covered by an application or offer are under the jurisdiction of a bureau of the Department of the Interior, other than the Bureau of Land Management, the district manager shall consult representatives of the bureau administering the land. If the lands covered by the application or offer are under the jurisdiction of an agency other than the Department of the Interior and that agency makes a technical examination of the type provided for, district managers and mining supervisors are authorized to participate in that examination.

Whenever it is determined that any part of the area described in an application or offer for a permit, lease, or contract is such that previous experience under similar conditions has shown that operations cannot feasibly be conducted by any known methods or measures to avoid --

(1) Rock or landslides which would be a hazard to human lives or endanger or destroy private or public property; or

(2) Substantial deposition of sediment and silt into streams, lakes, reservoirs; or

(3) A lowering of water quality below standards established by the appropriate State water pollution control agency, or by the Secretary of the

Interior; or

(4) A lowering of the quality of waters whose quality exceeds that -quired by the established standards -- unless and until it has been aff-matively demonstrated to the State water pollution control agency and t the Department of the Interior that such lowering of quality is necessa to economic and social development and will not preclude any assigned u s made of such waters; or

(5) The destruction of key wildlife habitat or important scenic, hi torical, or other natural or cultural features; the district manager may prohibit or otherwise restrict operations on such part of an area.

Approval of Exploration Plan. Before commencing any surface disturbing operations to explore, test, or prospect for minerals covered by the mi r-al leasing acts, the operator shall file with the mining supervisor a p n for the proposed exploration operations.

The mining supervisor shall consult with the district manager with respect to the surface protection and reclamation aspects before approving the proposed exploration operations.

The mining supervisor shall consult with the district manager with s-pect to the surface protection and reclamation aspects before approving said plan.

Before commencing any surface disturbing operations to explore, test or prospect for materials covered by the Materials Act, the operator sh l file with the district manager, a plan for the proposed exploration ope -tions.

Depending upon the size and nature of the operation and the requirement established, the mining supervisor or the district manager may require that the exploration plan submitted by the operator include any or all of the following:

(1) A description of the area within which exploration is to be conducted;

(2) Two copies of a suitable map or aerial photograph showing topographic, cultural, or drainage features;

(3) A statement of proposed exploration methods, i.e., drilling, trenching, etc., and the location of primary support roads and facilities;

(4) A description of measures to be taken to prevent or control fires, soil erosion, pollution of surface and ground water, damage to fish and wildlife or other natural resources, and hazards to public health and safety, both during and upon abandonment of exploration activities.

The mining supervisor or the district manager shall promptly review the exploration plan submitted to him by the operator and shall indicate to the operator any changes, additions, or amendments necessary.

Approval of Mining Plan. Before surface mining operations may commence under any permit or lease issued under the mineral leasing acts, the operator must file a mining plan with the mining supervisor and obtain his approval of the plan.

The mining supervisor shall consult with the district manager with respect to the surface protection and reclamation aspects before approving said plan.

Before surface mining operations may commence under any permit issued or contract made under the Mineral Acts, the operator must file a mining plan with the district manager and obtain his approval of the plan.

The mining supervisor of the district manager may require that the mining plan submitted by the operator include any or all of the following:

(1) A description of the location and area to be affected by the operations;

(2) Two copies of a suitable map, or aerial photograph showing the topography, the area covered by the permit, lease, or contract; the name and location of major topographic and cultural features, and the drainage plan away from the area to be affected.

(3) A statement of proposed methods of operating, including a description of proposed roads or vehicular trails; the size and location of structures and facilities to be built;

(4) An estimate of the quantity of water to be used and pollutants that are expected to enter any receiving waters;

(5) A design for the necessary impoundment, treatment, or control of all runoff water and drainage from workings so as to reduce soil erosion and sedimentation and to prevent the pollution of receiving waters;

(6) A description of measures to be taken to prevent or control fire, soil erosion, and hazards to public health and safety; and

(7) A statement of the proposed manner and time of performance of work to reclaim areas disturbed by the holder's operation.

In those instances in which the permit, lease, or contract requires the revegetation of an area of land to be affected, the mining plan shall show:

(1) Proposed methods of preparation and fertilizing the soil prior to

replanting;

(2) Types and mixtures of shrubs, trees or tree seedlings, grass, or legumes to be planted; and

(3) Types and methods of planting, including the amount of grasses or legumes per acre, or the number and spacing of trees or tree seedlings, or combinations of grasses and trees.

In those instances in which the permit, lease, or contract requires regrading and backfilling, the mining plan shall show the proposed methods and the timing of grading and backfilling of areas to be affected by the operation.

The mining supervisor or the district manager shall review the mining plan submitted to him by the operator and shall promptly indicate to the operator any changes, additions, or amendments necessary.

The operator shall comply with the provisions of an approved mining plan.

b. Performance Bonds

Upon approval of an exploration plan or mining plan, the operator shall be required to file a suitable performance bond of not less than $2,000 with satisfactory surety, payable to the Secretary of the Interior, and the bond shall be conditioned upon the faithful compliance with applicable regulations, the terms and conditions of the permit, lease, or contract, and the exploration or mining plan as approved, amended or supplemented. The bond shall be in an amount sufficient to satisfy the reclamation requirements of an approved exploration or mining plan, or an approval partial or supplemental plan. In determining the amount of the bond considerations shall be given to the character and nature of the reclamation requirements and the estimated costs of reclamation in the event that the operator forfeits his performance bond.

c. Revocation for Noncompliance

If the mining supervisor or the district manager determines that an operator has failed to comply with the terms and conditions of a permit, lease, or contract, or with the requirements of an exploration or mining plan, or with the provisions of applicable regulations under this part, the supervisor or manager shall serve a notice of noncompliance upon the operator.

Failure of the operator to take action in accordance with the notice of noncompliance shall be grounds for suspension by the mining supervisor or the district manager of operations or for the initiation of action for the cancellation of the permit, lease, or contract and for forfeiture of the performance bond.

d. Denial of Permit or Lease

An application or offer for a permit, lease, or contract to conduct exploratory or extractive operations may be denied any applicant or offeror who has forfeited a required bond because of failure to comply with an exploration or mining plan. However, a permit, lease, or contract may not be denied an applicant or offeror because of the forfeiture of a bond if the lands disturbed under his previous permit, lease, or contract have subsequently been reclaimed without cost to the Federal Government.

3. Coal Lease Provisions

The standard Federal Coal Lease (Form 3130-1, October, 196 used by the Bureau of Land Management includes the following Section 5, Protection of the Surface, Natural Resources, and Improvements:

"The lessee agrees to take such reasonable steps as may be needed to prevent operations, including operation of operating plants on the leased premises, from unnecessarily: (1) causing or contributing to soil erosion or damaging any forage and timber growth on the leased lands or on Federal or non-Federal lands in the vicinity; (2) polluting air and water; (3) damaging crops, including forage, timber, or improvements of a surface owner; (4) damaging improvements whether owned by the United States or by its permittees or lessees; or (5) destroying, damaging, or removing fossils, historic or prehistoric ruins, or artifacts; and upon any partial or total relinquishment or the cancellation or expiration of this lease, or at any other time prior thereto when required and to the extent deemed necessary by the lessor to fill any sump holes, ditches, and other excavations, remove or cover all debris, and, so far as reasonably possible, restore the surface of the leased land and access roads to its former condition, including the removal of structures as and if required. The lessor may prescribe the steps to be taken and restoration to be made with respect to the leased lands and improvements thereon, whether or not owned by the United States."

4. Stipulations in Coal Prospecting Permits and Coal Leases

The following stipulations were included in the Bureau of Land Management Manual, Part 3509, on November 9, 1970, and are authorized for use to specify surface management requirements for exploration, mining, and reclamation under the mineral leasing acts.

Stipulations may be selected from the following list for inclusion permits or leases. Care must be exercised to assure that any stipulati used apply specifically to the need for such stipulation. Other stipul tions may be drafted as needed to meet specific problems.

1. Activities employing wheeled or tracked vehicles shall be cond tec in accordance with industry practices and in such a manner as to minimi surface damage.

2. Trail widths shall be kept to the minimum necessary and may no exceed feet. Surface may be cleared of timber, stumps, and snag Care must be taken to avoid scarring or removal of ground vegetative co r.

3. Drainage systems shall not be blocked. No cuts or fills shall e made near or in streams which will result in siltation or accumulation debris. All damage to streams must be repaired to the satisfaction of e authorized officer.

4. All operations must be conducted so as not to change the chara er of cause pollution of streams, lakes, ponds, waterholes, seeps, and mar es or cause damage to fish and wildlife resources.

5. Surface damage which causes soil movement and/or water polluti must be corrected to the satisfaction of the authorized officer.

6. Vegetation must not be disturbed within 300 feet of any waters designated in a (prospecting permit), (lease), or (contract), except at authorized stream crossings.

7. No explosives may be used without written consent of the autho

ized officer.

8. Trails and campsites must be kept clean. All garbage and foreign debris must be eliminated by removal or burial. Burning is permissible only by prior written consent of the authorized officer.

9. Existing roads and trails shall be used whenever possible.

10. All survey monuments, witness corners, reference monuments, and bearing trees must be protected against destruction, obliteration, or damage. Any damaged or obliterated markers must be reestablished in accordance with accepted survey practices at the expense of (permittee), (contractor), or (lessee).

11. The operator shall make every effort to prevent, control or suppress any fire in the operating area. Reports of uncontrolled fires must be immediately sent to the authorized officer of his representative.

12. Fill all holes, pits, and excavations to the extent agreed in the approved mining plan and grade to the natural contour.

13. When surface operation are conducted, overburden or other waste shall be returned to the excavation, as set forth in the mining plan and except in instances when the district manager or state director determines that it would be desirable to use an excavation for the permanent impoundment of water or for other beneficial uses.

14. Disposal sites shall be selected and prepared so as to avoid downward percolation of pollutants into aquifers.

15. Disposal systems for solid and liquid wastes shall be designed and constructed so as to avoid landslides, control wind and water erosion, and establish conditions conductive to vegetative growth in the disposal area.

16. Casual accumulations of water on waste piles shall be avoided, and

where necessary, surface waters shall be directed around the piles.

17. Final grading of backfilled and other unconsolidated materials shall be so performed as to prevent a surface susceptible to vegetation or desired land form.

18. Excavations used for the permanent impoundment of water shall be graded to establish safe access to water for persons, livestock, and wildlife.

19. No solid rock face or bench face shall exceed   feet in height. Appropriate access suitable for persons, livestock, and wildlife shall be provided for every   feet of continuous rock or bench face.

20. Except for solid rock faces, bench faces, and excavations used for impoundment of water, those surface areas of the leased premises disturbed by operations conducted by the lessee shall be revegetated when their use is no longer required by the operator. (Species, methods, and season of seeding or planting, etc., should be specified. These requirements should be practical and generally should not require vegetative rehabilitation beyond level of production.)

21. Backfilling, final grading, and vegetation shall be completed within two years after the completion or termination of the particular operation involved unless the district manager extends the time.

22. Drill holes shall be permanently sealed or filled as directed by the district manager upon completion of operations.

23. Surface buildings, supporting facilities, and other structures which are not required for particular operations shall be removed and the area

aded and revegetated.

24. All operations shall be conducted with a view to avoidance of range
d forest fires and spontaneous combustion. Open burning of carbonaceous
terials shall be in accordance with suitable practices for fire prevention
d control.

25. The lease or contract premises shall be appropriately posted and
nced or otherwise protected to minimize injury to persons, livestock, and
ldlife.

26. All access, haul, and other support roads and trails shall be con-
ructed and maintained in such a manner as to control and minimize chan-
ling and other erosion. Roads and trails shall be constructed only at lo-
tions approved by the authorized officer.

27. All roads constructed in the operation shall be closed by barricades
protected from erosion by placing of water control bars as required by the
strict manager.

28. All existing improvements including, but not limited to, fences,
tes, cattle guards, roads, trails, culverts, water development and control
ructures, shall be maintained in serviceable condition. Damaged or des-
oyed improvements shall be replaced, restored, or appropriately compensa-
d for.

29. When agreed by lessee and lessor, the lease site shall be available
r other public uses including, but not limited to, livestock, grazing,
nting, fishing, camping, hiking, and picnicking.

30. Topsoil shall be removed and stockpiled prior to removal of over-
rden. Stockpiles shall be located so as not to be covered by spoil ma-

terials and to facilitate their use in final backfilling and grading.

5. Sample Stipulations

Following are four sets of stipulations actually incorpor ed in coal leases, as examples of requirements in effect in 1973, in Fede l coal leases on national resource lands managed by the Bureau of Land M a-gement. A fifth example is of supplemental stipulations prescribed by he Forest Service in the Rocky Mountain Region.

Example (a), Colorado (BLM)

<u>Coal Leasing Stipulations</u>

1. Before any mining operations or activities may be authorized, t e lessee must post a $5,000 bond to cover estimated reclamation c st and to insure compliance with surface protection stipulations c the lease. In addition, bond coverage in the amount of $10,00C is required in compliance with 43 CFR 3504.2-1 (b). An increas in the amount of the bond may be required at any time during th life of the lease on approval of mining plan or an approved cha ge in plan or to reflect changing surface conditions.
2. All disturbed areas must be returned as nearly as practicable t their original condition, or to a condition to be agreed upon b both the lessee and the Regional Mining Supervisor, Geological Survey, after the Supervisor has agreed with the District Manag , Craig, Colorado, as to the satisfactory standards for such rest -ation.
3. All operations must be conducted so as not to change the charac r or cause pollution of streams, lakes, ponds, waterholes, seeps,

and marshes, or damage to fish and wildlife resources. No contaminants or pollutants will be allowed to enter streams, springs, stock waters, or groundwaters. No water will be used from stock ponds or springs without the written consent of the owner. The lessee will be required to comply with all Federal and State laws, regulations, and standards relating to air, water, and land pollution.

4. The lessee shall be required to comply with all Federal and State mine safety laws, regulations, and standards.
5. All new roads and trails shall be constructed and maintained in such a manner as to control and minimize channeling and other erosion. Roads and trails shall be constructed only at locations approved by the Regional Mining Supervisor.
6. All existing improvements including fences, gates, cattle guards, roads, trails, culverts, pipelines, bridges, public land survey monuments, and water development and control structures shall be maintained in serviceable condition to the degree practicable. Damaged or destroyed improvements shall be replaced, restored, or appropriately compensated for. When it becomes necessary, and only upon prior approval of the Regional Supervisor, the lessee may disturb a public land survey corner marker or monument; however, the lessee shall bear all costs of any surveys required to preserve the true point for the marker.
7. Grazing or resting livestock will not be unnecessarily disturbed.
8. All garbage and foreign debris must be eliminated by removal or

burial. Burning is permissible only by prior written consent c the Regional Mining Supervisor.

9. The clearing of timber, stumps, and snags will be kept to a mir and due care will be used to avoid scarring or removal of grour vegetative cover.

10. The lessee shall comply with the Moffat County Planning Resolut which requires written approval from the Moffat County Planning Commission prior to commencing any on-the-ground activities.

11. Drill holes and other excavations shall be conditioned at all t so as to prevent injury to persons, livestock, and wildlife, an upon completion of explorations, will be permanently sealed or led to the satisfaction of the Regional Mining Supervisor.

12. No explosives may be used without prior written consent of the Regional Mining Supervisor.

13. Excavations used for the permanent impoundment of water shall b graded to provide safe access to the water for persons, livesto and wildlife.

14. The mining plan shall include provisions for housing and other vice facilities to the satisfaction of the Regional Mining Supe visor.

15. Where compatible with operations conducted by the lessee, the l area shall be available for other public surface uses, includin livestock grazing, hunting, fishing, camping, hiking, and picni ing.

16. Mining or exploratory operations shall not be conducted on the

which, in the opinion of the Regional Mining Supervisor, Geological Survey, would constitute a hazard to oil and gas production, or which would unreasonably interfere with the orderly development and production under oil and gas leases issued prior to the date of this lease.

17. When American antiquities or other objects of historic or scientific interest, including, but not limited to, historic or prehistoric ruins, vertebrate fossils or artifacts, are discovered in the performances of this lease, the item(s) or condition(s) will be left intact and immediately brought to the attention of the District Manager through the Regional Mining Supervisor.

18. Prior to commencing any on-the-ground activities, the lessee shall submit to the Regional Mining Supervisor, a mining plan which considers these stipulations and includes those items listed in Section 1, Coal Lease Form 3130-1.

Example (b), Colorado (BLM)

<u>Coal Leasing Stipulations</u>

1. Cutbank and fill slopes are to be terraced, seeded with grass and shrub species (at the rate of eight pounds total per acre), fertilized, and sprinkled.

2. The lessee will channelize runoff from the drainage near the portal and adjacent hillsides to prevent erosion of the parking area, steep slopes, and access road. The lessee is to provide an adequate drainage structure across the State Highway or carry runoff. The outlet is to be rip-rapped to prevent gully erosion from the high-

way to the river.

3. New mine entrances and ventilation shafts will be opened with th minimum possible amount of disturbance of vegetation and wildlif Roads and trails shall be constructed only at locations approved in advance by the Regional Mining Supervisor after consultation with the District Manager.

4. Where practical, existing roads shall be used. Activities emplo- ing wheel or track vehicles shall be conducted in a manner to mi- mize surface damage. If damage occurs, the road shall be restor to a condition prescribed by the District Manager. No off-road travel will be permitted except in an emergency. All new roads and trails shall be constructed and maintained in a manner to co- trol and minimize channeling or other erosion.

5. Applicant will contact the Colorado State Highway Department to e- termine the need for signs to warn motorists of trucks turning the highway.

6. Issuance of the renewal is dependent on statements of approval sewage and drainage disposal facilities by the Colorado State D partment of Health and the Colorado Division of Game, Fish and Parks.

7. Operations must be conducted so as not to adversely change the character or cause pollution of streams, lakes, ponds, waterhol seeps, and marshes or damage to fish and wildlife resources. Co taminants or pollutants shall be controlled and not be allowed enter streams, springs, stock waters, or groundwaters.

8. Open burning is permitted only after securing a burning permit from the Colorado Air Pollution Control Commission. A copy of such burning permit shall be presented to the District Manager for his approval prior to conducting any such burning through the Regional Mining Supervisor.

9. The lessee's attention is directed to the requirements that he must comply with all Federal and State laws, regulations, and standards relating to safety and air, water, land, and noise pollution.

10. Stockpiling of waste material shall be in as small an area as possible. Coal and waste material shall be stored or stockpiled in a way to prevent the production of agents or pollutants that may damage or kill vegetative cover. Mine waste dump material shall be stockpiled as authorized by the Regional Mining Supervisor, after consultation with the District Manager. All solid or liquid waste shall be disposed of by using accepted State and Federal laws, regulations, and standards.

11. No salable minerals, such as sand, gravel, or stone, found on the lands covered by this lease shall be used by the lessee or its assignees for exploration, development, and prospecting purposes unless said salable minerals have been purchased from the United States under the provisions of the Materials Act of July 31, 1947 (61 Stat. 681).

12. Accumulated debris, including old machinery, dilapidated structures, oil cans, structural material and garbage, is to be removed from the lease area and disposed of in accordance with Colorado State laws

and regulations. Litter and debris shall be cleaned up within the lease area at least monthly, but on a continuing basis.

13. Housing and other facilities and services related to community or urban development shall be kept to a minimum on the leased premises and shall require the written approval of the RMS after consultation with the District Manager prior to construction or location thereon of the facilities.

14. All structures shall be colored, painted, or finished in a manner that will blend with the landscape character of the vicinity.

15. When the mining activity is completed, the lessee shall return the site to a condition to be agreed upon by the Regional Mining Supervisor after consultation with the District Manager at the time of closing. As a minimum, mine entrances and vents shall be closed and their surface area reseeded, on seedbeds of good surface soil, with species designated by the RMS after consultation with the District Manager.

Example (c), New Mexico (BLM)

<u>Coal Leasing Stipulations</u>

1. Gates or cattle guards must be constructed to Bureau of Land Management specifications, by the lessee, in fences through which an access road passes. Gates must be kept closed, unless by permission from the owner, they may be left open.

2. Where a road and/or an exploratory site is constructed that cuts a natural barrier that is used for livestock control, this opening shall be closed by a BLM standard fence.

3. Acquiring the right to cross privately owned lands or other lands not under jurisdiction of BLM, is the responsibility of the lessee. Permission to cross or a right-of-way to cross such lands should be obtained from the landowner.

4. Any valuable subsurface water encountered in exploration, development, or mining operations will be kept open and the right to use the water is reserved to the United States. The District Manager will be advised promptly of any subsurface water encountered and if usable, may purchase any casing in the well at its reasonable value thereof, such value to be determined by the Director or his authorized representative.

5. Existing roads and trails shall be used whenever possible for all mining activities.

6. Drainage systems shall not be blocked. Cuts or fills causing siltation or accumulation of debris in stream channels shall be avoided and if they occur, must be corrected immediately to the satisfaction of the District Manager.

7. The premises shall be appropriately posted and fences (or other protection) provided to minimize the possibility of injury to persons, livestock, or wildlife.

8. The lessee agrees to take such reasonable steps as may be determined necessary by the District Manager to prevent his operations on or near the subject lands from:

   a. causing or contributing to soil erosion or crop damage.

   b. unnecessarily creating or contributing to pollution of the air and water,

c. damaging improvements owned by the United States, its licensees, permittees, or lessees,

d. damaging or destroying or removing historical or prehistorical ruins or artifacts.

9. When surface operations are conducted, overburden or other wastes shall be returned to the excavation unless an alternative treatment is authorized by the District Manager or State Director. The surface of such areas shall be graded so as to minimize the potential for erosion and to leave a surface susceptible to revegetation. Such backfilling and grading shall be conducted concurrently with the mining operation to the extent practicable.

10. Except for solid rock faces, bench faces, and excavations used for the impoundment of water, those surface areas of the leased premises disturbed by operations conducted by the lessee shall be revegetated when their use is no longer required by the operator. Replacement vegetation shall be of species, composition, and density having the approval of the District Manager. Revegetation of each segment of the operating area shall be completed promptly, and as soon as that segment is no longer needed for the operator.

11. Excavations used for the permanent impoundment of water shall be graded to establish safe access to the water for persons, livestock, and wildlife.

12. Drill holes shall be permanently sealed or secured as directed by the District Manager, when no longer needed in the operation.

13. All existing improvements including, but not limited to, fences, gates, cattle guards, roads, trails, pipelines, bridges, public land survey monuments, and water development and control structures shall be maintained in serviceable condition to the degree practicable. In the event any such improvement owned by the United States, or its licensees, permittees, or lessees, is destroyed, immediate replacement or reimbursement for its full value will be made as determined by the District Manager.

14. Surface buildings, supporting facilities, and other structures, when no longer required for mining operations, shall be removed and the area graded and revegetated.

15. All operations shall be conducted with a view to avoidance of range and forest fires and spontaneous combustion. Open burning of carbonaceous materials shall be conducted with suitable practices for fire prevention and control.

16. All access, haul, and other support roads shall be constructed and maintained in such a manner as to control and minimize channeling and other erosion. Roads shall be located to the degree practicable with a view to conforming with resource management and scenic beauty.

17. Where compatible with the operations conducted by the mineral lessee, the lease site shall be available for public uses, including, but not limited to, livestock grazing, hunting, fishing, camping, and hiking.

18. The minimum bond of $5,000 will be required initially, with the understanding that the amount of such bond may change when lessee's

plan is approved.

19. Upon completion of open cut operations, the lessee shall fill t last cut and slope all highwall faces and benches to a ratio of two to one.

20. The laws of the State of New Mexico, present and future, concer ng coal mining (strip, auger, etc.) are made a part of this lease, additional to the terms of this lease and the applicable Federa laws and regulations.

21. The bond listed above is also conditioned to guarantee complian with these laws as well as with all other terms and conditions the lease.

Example (d), Wyoming (BLM)

<u>Coal Leasing Stipulations</u>

1. <u>Bond</u> - Before any exploration or mining activities may be autl r- ized, the operator must post a $2,000 performance bond to cover s- timated reclamation costs and to insure compliance with surface ro tection stipulations of the lease. An increase in the amount oi the bond may be required at any time during the life of the leas on approval of an exploration plan or an approved change in plar or to reflect changing surface conditions.

2. <u>General</u> - In order to control conditions causing or contributi g to water pollution, soil erosion, hazards to health, safety and property damage, and for the conservation of the resources and t e preservation of natural beauty, the lessee will design and perfc n all operations with a view to the prevention of pollution and er -

sion and the utilization of the natural topography to achieve harmony with the landscape.

3. Surface Reclamation - All overburden, coal waste and other wastes shall be disposed of and the area of land affected reclaimed in accordance with the following requirements:

   a. Disposition of Wastes and Placement of Overburden:

      (1) Soil Material - In those areas to be strip-mined and identified by the District Manager, soil material will be removed and stockpiled for final reclamation of the spoil banks. The soil material will be replaced on the disturbed areas after completion or termination of that particular phase of the mining operation at a depth sufficient for plant growth on slopes of 2:1 or less.

      (2) All mine and other wastes shall be returned to the excavation. All overburden shall be returned to the excavation, unless that excavation is to be used for the permanent impoundment of water, or where more than three successive cuts are made adjacent and parallel to each other in which case the last excavation will not have to be filled, but its slopes must be sloped to 2:1 and topsoil distributed thereon sufficient for vegetative growth.

      (3) Where an excavation is to be left for the impoundment of water, the sides shall be graded to at least a 2:1 slope so as to provide safe access to water for persons, livestock, and wildlife.

(4) All overburden shall be flattened on the top to a width of 25 feet and have side slopes no greater than 2:1, unless otherwise specified, and shall be so deposited that it does not inhibit the flow of water nor produce sediment into the drainages of the North Platte River. Overburden piles shall be located so as to minimize damage to the surrounding lands.

(5) Backfilling of excavations and sloping and grading of spoil piles shall be undertaken concurrently with mining operations. Final grading of backfill, spoil piles, and other unconsolidated materials shall be so performed as to present a stable surface which is susceptible to vegetation. In all cases an even or gently undulating skyline is the objective.

(6) Where outcrop stripping is conducted, the disturbed area shall be sloped to a 2:1 slope and topsoil distributed on waste piles and all disturbed areas from which topsoil has been removed.

(7) Where underground mining operations are conducted, all dump piles and mine wastes shall be sloped to a 2:1 slope and sufficient topsoil distributed thereon to provide a surface which is susceptible to vegetative growth.

(b) Seeding:

(1) All overburden piles and disturbed areas shall be seeded when mining operations are completed in a given locality

at the rate per acre, with grasses, legumes, and shrubs specified by the Mining Supervisor. Such species will generally be the same as those found growing in the area or such exotics as are adaptable to the particular soil and climate. Seeding is to be accomplished between April 1 and April 30 or between September 2 and October 30.

(2) On slopes too steep or rocky for drilling, aerial or ground broadcasting of seed will be acceptable. On the more level, smooth areas, drilling will be required.

(3) All seed sown must be tested and meet the standards for purity and germination as established for the area. Cost of seed test to be borne by the operator.

(4) Planting any affected land whose chemical and physical characteristics are toxic, deficient in moisture or plant nutrients, or composed of sand, gravel, or stone to such an extent as to seriously inhibit plant growth will generally be deferred for a period of time, depending upon soil properties and characteristics as determined from soil tests. The operator shall notify the Mining Supervisor when seeding operations are to be started.

(5) In the event that the first seeding is not successful, the operator will make a second attempt. Such attempt will generally not be sooner than two years after the first. In no event will more than two seedings be required of

the operator.

(6) When water, suitable for irrigation, is available in an excavated area, the seeded area shall be irrigated by sprinkling.

4. Water Pollution Control:

All operations must be conducted so as not to change the character or cause pollution of streams, lakes, ponds, waterholes, seeps, and marshes, or damage to fish and wildlife resources. No contaminants or pollution will be allowed to enter streams, springs, stock waters or groundwaters. No water will be used from stock ponds or springs without written consent of the owner. The lessee will be required to comply with all Federal and State laws, regulations and standards relating to air, water and land pollution.

5. Air Pollution Control:

All operations shall comply with all applicable air quality standard and criteria established by Federal, State, and local authority.

6. Miscellaneous Requirements:

a. All operations shall be conducted so as to prevent the occurrence of range and forest fires.

b. All access and haul roads shall be constructed and maintained in such a manner as to control and minimize erosion. When no longer needed for mining operations, unless otherwise designated by the Mining Supervisor after consultation with the District Manager, all spur and haul roads, will be treated with water bars to prevent erosion and seeded as in b. above.

c. All existing improvements including, but not limited to, fences, gates, cattle guards, pipelines, reservoirs, and other water developments damaged or destroyed by the operation of the lessee shall be replaced or restored to their original condition or appropriately compensated for.

d. Hunting, fishing, and other outdoor recreational activities shall be allowed on the lands covered by the permit, except in areas where such activities are found to be hazardous and interfere with the operations of the operator.

e. Equipment, trash, abandoned buildings, etc., shall be removed or buried and the area restored as near as possible to its original condition upon completion of operations in the area. Area to be kept clean and orderly at all times.

f. Areas where spoil piles and strip-pits have not been sloped to a 2:1 slope must be fenced for the safety of man and animals.

g. When American antiquities or other objects of historic or scientific interest including, but not limited to, historic or prehistoric ruins, vertebrate fossils or artifacts are discovered in the performance of this lease, the item(s) or condition(s) will be left intact and immediately brought to the attention of the Regional Mining Supervisor.

Example (e), Rocky Mountain Region (FS)

Coal Leasing Stipulations for Lands Under Jurisdiction of Department of Agriculture

A. Applicable to Exploration Activities

1. At least two weeks before beginning any exploration work, including access and work road location and construction, the lessee shall prepare a "Lessee Exploration Plan" with the District Ranger, ,
and the Branch of Mining, Conservation Division, U.S. Geologic Survey. The plan shall be prepared in triplicate, including maps, for approval by the Forest Supervisor. Such approval will be conditioned on reasonable requirements needed to prevent soil erosion, water pollution, and unnecessary damages to the surface vegetation and other resources of the United States and to provide for the restoration of the land surface and vegetation. The plan shall contain all such provisions as the Forest Service may deem necessary to maintain proper management of the lands and resources within the exploration area. Where appropriate, depending upon the location and type of operation, the Forest Supervisor may require the plan to contain, at a minimum, the following items:

   a. The location, construction specifications, maintenance program, and estimated use by the lessee, his employees and agents, of all access and work roads.

   b. The location and extent of any and all areas to be occupied during the explorations.

   c. The methods to be used in the explorations, including disposal of waste material.

d. The size and type of equipment to be used in the explorations.

e. The capacity, size, charcter, standards of construction and location of all structures and facilities to be constructed.

f. Typical profiles of cuts and fills of all areas to be graded for the installation of structures and facilities.

g. The location and size of areas upon which vegetation will be destroyed and/or soil laid bare and the steps which will be taken to prevent and control soil erosion thereon, including, but not limited to, the proposed program for rehabilitation and revegetation of these disturbed lands both during and upon cessation of explorations.

h. The steps which will be taken to prevent water pollution.

i. The character, amount, and time of use of explosives or fire, including safety precautions which will be taken during their use.

j. The coordination and rehabilitation measures that will be taken to protect other uses of the land, permitted livestock, and wildlife.

If later explorations require departures from or additions to the approved plan, these revisions or amendments, together with justification statement for proposed revisions, will be submitted to the District Ranger for approval of the Forest Supervisor. Any and all operations conducted in advance of approv of an original, revised, or amended exploration plan, or whic are not in accord with an approved plan, constitutes a violat of the terms of this lease and the Forest Service reserves th right to close down explorations until such corrective action, as is deemed necessary, is taken by the lessee.

2. To guarantee the successful rehabilitation and revegetation of abandoned exploration sites, roads and other disturbed areas, as provided for in the "Lessee Exploration Plan" (paragraph 1) above, the lessee will furnish the Forest Service a surety bond in the amount of $ prior to undertaking any work on the lease area. Provided that, in the event the work is conducted in separate phases, each phase will be covered by a separate bond in the minimum amount of $, before the start of any work on each phase. In lieu of surety bond, the lessee may deposit into a Federal Depository cash, through the Unit Collector Officer, National Forest, or negotiable securities through the Regional Fiscal Agent, U.S. Forest Service, Building 85, Denver Federal Center, Denver, Colorado, 80225, in the amounts stated above or each separately bonded phase area. As soon as the lease area has been successfully rehabilitated and revegetated and approved in writing by the Forest Supervisor, surety will be notified, or cash deposits returned without interest, or securities returned without interest. The lessee agrees that all monies or

deposits in lieu thereof, deposited under this authority may be retained by the United States to cover the cost of any said restoration and rehabilitation rendered necessary by failure of the lessee to fulfill all and singular the requirements assumed hereunder without prejudice whatever to any rights and remedies of the United States.

3. No occupancy of the surface of the following areas is authorized by this lease. The lessee is, however, authorized to employ directional drilling to explore the mineral resources under these areas provided that such drilling or other works will not disturb the surface area or otherwise interfere with their use by the Forest Service. It is understood and agreed that the use of these areas for National Forest purposes is superior to any other use. The excluded areas are:

   a. Within the normal highwater line of any and all lakes, ponds, and reservoirs located within the lease area.

   b. Within 200 feet of the normal highwater line of any and all live streams in the lease area.

   c. Within 400 feet of any and all springs and wells within the lease area.

   d. Within 400 feet of any improvements either owned, permitted, leased, or otherwise authorized by the Forest Service.

   The distances in subparagraphs a, b, c, and d, may be reduced when specifically agreed to in the exploration plan, (paragraph 1).

B. Applicable to Production (Operation) Activities

1. The lessee, before the start of any mining operations, agrees to enter into such additional specific stipulations with the Forest Service covering the lessee's mining operations as are deemed necessary and appropriate, depending upon the mining methods to be used and current mining and restoration technology, to meet the following land management principles:

   a. Maintain and protect the areas which will be either directly or indirectly affected by the lessee's mining operations to minimize the effect on grazing capabilities.

   b. Install structures and facilities and revegetate disturbed areas to protect the soil from excessive erosion and return the land to a usable condition.

   c. Take all measures reasonably necessary to minimize the pollution and contamination of the surface and subsurface water sources.

   d. Protect, insofar as is practicable, and restore or replace these said improvements in event they must be destroyed or disturbed by the lessee's mining operations.

   Such stipulations will be developed jointly by the lessee; representatives of the Branch of Mining Operations, Conservation Division, U.S. Geological Survey; and the Supervisor   , Forest Service.

2. The lessee shall prepare in triplicate and submit an annual operating plan to the Forest Service which will include as a

minimum:

a. The mining operating areas and the methods of operation planned for each area.

b. The areas to be treated and details of the rehabilitation and revegetation measures to be initiated in the planning year to meet the stipulated requirements of the Forest Service.

c. The location and construction specifications of all roads necessary for the mining operation during the planning year.

d. The steps to be taken to minimize water pollution and soil erosion.

e. The correlation of the mining operation with the Forest Service's use and management of the lands not included in that year's operating plan.

3. The lessee shall submit to the Forest Supervisor an annual progress map and report of mining, restoration, and revegetation operations.

4. The lessee shall furnish performance bonds as required by the Forest Supervisor to guarantee fulfillment of the stipulations, entered under (1) above, and the operating plans, prepared under (2) above.

5. The Forest Service reserves the right to amend, alter, or otherwise change during the life of the lease, any and all stipulations necessary to meet the land management principles

outlined in paragraph 1 above provided that before any such amendments, alterations, and other changes are made, the lesse shall be invited to make any comments as he may deem necessary and, provided further, that no such amendments, alterations, and changes in these stipulations shall be made unless agreed to in writing by the lessee and the Forest Service.

6. The Forest Service reserves the right to manage and use all lands administered by it which are embraced within the lease for such purposes as they may deem desirable, provided, that this use and management shall not interfere or conflict with the current mining operations of the lease.

C. Supervision to Mitigate Environmental Impacts

The procedures followed in administering Federal coal prospecting permits and coal leases have been previously summarized herein. Likewise, the laws, regulations, and commonly used stipulations designed to minimize environmental impacts have been noted, along with penalties for noncomplianc However, a large measure of the success in minimizing adverse impacts of coal mining depends on how the operation was planned and how the requirements of the permit or lease are administered.

The Bureau of Land Management's appropriate district manager and the Geological Survey's appropriate mining supervisor share the responsibility for securing compliance with the terms of the permit or lease. If the operation is on the lands of a Federal resource management agency other than BLM, that agency's representative is also involved.

A prime responsibility of the Federal representatives is to see that the erator and his employees know and understand the objectives relating resource protection during exploration, development, production, rehab- itation. It is equally important that they know and understand the anned uses of the land following mining. With such understanding, they n devote their individual and collective efforts toward the long-range als at various stages during the operation. For example, it may be pos- ble for the dragline operator to scatter the spoil as he goes rather than le it in neat ridges. It may be possible to drill grass seed in advance predicted rains to improve germination. A drill crew or a bulldozer erator may discover, protect, and report some evidence of prehistoric ellings. A sprinkler truck driver may be able to provide drinking places r pronghorn antelope and other wildlife. A mining operator may be able design haul roads to minimize erosion.

With frequent review of the mining operation, the Federal representa- ive can observe whether or not the people on the job are carrying out the pirit of the resource protection stipulations and can take corrective ction promptly if something is wrong, before major damage occurs. Coal is valuable public resource associated with other valuable public resources, ll of which deserve the careful attention of Federal resource managers to nsure that uses are balanced in the public interest.

D. Operational Techniques to Mitigate Environmental Impacts

Previously considered measures useful in mitigating the adverse en- ironmental impacts of the Federal coal leasing program have been: (1) lanning on a national, state, regional, community, and mine basis; (2) equirements of laws, regulations, and the terms of leases to ensure that environmental objectives are achieved; and (3) supervision of prospecting the coal mining operations (including rehabilitation measures) to gain cooperation and compliance by operators.

This section will consider the specific techniques that are employed during exploration for coal; development of plans and facilities for coal mining, production -- the removal of coal from the ground by several methods, and concurrent and final rehabilitation of the mined area to put it in a condition suitable for future uses.

In mining Federal coal, the environmental impacts that are most obvious and of widest scope are those resulting from the use of surface mining methods. Consequently, the means of mitigating them are considered in greatest detail.

Actually, measures to minimize the environmental impacts of coal mining are integral parts of the coal mining operation. For that reason, net impacts cannot be assessed until mining and rehabilitation are completed. The techniques discussed here are primarily those that are requirements of coal prospecting permits and coal leases. In addition, mention is made of the need to mitigate adverse environmental impacts associated with off-site plants and facilities and of the need to provide continuing maintenance and management of mined areas.

1. Exploration for Coal

Exploration for coal involves aerial reconnaissance, library research, geologic study, and examinations on the ground. These often require travel where no roads exist so core drillings or excavations to sample coal occurrence can be made. Measures to mitigate any adverse environmental impacts from coal exploration are discussed below.

a. Off-Road Vehicle Travel

Prospecting permits incorporate an approved operating plan which specifies mitigating measures that are required for correction of environmental damage caused by both authorized and unauthorized actions. Since conditions vary, so must the provisions of prospecting permits. Upon occasion, the responsible Federal agencies may call upon the services of various specialists to determine appropriate requirements. Such specialists with knowledge of soils, hydrology, vegetation, mining, landscape architecture, history, archeology, forestry, engineering, etc., may be consulted. Guidelines for selecting prospecting travel routes include: (1) minimize visibility of prospecting road. especially in scenic areas; (2) select routes on topographic contours or on grades under ten percent; (3) Utilize existing roads whenever possible; (4) avoid erosive terrain; (5) avoid travel on wet soils; (6) avoid destroying vegetation, particularly in dry climates; and (7) avoid damaging historic resources.

A thorough research effort to identify and inventory historic resources (trails, event sites, structures, etc.) in the area to be explored will be necessary in order to keep exploration activities away from such resources. To facilitate such an inventory, a comprehensive area history should first be prepared.

Adherence to and enforcement of Federal and State laws and regulations, such as the Antiquities Act, Historic Sites Act, and the Historic Preservation Act, along with non-intrusion on the environs of historic resources, can do much to mitigate exploration impacts. Historic objects and sites revealed by exploration activities should be researched and evaluated prior to continuance of operations.

Time and method stipulations for travel can be incorporated into the prospecting permit which will mitigate most wildlife impacts. Crucial habitat areas can be avoided during critical nesting, breeding, or wintering periods.

Both the Federal Aviation Administration and the State Wildlife Department can establish minimum aircraft flight elevations over waterfowl refuges and other critical wildlife areas.

Access provisions should be reviewed on the ground with the applicant so all potential conflicts can be resolved. Frequent inspections by the resource managing agency will help to assure compliance with the permit.

b. Drilling and Excavating

Measures to mitigate damages or actions resulting from exploratory drilling are as follows:

(1) Leave the vegetation on the drill site or pad.

(2) If grading is necessary at a drill site, return the site to the natural grade, with the same topsoil, and reestablish the native vegetation.

(3) Plug drill holes and scatter drill cuttings. If drill cuttings contain toxic materials in quantity, keep them away from water bodies. Dispose of by burial deep enough to avoid leaching.

(4) Seal all aquifers if they contain undesirable water.

(5) If good water is available in a drill hole and it is needed in the area, insure that it is properly used and transported and does not create erosional or other problems.

(6) Encourage proper drilling by a public agency so the data will be available to all interested parties. This would resolve the need for competitive companies to drill the same area with consequent added environmental impact.

(7) Restrict drilling on steep slopes or highly erosive soils where permanent damage could be encountered.

(8) Take advantage of natural benches, rims, or other level areas.

(9) If drilling would cause more irreparable damage than would be offset by exploration benefits, do not allow drilling.

Measures to mitigate environmental impacts caused by digging trenches and pits for the exploration of coal include:

(1) Restrict the size of the pit to as small an area as is needed.

(2) Topsoil should be stored next to the cuts, to be returned as soon as the temporary need is fulfilled.

(3) Small cuts or pits should be graded to a 4:1 slope, large pits or sample areas may only require a 3:1 slope.

(4) If good quality water stays in any of the excavations, consideration of possible beneficial uses should be made.

(5) If there is significant potential for sediment damage to aquatic habitat or spawning beds downstream the use of erosion control structures can be helpful in trapping sediment while revegetation is accomplished.

Surface excavations must be filled and compacted to prevent spontaneous combustion of coal seams on Federal coal lands.

Hole plugging and excavation reconditioning are included in the exploration plan which must be approved by the Government before work begins on

the lands.

2. Development for Mining Operations

Development refers to those actions under a Federal coal lease that are necessary to prepare the coal extraction. Primarily, they involve construction of roads from public highways to the mine site, provision for needed utlities, and construction of buildings and coal handling facilities, possibly including railroads.

a. Roads and Railroads

A master transportation plan is required of the lessee as an integral part of the proposed mining operation plan. The Bureau of Land Management and other agencies involved use such specialists as necessary in the analysis of the proposed transportation system. An engineer and landscape architect should investigate and assist in location and design, along with specialists in mining, soils, hydrology, vegetation, and wildlife to focus on areas of critical terrestrial and aquatic habitat to assess disturbances and plan rehabilitation. Archeologists and historians may also be required.

Pre-planned road location, construction, and maintenance practices with concern for stream protection will reduce interference with animal movements and the need for rehabilitation. Adequate use of culverts, water bars, ditches, seeding, and bridges for stream crossings will further protect aquatic habitat from siltation damage. Road culverts should be designed and installed to allow fish passage.

There are general guidelines which should be followed in road location, although there may be unique situations on a case-by-case basis. Adhering to the premise that mining is an interim activity, the affected agency should coordinate all road development with a comprehensive land use plan so that major mining roads might serve multiple uses. Lease stipulations should include rehabilitation of all access that will not be retained for future use. Rehabilitation should include erosion protection such as road drainage, water bars, mulching, and seeding.

The width of a road may affect mass wasting in addition to causing erosion. To prevent "over construction" of roads and railroad beds, the maximum acceptable road width should be identified. Every effort should be made to locate roads and railroads where there are no signs of active soil movement or slope instability. Short, steep pitches in road grade can be used when necessary to avoid zones of slope instability. Where a short section of road or railroad must traverse an area with signs of instability, plans should include design features which will reduce the potential for mass wasting.

Clues to potential mass movement are summarized as follows:

(1) Soil wetness, as indicated by seeps, springs, and other areas where water surfaces; presence of hydrophytes; meadows; black soils (these types of soils must be defined locally as having high water tables because many black soils are well drained); soils that are gleyed or mottled; and small ponds of water located adjacent to an old slump escarpment (sag ponds).

Soil wetness is very important because water tends to "float" the soil mantle, just as a sperm "floats" in a swimming pool. The soil mantle slides out of a wet area if a road cut removes the support just as water runs out of a swimming pool if a slide is removed.

(2) Areas where consolidated bedrock is more than about ten feet below the soil surface, as indicated by fault zones (consolidated bedrock is ground and fractured by the faulting action; pockets of colluvium that have accumulated from previous erosion processes; any type of rock that is composed of hard fragments cemented by a finer grained matrix and the matrix is weathering into clay minerals (examples of this situation would be conglomerate, agglomerates, tuffs, shales and breccias where the matrix has undergone considerable weathering; and areas where the rock has weathered to great depths into soft materials that can be dug with a shovel.

Consolidated, continuous bedrock close to the surface provides a sound foundation to support the soil mantle above an area of disturbance. Fractured, weathered, or deep bedrock does not provide support once the area is disturbed. Consequently, the soil mantle slides down the hillside. Cohesionless soils pose the greatest hazard for landsliding on areas described in this category.

(3) Areas where the soil mantle is presently sliding, as indicated by tension cracks (this is where the soil mantle has cracked-open as soil moves downhill away from soil that has stayed in place); hummocky hillsides usually occur in plastic soils that are slowly moving downhill); "jack-strawed" or "crazy" trees (trees tilted at different angles while having a straight trunk denotes very recent soil movement); curved tree butts (the soil mantle has slid during the lifetime of the tree); or depressions resulting from the displacement or withdrawal of material downslope.

Present sliding, as denoted by above clues, will be accelerated if the soil mantle is disturbed. Many times clues listed under the first and second categories will be found in conjunction of those listed in the last category.

Precautions to reduce the potential for mass wasting may include, but are not limted to, the following items:

(1) The road segment should be designed to the minimum width which will safely accommodate traffic and equipment for the intended uses.

(2) Road and railroad location and design should be such that excavation will not remove support from the base of over-steepened slopes or remove the toe of previous slides.

(3) Every effort should be made to avoid road locations in steep head-walls of drainages where sidecast of excavated material will increase the potential for mass wasting. If this is not possible, materials should be endhauled to a suitable disposal site.

(4) Where compaction is desirable, fill material should be compacted in six to twelve inch lifts to a uniform density within 95% of maximum as described by the AASHO T-99 at a moisture content as determined to be suitable.

(5) Perforated pipe should be installed in road ditches where ground-water is contributing to a slope instability. Enclose perforated pipe in a gravel filter and cover with gravel and coarse rock to protect the pipe from road traffic, to help prevent siltation of the pipe, and to support the base of the cut slopes.

(6) Flow and dissipation of energy of water from culvert outfalls should be carefully controlled. Where half-rounds or other conduits are used, they should be bolted to the culvert and firmly staked to the slope. Conduits

should discharge water onto rocks or other energy dissipaters.

(7) Roads which will have use over a prolonged period should be surfaced and maintained adequately. Material should not be removed from stream channels, for road surfacing or any other purpose, unless a permit is obtained by the lessee from the appropriate state agency, and a satisfactory plan to protect aquatic life and prevent siltation while removing the material has been approved.

All trails and fire lines should be seeded or mulched, cross-ditched, or waterbarred before the first winter after construction. Spacings and design of cross-ditches and waterbars should be adequate to remove water from the trail before it gains enough erosive power to cause rilling. The water should be discharged onto materials or structures which will dissipate its energy and disperse the flow to prevent erosion of the slope below the waterbar.

b. Buildings and Other Structures

Since a number of structures are necessary to support the mining operation, proper siting and designing can significantly lessen their impact.

The agency involved should require a site plan of all buildings proposed during the life of the mining operation. The planned structures should be examined relative to their visibility from public access, color compatibility with surrounding landscape, and siting to avoid skylines and conflict with dominant landscape features. The lessee should flag or stake proposed building corners for a joint field examination with the involved agency prior to issuance of the lease. The agency should furnish an

gineer, landscape architect, and architect, if required, to evaluate e entire proposal as individual buildings relate to one another and to e surrounding landscape. Approval of the lease should include methods r removing the structures and returning the site to a natural or anned condition.

Building sites on steep terrain can be a source of mass wasting or cess site disturbance if they are incorrectly located or carelessly con-ructed. To reduce the potential for mass wasting and reduce the loss site potential from structures, transportation facilities, etc., the llowing precautions should be considered:

(1) Size, location, and construction of building sites should conform local ordinances and regulations. Leases should contain stipulations equiring proper compliance.

(2) Where practicable, topsoil should be stripped from the site and tockpiled for replacement after work has been completed and the area is eady for rehabilitation. Care should be taken to insure locating the tockpile where it will not contribute to or cause mass wasting or dditional erosion.

(3) Topsoil stockpiles should be seeded, mulched or covered to prevent oil erosion if they are to remain over a winter season.

(4) Debris left in steep, ephemeral stream channels are often the source f debris slides during winter storms or spring runoff. Debris from con-truction activities should be removed from the channels promptly.

(5) Construction methods which leave an over-steepened fill on a slope elow a building site create a potential for sliding or slumping. Such

conditions should be avoided or preventative measures taken to stabilize the slope.

Following removal of structures, heavily compacted areas may need to be scarified or ripped to a depth of 15 to 18 inches, or to hard bedrock, whichever is shallower prior to revegetation. Stockpiled topsoil should be evenly distributed over the area and the surface roughened on the contour prior to seeding. Erosion should be controlled until vegetation is re-established.

Buildings and other structures should be designed to utilize the least amount of soil surface possible. This will lessen the impact of changing ground from its natural state.

Where possible, facilities should be located away from important and crucial wildlife habitats. Habitat for rare or endangered species should be identified by professional wildlife biologists and excluded from leases, or protected by special lease stipulations.

Construction of outlying facilities (i.e., roads, fences, and power-lines) in areas where wildlife will continue to use critical habitat should be timed seasonably to minimize adverse impacts.

Impacts are minimized if power and water sources and if sewage disposal are on site. If utilities must be routed to the mining operation they should be placed in a utility corridor so that all the disturbance is concentrated. Ideally, it should be combined with the design and location of the roadbed so that total impacts and rehabilitation will be minimized.

Further steps can be taken to reduce the visual impact of utility structures, including fences. Poles and posts may be colored to blend with the

surroundings and their placement should avoid skylines. Water tanks should avoid skylines and be painted to harmonize with surroundings. Powerlines located on or near heavily used flyways should be placed underground. Safety devices, to prevent electrocution of perching birds, should be installed on power poles and cross arms. Utility poles located near busy roads should be designed to prevent raptors from perching on them.

The impacts on historic resources of all on-site facility construction, mine operations and transportation facilities can best be mitigated by avoidance. Other measures can be taken to mitigate impacts in some degree, as described above in dealing with Exploration and Mine Development.

Upon abandonment, revegetation of road and other facility sites as discussed under overburden-waste piles-settling ponds will restore most wildlife habitat.

Fences should be kept to a minimum on big game migration routes. If fences are necessary, they should be built incorporating features to allow passage and reduce hazards to such species as antelope, deer, elk, and moose. An exception would be where fences were necessary to keep the animals out of a particularly hazardous area. In this case, the fence should be designed adequately to do the job.

Surface structures, dams, and diversion channels should be constructed in a fail-safe manner to withstand the maximum possible storm event in the area without causing adverse impacts.

3. Production of Coal

The measures that are effective in mitigating the impacts of coal mining are considered for each of the principal methods of extraction.

For each method, the major causes of environmental impact are treated separately.

a. Underground Mining

(1) Subsidence

Possibly the most serious problem to mitigate as a result of underground mining is subsidence. It can be controlled to some degree by backfilling with waste, fly ash, sand, and gravel or other available material. Not only does this help fill the void, but it may provide a place to get rid of unwanted waste material. Research is being done by the Bureau of Mines in Wyoming and Pennsylvania to develop methods to pump material back underground. Another method to control subsidence is to cause the underground mined area to collapse uniformly at a predetermined rate. This will eliminate holes, cracks, and other hazards and permit rehabilitation at the earliest possible time. Blasting can be used to control cave-in.

A third mitigating measure is to leave adequate support in the mined area so that the roof does not collapse. This method may leave large reserves of coal unmined. Another alternative is to not mine coal by underground methods where subsidence can be a problem. If subsidence is a problem and the coal seam is within economic limits of surface mining, strip-mining avoids this problem. Subsidence should be a consideration in developing an underground mine plan.

All shafts, drifts, or portals that are no longer used are sealed or caved in to prevent children, wildlife, or domestic animals from entering an unsafe situation. Any holes or pits caused by subsidence should also safely covered.

(2) Coal Fires

Federal safety regulations require a proper sealing l fire-fighting plans. Government inspectors are responsible for safe :king conditions underground. All underground operations are regularly amined.

To mitigate or prevent fires in coal storage piles, the coal should be yered and compacted with gentle side slopes. Conical piles tend to devep spontaneous heating (Paulson, et al, 1973).

Fires in waste piles can best be avoided by first spreading and comcting any waste with a high coal content. Such compacted layers should covered with dirt, again compacted. Once a fire is burning, it can best put out by digging it out and spreading the burning and hot unburned el. This, in effect, cools it to the point where burning ceases. Water uld further cool and take away the oxygen necessary for combustion.

(3) Waste Piles

To the extent possible, underground mine portals, ildings, facilities, and waste piles should be so located, designed, and intained that they are esthetically unobtrusive.

Dust abatement measures through physical control, watering or other ans should be employed.

Upon completion of mining, mitigating measures involve the return of e site to near-natural conditions. Rehabilitation would include reaping and contouring the access routes, waste piles, and all disturbed reas around the mine-mouth. Establishing vegetation is necessary to control erosion as well as to blend into the natural landscape. For this reason it is desirable for reestablishment of vegetation be of the same type as that occurring previously.

Waste piles, coal storage piles, and settling ponds must be located so they cannot be eroded or washed away by floods.

If drainage or seepage will be a problem, the surface beneath sites of waste piles, coal piles and settling ponds should be stripped of topsoil which is to be stored for later use in rehabilitation.

Waste or coal storage piles should be surrounded by berms and drainage from them, and from mines as well, routed through the settling pond. Berms and ponds should be big enough to handle maximum intensity storms.

(4) Wastewater

Another major problem to mitigate from underground mines is wastewater. Acid mine drainage to streams, from underground mine operations can be mitigated by direct treatment of the acid water before releasing it to streams, or by minimizing the quantity of water discharged from the operations and getting rid of the excess by evaporation in collecting ponds. Numerous methods of neutralizing mine discharge have been developed, and there is much current research aimed at developing new methods and making old methods more efficient. The most common methods in present use involve neutralization using limestone or CaO. Sealing underground workings after abandonment has proved successful in many mining areas. However, additional research is needed to develop methods that will be more effective in more areas. Injecting mine water into saline aquifers may be possible in some areas.

Little work has been done on the removal of undesirable concentrations certain trace elements in mine drainage water. Often neutralization of id mine drainage does not remove high concentrations of certain trace ements. Research has shown that the iron hydroxides produced in acid ne drainage are an effective absorbant for many trace elements. Subsecent removal of the iron hyroxides from mine drainage water is an effective y of removing high concentrations of many trace elements in the water. gh concentrations of undesirable tract-elements can be treated by absorpon on aluminium or iron flocculants, and by reverse osmosis. High conntrations of many individual trace-elements can be lowered by specific emical treatments.

Impacts caused by underground mining methods which result in collapse overlying beds can be mitigated by not allowing such procedures where ne drainage can cause problems. In area of low precipitation, diversion ructures can eliminate most problems resulting from surface runoff into e collapsed area. However, damage to usable aquifers will not be mitited.

Rapid reclamation of the disturbed surface can eliminate erosion and ream sedimentation problems. In addition, in hilly terrain contouring e disturbed ground can help mitigate erosion problems.

Contamination of underlying and overlying aquifers with mine water can mitigated by sealing the walls of mine shafts and access tunnels, and eing careful not to fracture the overlying and underlying beds during ining. Not having disturbed the overlying and underlying beds becomes specially important when the mine is abandoned and allowed to fill with water. Sealing mine openings after abandonment has been tried in some areas as a means of eliminating acid mine drainage. There should be a continuous monitoring program to determine the quality of water and water levels in aquifers which may be effected by mining operations. This program should start before mining operations in order to plan proper protective procedures, and should continue after the operations to monitor the effectiveness of procedures used. It is also imperative that a monitoring program for streams, slopes, vegetation, wildlife, and all other environmental factors subject to changes resulting from underground mining, be started before mining begins, and continue during and after mining ceases.

Waste piles, coal storage piles, and settling ponds must be located so they cannot be eroded or washed away by floods.

If drainage or seepage will be a problem, the surface beneath sites of waste piles, coal storage piles and settling ponds should be stripped of topsoil which is to be stored for later use in rehabilitation.

Waste or coal storage piles should be surrounded by berms and drainage from them, and from mines as well, routed through the settling pond. Berms and ponds should be big enough to handle maximum intensity storms.

b. Surface Mining

Of the several coal extraction methods, surface mining (stripping) creates the greatest disturbance of the land. Consequently, measures that can be used to mitigate the impacts of surface mining are treated separately and in detail.

Regardless of the method of extraction to be employed, coal exploration thods are similar. Development methods -- including construction of ads, utilities, and structures -- are similar. Coal-using plants are e same, regardless of whether surface or underground mining methods are ed. The aspect of surface mining that is different is the translocation overburden to permit coal extraction and to fill the excavation as mining ogresses. That operation affects the various components of the environ-nt in a variety of ways, as previously discussed. This section examines e measures that are undertaken to mitigate those impacts on the geology d topography of the area mined, on the hydrology, soils and vegetation, ldlife, land uses, and human-value interests.

(1) Geology and Topography

Surface mining alters the geological structure and pography of the area mined. While the structure and location of strata annot be restored as they were, the topography of the area can be restored approximately its former shape. The level of the land will be lowered n an amount that would be equivalent to the thickness of the coal seam emoved, except that loosening of the earth during translocation tends to ncrease its volume.

Federal mining regulations, as embodied and specifically defined in the tandard requirements and special stipulations of each coal lease, require he operator to replace spoil in the excavation after coal removal and to rade the surface in accordance with the Federally approved mining plan. perators are generally cooperative, if the standards they are held to re the same as those required of their competitors.

The cost of reshaping the topography of the mined area to specified

andards is a direct expense of coal mining, but that cost is ultimately ssed on to the user of the coal's energy, perhaps a thousand or more miles ay. Consequently, it is the consumer's willingness to pay for environntal quality that makes the rehabilitation of mined areas possible.

The final use of the land should be determined prior to mining so spoilnks can be recontoured to fit the need. For example, a lake might make e site more suitable for wildlife, grazing, recreation, or residential e. If barren rock or highly alkaline soils are present on the surface, re suitable material might be used to cover it. If badlands or a highly oded surface is mined, the site can be graded to a smooth slope. Normally, site is graded to resemble its original pattern. Serious hazards of ndslides and slumping associated with contour mining are virtually nonistant with area mining. Erosion and sedimentation can be controlled if rface water is managed and rehabilitation is timely.

In normal surface mining operations, overburden from the newly excavad strip is placed in a previous excavation, graded, and revegetated. Howver, to replace the first overburden removed in the last strip excavated not always practical. Each mining plan must address the problem of what do with the initial spoil and how to fill the last excavation. Sometimes e first overburden removed is needed for road fills, to level a site for ffice and coal handling facilities, or to construct dams for settling bains. On other occasions, it might be stockpiled for refilling excavations ater.

If the last excavation is not filled, special measures must be taken o mitigate the disadvantages of the remaining trench and highwall. Depending on the situation, the slope of the highwall might be reduced either during or after overburden removal. Material cut from the upper portion of the highwall can be used to fill the excavation to the extent that the remaining slope is within acceptable limits. If the highwall is on the upper side of an already steep slope the problem becomes more difficult. Expanded use of new equipment that permits replacement of spoil in excavations as mining progresses on the contour around a mountain offers promise. Special techniques for stabilizing spoil in steep terrain are employed, as previously described in connection with the pertinent mining methods.

Mining regulations require that all coal exposures must be covered with compacted earth to prevent fires.

Problems created by dust generated through the use of vehicles to transport coal can be mitigated by sprinkling haul roads with water, by surfacing them with rock, or by using dust pallatives.

(2) Hydrology

Impacts on the hydrology of an area during surface mining can be mitigated in several ways.

Mixing or disruption of subsurface aquifers can be mitigated by avoiding those of special importance to an area. These important aquifers can be identified by advance studies which determine the quality and quantity of their yield and the existing or potential uses dependent on them. Once disturbed by surface mining, they cannot be reestablished although water from them might be salvaged and put to use.

Poor quality water from surface mine drainage can be treated directly, evaporated, or in some areas injected into saline aquifers. Disposal by ijection into saline aquifers would not be practical for mines yielding arge quantities of water. In areas with high precipitation and low evaporation rates, evaporation would be impractical. Mine drainage treatment acilities would have to be specifically designed to treat numerous diferent water quality problems. Among the water quality problems and the reatment methods are:

(1) Excessively high dissolved solids, can be treated by dilution with ood quality water or desalinization.

(2) Acid mine water can be treated using limestone or CaO. Recent reearch (C.S. Decker and D.L. King in Press) on accelerating the recovery f acid-strip lakes has shown that addition of organic wastes, including ewerage wastes to the lakes can remove the acidity sulfate and make the akes productive.

(3) High concentrations of undesirable trace-elements can be treated y absorption on aluminum or iron flocculants, and by reverse osmosis. igh concentrations of many individual trace-elements can be lowered by specific chemical treatments.

At present, there is much research being conducted to develop new and nore efficient ways to mitigate the above problems. In addition to treatnent and disposal of poor quality mine water, mining methods can be adopted which can improve the quality of mine discharge water. Removing all the coal during surface mining eliminates the problem of water seeping through spoil piles and reacting with the coals. As well oxygenated water seeps through permeable spoil piles containing coal it can pick up high dissolved solids, trace-elements, and if pyrite is present, high acidity. Not only can water seeping through spoil piles increase mine-drainage problems, the poor quality may contaminate aquifers underlying the spoil pile.

In mines containing much carbonaceous shale, the shale should be buried at the bottom of the spoil pile to mitigate the contamination problems caused by surface runoff and ponded water contacting the shales. In mines where all the coal cannot be economically removed because some of it contains abundant shale partings, this waste should also be buried at the bottom of the spoil pile.

Spoil piles should be reclaimed as soon as possible to mitigate the problems of erosion and sedimentation in streams.

Surface water diversion structures should be built at mines subject to flooding, and around spoil areas. Where natural drainage is diverted around mine workings, they should be constructed in a fail-safe manner and should be designed to withstand a maximum possible flood event. Settling ponds should be located to collect sediment washed from all surface structures that may contribute sediment to streams. These settling ponds should not be constructed where they are susceptible to washing out during a severe storm event.

Contamination of underlying aquifers can be mitigated by keeping the mine pumped dry at all times, and not allowing water to collect in pools on the mined surface. Coal and waste storage piles should be located on impermeable ground or an impermeable sealer should be used below the piles. Waste could be returned to the mined out area and buried under spoil.

There should be a continuous monitoring program to determine the quality of water in: (1) aquifers below mine and plant operations: (2) streams raining the mine area; and (3) drainage from mines and surface storage les. The data thus collected could be used to plan modifications of perating procedures to mitigate unforseen problems. The monitoring ould begin before mining starts and continue after mining ends.

It is also imperative that a monitoring program for streams, slopes, getation, wildlife, and all other environmental factors subject to anges resulting from surface mining, be started before mining begins, d continue during and after mining ceases.

(3) Vegetation and Soils

Vegetation is destroyed where surface mining occurs, d soils are dislocated. Productivity of surface soils, even though stock- led for later use in covering reshaped spoil piles, can be seriously paired. Once the topography of a mined area is restored to the pres- ibed condition, replacement of topsoil and revegetation are usually the xt steps toward rehabilitation.

Techniques for revegetating spoil banks in the East have been generally reed upon "--- we know reasonably well what species will or will not grow, ere they will grow, what they require to make them grow, and their effec- ve use for reclamation purposes. We also know that 90 percent or more of e spoil areas in the Northeast will support vegetative growth sufficient stabilize spoil areas ---." (Ruffner, 1973).

Ruffner excepted steep unstable areas, erosive areas with water impro- rly disposed of, and acid or spoils.

Mining must be limited to slopes on which slides are unlikely to occur. ceptable slopes depend on ability of spoils to resist shearing stress and other factors, including the mechanical and physical characteristics of the surface on which they are placed (Williams, George P. Jr., 1973).

In the wetter coal provinces and wetter biomes or portions of biomes in other provinces, vegetation can generally be reestablished.

Experience in West Germany, where lignite mining causes relocation of entire communities, shows the benefit of removing topsoil and later replacing if for agricultural or forest production. With the coal industry nationalized since 1947 in the United Kingdom, topsoil, subsoil, and overburden are treated separately, and mined land is restored to productive use, (Council on Environmental Quality, 1973).

Coupled with experience and knowledge already existing in the United States, restoration of mined lands under sub-humid conditions seems likely. This is in spite of the fact that in a national study of 689 sites in the United States, effective plant cover had been established on only about 29 percent, cover was inadequate on 53 percent, and 18 percent were unsuited to plant growth, (Puffner, 1973).

In the drier biomes, and places in the semi-arid West, rehabilitation is still in an experimental stage. There are many "unanswered questions ------about revegetation in the far West------none of the (reclamation) projects has continued for an adequate time to demonstrate that the vegetation will not be successful", (Council on Environmental Quality, 1973).

"No significant progress has been made in revegetating reclaimed strip-mined areas at the relatively arid Black Mesa and Navajo sites. Strip-mining reclamation for semi-arid areas is in an experimental stage," (Study Management Team, 1972). Natural vegetation was very sparse.

Of great importance in the West, but of help in the East would be strip-
ining, where practical, in a northeast-southwest direction. This would
lign spoil piles to expose the least amount of surface to the south and
est. South and west slopes are more difficult to grow plants on because
hey are hotter and drier.

Measures to mitigate the impact on soils and vegetation from overburden
emoval and stockpiling must be planned before mining commences. Logs from
ore drillings need to be examined. Core drillings of overburden materials
eed to be analyzed by stratigraphy or depth classes for physical character-
stics capability of weathering into soil size, particulates (Brube, et al,
973), essential plant nutrients and toxic materials, especially for sodium
n the West and acidity in the East. Local experience is needed to deter-
ine which quantative tests are needed. An intensive soil inventory of the
rea to be disturbed is required prior to any disturbance. Soil inventories
ust include enough laboratory data on chemical and physical soil properties
o intelligent decisions may be made concerning the soils resource both
n-site and on affected off-site areas.

The ultimate goal is to restore vegetation on disturbed areas. The im-
ortance of doing this is brought out by the statement, "Area mining in the
ar West may well be unacceptable unless vegetation can be reestablished."
(Council on Environmental Quality, 1973, p. 2)

Minimizing the area on which soils is disturbed and vegetation destroyed
is of primary importance.

Four actions absolutely necessary to protect soils during and success-
fully reestablish vegetation after mining are:

(1) Stripping and stockpiling of topsoil.

(2) Shaping spoil or waste piles to simulate natural topography, cluding backfilling the last area mined so no highwall exists, reestabshing natural drainage ways and eliminating steep slopes.

(3) Redistributing topsoil over the spoil piles.

(4) Protecting the area from erosive forces of wind and rain.

Sindelar, Hodder, and Majerus, (1973), reported that topsoiling can gnificantly increase establishment and production of vegetative cover on shaped mine spoils in Montana. They also state, "Many materials may nction as substrata for plant growth by acting as a nutrient and moisre pool and by providing mechanical support for plants. Overburden of tisfactory texture and chemical and physical properties may serve as a itable growth medium for vegetation with replacement of plant nutrients they are used. But, many other manipulations and modifications of verburden are necessary to produce a life support system for permanent lant communities on surface mined lands."

They reported in Montana, that between four and eight inches of topsoil edistributed on a 3:1 slope was adequate.

Sutton (1971) and Hodder (1973) support the practice of putting topsoil ack on top if it exists to begin with. Topsoil may be lacking or very thin n some areas in the West.

Moving topsoil from another area is not acceptable if both areas will e unable to support enough vegetation to protect the area against erosion r exposing greater-than-normal amounts of toxic material."

Topsoil should be placed in its final position as soon as possible af-

er its removal. Its quick use will take advantage of any live native eed or root stocks it contains. If not used within a year, stored top-oils should be revegetated or otherwise protected against loss due to ind or water erosion.

Populations of soil microorganisms fluctuate very rapidly (Russell, 950). They may fluctuate as much as 40 million per gram of soil within 24-hour period. Proper use, handling, and storage of chemicals can inimize spillage which harms soil organisms. Incorporating organic ma-erials, especially litter and manure, in the redistributed topsoil will ccelerate population growth.

Knowledge is very limited as to the fate of soil organisms during ining operations. Some research is presently underway in England, but esults are not available.

In the West, where topsoil may not exist or it and subsoil are too thin to allow early revegetation, the next best thing is to bury the commonly ccurring fine textured, saline and/or sodic earth material, (Hodder, 1973). Problem materials are usually found in greater quantity with increasing depth.

Sandoval, Bond, Power, and Willis (1973), surmised that for fine-tex-tured, sodic spoil materials that a period of several years might be re-quired for adequate rehabilitation. They suggested that the sodic con-ditions may be overcome by applying gypsum and leaching the sodium so it is below the rooting zone or redistributing non-sodic topsoil. Sindelar, et al, 1973 are currently studying the possibilities of placing a buffer material between extremely adverse spoil and topsoil.

Acid soils, more common in the East, or any other spoil material unsuitable for plant growth must also be buried below rooting depth.

Placing light colored soil, if suitable for plant growth, on the surface would reduce soil surface temperature and aid in growing plants, (Sutton, 1973).

Soil and spoil material requires certain properties favorable for plant growth before complete rehabilitation can be achieved. Acidity may be treated by adding lime in addition to burying the acid layers. The lime equivalent needs to be known as large amounts of lime could be required initially and at regular succeeding intervals to maintain the desired pH level. Vogel, 1972, suggests that one treatment of acid layers which cannot be buried properly is to leave them in-situ. That is ---not mined.

Neutralization of acid spoils is possible with the addition of alkaline fly ash which may also contain boron, phosphorus, and zinc which are necessary for plant growth. Fly ash may also improve soil texture, (Capp-Gilmore, 1973).

Addition of sewage sludge or manure can neutralize acid or alkaline soils, or spoils, improve structure and water holding capacity, and provide plant nutrients, (Dean, Havens, 1971; Gordon, 1969; Peterson, Gschwind, 1973; Sutton, 1973; Sopper, Mardos, 1972). Sutton, (1973), states, "Several years will be required before there will be enough improvement in the untreated portion (below zone of mixing of spoil with sewage sludge, manure or limestone or below a topsoil layer) of highly pyritic spoils to support plant roots."

As with fly ash, sewage sludge and manure must be tilled into the soil spoil and growth of roots is initially limited to the depth of mixing. Mixing of sewage sludge, manure, or other materials high in organic itter apparently is almost as acceptable as replacement of topsoil.

Slopes or reshaped spoils and waste should not exceed 33 percent in etter provinces and biomes. In pinon-juniper and areas with less than ight inches annual precipitation, northeast and southeast facing slopes hould not exceed 20 percent and 25 percent respectively, (U.S.E.P.A.,1972).

Steep slopes on the periphery of the spoil bank are very conducive) erosion by rill, gullies or mass movement. Wischmeier and Smith, 1965, ave shown that water erosion is influenced exponentially (1.4 power) by lope. The S (slope) factor in their erosion formula is 5.38 for a 30 ercent slope, 8.10 for a 40 percent slope, and 14.2 for a 60 percent slope. ne may see that steep peripheral slopes have tremendous potential to be ne source of erosion and subsequent off-site sedimentation. Sindelar, t al, 1973, reported that no serious difficulties were experienced in tabilizing topsoil on a 2-1/2:1 gradient, but tilling and seeding with arm machinery were impossible. Unfortunately, their work has not gone on ong enough, so that a 40 percent slope can be accepted. Kentucky's ined land reclamation law requires the operator to backfill to the top f the highwall and grade to original contour, eliminate spoil peaks, bury cid forming materials and revegetate.

Surface configuration of the reshaped spoil banks were shown by Sindelar, t al, 1973, to be very important in the west. They reported a distinct dvantage in manipulating the surface of shaped areas into configurations hich limit runoff and encourage infiltration of precipitation. The most

fficient treatment was gouging on the contour. Gouged basins trapped edıment and snow, reduced runoff, and aided in moisture storage within he materials.

Reshaped spoil areas that are compacted by equipment to such a degree hat root penetration or permeability is seriously affected should be hiseled or scarified prior to revegetation.

Tabler (1973) has found that properly designed snow fences can retain ost of the moisture coming as snow. Thus, at Kemmerer, Wyoming, more han 4.5 inches out of a total of nine inches of precipitation coming nnually could be saved.

In the East, mechanical methods for keeping moisture on a disturbed rea to help get plant growth started include "seed ledges" and "furrow rading" (Riley, 1973; Jones, et al, 1973).

Potential water erosion from spoil areas or rehabilitated areas may be alculated before mining by knowing the characteristics of the overburden nd how it is to be reshaped (Wischmeier and Smith, 1965, Wischmeier, Johnson, and Cross, 1971, and USDA, 1972). The amount of protection eeded for a defined level of erosion must then be determined. This pro- ection may be provided by vegetation, redistribution of desert pavement r artificial cover. In the most arid areas, hard surfacing of spoils ight be studied. Such surfaces create artificial watersheds. They could ield water of extremely high quality. Maintenance requirements would be erpetual. If caught in covered reservoirs immediately downstream, loss hrough evaporation could be minimized. Research into such a technique ould require complete environmental and benefit - cost analysis.

Drainage problems involving surface water can be lessened by directing water around the disturbed area, but such action must not create new problems. The new drainageways must be able to handle the water and remain stable.

Potential wind erosion cannot be quantified like water erosion at this time. Wind erosion is quite insignificant, especially on sandy soils. Nielson and Peterson, 1972, reported that chemical binding agents on areas susceptible to wind erosion have been used with good short-term results. Long-term results are not known. Soils tables in Section II, identify some soil series which have a severe or very severe wind erosion hazard. Soils identified as such usually have sandy loam or loamy sand surface textures.

To reduce or eliminate off-site problems caused by coal mining, several methods can be used. For strip-mining on slopes, minimum-height walls can confine to the disturbed area any waters poisonous to vegetation. To serve the same purpose in flatter areas, berms can be used (Peterson, Gschwind, 1973).

To eliminate the possible over-fertilization of downstream waters and the related effects on plants, "nutrient barriers" (dense vegetation surrounding disturbed areas) may prove beneficial, (Peterson, Gschwind, 1973).

Use of flocculants in settling ponds may be necessary to control sedimentation, (McCarthy, 1973).

In addition for acceptable reestablishment of vegetation:

1. Collect base-line data describing the quantity and quality of vegetation before disturbance.

2. Select desirable plants which will grow permanently in the environ-

ment.

3. Nourish and care for the plants until they may sustain themselves while not receiving more care than adjacent vegetation.

Baseline data will serve as a possible target during rehabilitation and can be used to finally measure what has been lost or gained as a result of coal mining.

Selection of plants to be grown is especially important in the semi-arid and arid west. Native species, even ecotypes (plants from the particular location), usually prove more successful than plants from more distant areas. Plants from the south will more likely not grow well in the north and often vice versa, (Ward - Richardson, 1969).

Northeast and southwest facing spoil slopes require different kinds of plants and different amounts of seed.

Mixtures of grass, forbs, and brush should be used to avoid the hazard of monocultures (plants of only one kind growing in an area). Experience with serious pest attacks in wheat, corn, black locust, etc. should provide the lesson. Use of many species can be a form of natural biological pest control, (Knight, 1969).

Brush is of value for its windbreak and shading effects. Brush also will stop snow from blowing away.

Wind erosion from dried-up settling ponds may be reduced by applying chemical agents which bond the particles. Mulches may also be utilized for controlling wind erosion.

All seeding should include dryland alfalfa or some other plant which can fix nitrogen naturally in the soil. Any legume seed should be inno-

culated with the correct species of micorrhizal fungi before sowing.

The roots of different plants also use the soil differently. Grasses are relatively shallow rooted (18" - 24") while forbs and brush can have shallow roots and also have more roots extending to much greater depth. Thus, a variety of plants uses an area more completely. At least some are likely to survive under a wide range of weather conditions.

As a last resort in areas with eight inches to ten inches of precipitation and saline soils, exotic Russian Wildrye may be the only hope.

Sindelar, et al, 1973, are conducting rehabilitation experiments using a wide variety of native and exotic grasses, forbs, and brush.

Use of pioneer (nurse) crops may be beneficial or in semi-arid areas; they may hurt chances of establishing permanent vegetation cover (Thirgood, 1973).

Time of seeding to best use natural moisture as it comes is also important. This is particularly important in semi-arid western regions and recommended times for seeding are: Northern Great Plains - late fall or early spring; Southwest - late summer; and Intermountain Colorado, Utah, and Wyoming - fall, just prior to first snows.

Seeds should be placed at the proper depth. Soil coverage is highly desirable, but various mulches provide a substitute.

Cook, et al, 1970, stated that for seed to grow, it must be kept constantly moist (not wet) for two to three weeks.

Mulches are effective agents to reduce wind and water erosion hazard, slow surface evaporation, conserve soil moisture, and reduce soil temperature. Sindelar, et al, 1973, reported that disced in straw makes an cellent mulch. There are commercial mulches on the market that may be rayed on the surface. There are mats made of various materials which so may be used for the above mentioned purposes. Local knowledge of il, climate and vegetative requirements is needed to determine if and at kinds of mulches may be beneficial.

Coal mine spoils throughout the United States are low in nitrogren and osphorous. Where acid conditions exist, aluminum and manganese toxicity y be expected (Berg and May, 1969; Bery and Vogel, 1968; Sandoval et , 1973; and Sandelar et al, 1973).

To establish seedlings will require some artificial fertilization usual- with nitrogen and phosphorous and irrigation. Neither of these artifi- ial aids to revegetation can be continued indefinitely, but must be with- rawn slowly until the new vegetation can survive under natural conditions.

However, nitrogen and phosphorous fertilizing programs must include main- enance applications following the initial applications to perpetuate the esired vegetative cover.

Artificial fertilizer must be used with care to avoid the possibility f its contaminating downstream water (Porter, 1969).

Protection of rehabilitation efforts from too heavy use by livestock, odents, deer, and other plant eaters require special efforts, but is ssential to prevent destruction.

Fencing against larger animals may be necessary. Use of thorny or bad- asting plants may reduce animal damage. Particularly on small areas, 200 cres or less, plants that are especially liked by any one or several kinds of animals may soon be killed out.

Repellants which ward off animals until vegetation becomes established have been tried, with but little success.

Once vegetation has been reestablished, it must be properly managed (along with surrounding areas) to keep it growing. This is especially important in semi-arid western areas, but also true in the sub-humid east. (Thirgood, 1973; Heine, Guckert, 1973; and Higgins, 1973).

A follow-up schedule for treatments is needed if rehabilitation of disturbed areas is to remain at its optimum. A one-shot treatment is not adequate.

From available information, likely conclusions are:

(1) In desert areas with eight inches or less of precipitation or areas with sodic soils, revegetation may be impossible and the only reclamation will be to restore the original hydrologic conditions and minimize the off-site effects of erosion.

(2) In foothill-type lands, cold deserts of the desert biome, and pinon-juniper areas of the woodland-brushland biome, with 9-18" of precipitation, (30 - 40 percent as snow), successes will be few without every precautionary measure. During drought, failure is nearly certain. South and west slopes will be extremely difficult to revegetate.

(3) In the drier portion of the grassland biome, within the Northern Great Plains, low organic matter in the soil and high sodium levels in marine shales will require particular attention if revegetation is to be successful.

(4) In sub-humid areas, proper application of appropriate mitigating

measures discussed above, will in most cases, assure successful rehabilitation. For semi-arid lands, revegetation may require effort for twenty years or longer.

(4) Wildlife

Where surface mining would destroy or render unsable large acreages of big game winter range, the impact can be mitiated only to the extent that the habitat can be avoided or rehabilitated. otential long-term loss of crucial, herd-limiting big game winter range ay justify withholding an area from leasing, especially if coal reserves f similar minability and less conflict are available within the same rea or region.

Stipulations in a lease or mining plan could require that parts of a ease not be surface mined or not be used for spoil-piling, to reduce inter range losses.

Although rehabilitation of big game winter range has been successful in some areas (Plummer, Christensen and Monsen, 1968), due to a variety of inherent environmental and land management problems, it can generally be expected to be the least successful in areas where it is the most crucial.

The habitat of threatened species should be excluded from leases or protected by special lease stipulations.

In order to mitigate the impacts of reduced habitat and improved access more restrictive hunting and fishing regulations should be established to protect wildlife populations until rehabilitation restores productivity of the area.

Impacts on some species affected by surface mining may not be mitigated

t all, but after mining, new habitats, new species and new population atios in the impact area are established. A threatened native species ould conceivably be lost, or a number of species or types of animals ormerly present, may now be missing from the fauna, but, from the broad iewpoint, their loss may have been mitigated by increases of other species.

In this vein, aquatic habitats in the form of lakes are often created n surface mine areas. If properly designed, constructed and managed, these aters can provide good aquatic habitat for fish, waterfowl, amphibians, uskrats, and a variety of other species (Arata, 1959; Riley, 1954; Sheve, 971).

Intensive development, improvement and management for terrestrial species and habitats has also been very successful in some areas, (Riley, 1954). This has been mostly in the deciduous forest areas of the midwest.

All surface disturbed areas not occupied by the mine facilities should be revegetated and shaped with proper drainage and erosion control structures, designed to minimize erosion and sediment pollution of down-drainage aquatic habitats. Plant species used in revegetation should include food and cover species suitable for native wildlife found in the area.

Loss of wildlife drinking water sources due to lowered water tables, from demands for road sprinkling, coal beneficiation, or any other reason might be mitigated to some extent by raintrap construction, deep well drilling, or pipeline construction from a distant source. Loss of springs in semi-arid areas can be mitigated similarly.

Streams should not be channeled or relocated unless it is absolutely necessary to do so. In any case, advice and concurrence from the appropriate state wildlife agency should be obtained beforehand. It may be possible to transplant fish in order to prevent their loss.

Long highwalls which could inhibit animal movements should be sloped and shaped at sufficiently close intervals to allow relatively free passage and habitat utilization throughout the area. Occasionally, tall stable highwalls in short lengths could be left standing to provide nesting sites for swallows, falcons, hawks, and other birds.

Aquatic wildlife habitat should be rehabilitated by improving water quality and restoring riparian vegetation. Silt and sediment movement through slower reaches of streams can be accelerated and directed through the use of in-stream devices, sediment collecting basins and dredging. Shifting streambed loads can be stabilized and food production and spawning areas will be improved while further downstream damage is reduced, (Spaulding and Ogden, 1968).

(5) Land Uses

The best way to mitigate impacts of coal mining on land uses is to minimize the area of disturbance. Coal should be mined first in areas of least rather than most value for a given use. If a choice can be made, it should first be done on areas with surface values less necessary to society than others.

For example, grazing land should be mined before land producing truck crops. The poorest of the grazing land should be mined first and the smallest area possible should be disturbed. If the poorest grazing land has a high scenic value, the latter value must then dominate judgements.

To least interfere with timber production, mine only where timber is ready for harvest. The period of time during which timber production is lost is then minimized to the time the site is occupied for mining plus the period necessary for reforestation. The same is not true for areas with non-marketable young tree growth.

If mining physically displaces a recreation site, the impact may generally be mitigated through the relocation of that site to another area. Care should be exercised in providing a similar facility with equal recreational opportunities in the same general area. If the site is unique and mining operations would forever destroy the quality of the recreation experience, then mining activities should be avoided.

Impacts on the production of forage for livestock and wild horses can be mitigated by early modifications of allotment management plans to provide additional forage in other locations. The availability of water in alternate locations also must be assured if the animals were accustomed to drinking in the area mining is to occur. If alternate feed and water cannot be provided, the numbers of livestock and wild horses using the area must be reduced to protect the environment, assuming that coal mining in that area has been determined to be the preeminent use.

If areas to be mined are traversed by roads, fences, power lines, or other structures, the facilities must be removed to alternate locations, temporarily or permanently, depending on the situation.

If Federal coal underlies towns, farms, or other areas devoted to high-value land uses, careful evaluations must be made of the alternate benefits of present uses versus those of coal to be mined. Should the determination be to proceed with mining, careful planning to minimize disruption of normal activities is necessary.

Special measures also are necessary to minimize the impacts of mining in close proximity to urban areas. These might include care to maintain suitable esthetic qualities, reduction of noise and dust, operation during hours of least disturbance, provision for guided tours, company participation in community activities, and reimbursement for services received and nuisances created.

In cases where other minerals of commercial worth occur in the same lands where coal is present, plans should be to capture the values of all. Concurrent mining operations to produce both (all) minerals is one possibility. Stockpiling of one mineral for future use is another. If the other mineral or minerals have greater potential value than coal, then coal mining could be postponed until it could be conducted concurrently with mining of the other mineral.

(6) Human-Value Interests

Impacts on the human-value interests of land where mining is to occur can best be mitigated by advance planning. Interests considered include those that are esthetic, historic, geologic, paleontologic, and archeologic in nature.

(a) Esthetic Values

Coal mining in areas of outstanding beauty should be avoided. Other areas of unique characteristics and great human-interest value — such as wilderness areas, parks, scenic areas adjacent to principal highways, etc. — should be in the lowest priority of areas to be mined. Likewise, areas of somewhat lesser esthetic values which are highly susceptible to long-term reduction of aesthetic quality -- such as tundra, semi-arid areas, or highly erosive slopes -- should be given low priorities for coal mining.

To mitigate the adverse visual impacts of mined areas, disturbed areas should be shaped to form nonerosive gradients; natural drainage patterns should be reestablished to the extent possible and in such a manner as to minimize erosion; spoil areas should be promptly revegetated to grasses, forbs, shrubs, and trees that harmonize with the surroundings; and the planned future uses of the mined area should be esthetically compatible with the surrounding countryside.

Select the mining method such as the modified block cut, that least disturbs slopes. If possible, fill the last excavation with spoil removed from the first so that no cuts are left empty. Shape spoil to the configuration required for final use. Blend the spoil area through a transition zone of rolling into the adjoining grade. Slope highwalls to suit the planned future use. Plant trees or brush near the base of any remnant highwalls in need of disguise.

(b) Historic Values

Since the impact on historic resources will in large measure be in proportion to the amount of surface disturbance, extensive recording, salvage, excavation, and structure relocation may be required. These steps should all be taken prior to issuance of a coal lease. If historic values are sufficient to warrant it, mining should be prohibited.

(c) Geologic Values

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(c) Geologic Values

Surface mining of coal should avoid all geologic features of high-value interest to best mitigate environmental impact. Surface mining can also be executed in a manner which would avoid these features and still extract the mineral from nearby.

A degree of mitigation can be bad by mining around surface features and restoring as nearly as possible the setting prior to mining. This will apply to features such as caverns, caves, geomorphic features, rock formations, badlands areas, and scenic viewpoints.

(d) Paleontologic Values

Of very high value and great importance are the paleontological values to be found in some of the coal provinces. It is very difficult to keep from destroying paleontological specimens in the overburden. A mitigating measure would be to make a paleontological survey prior to excavation, to determine if paleontological materials exist in the overburden. Initially this would be a search of published information. Certain formations and geologic time scale are more likely than others to reveal paleontological materials. Certain areas and formations have more than others and the paleontologist will know what can be expected. From this and other information such as drill cores, the probability of paleontology values in a given area can be predicted. A paleontology-trained miner or contracted scientists should be available to salvage and preserve paleontological values unearthed during mining. Materials found remain Federal property for further study and public display.

Fossils have the protection of the Antiquities Act of 1906. The law provides penalties of $500 and six months in jail for anyone who damages anti-

quities. This is a mitigating measure if it is enforced. It is applicable :o the person which does the damage and also to the Federal official who ıllows it to happen. Solicitors'opinions have placed vertebrate fossils ɔn a higher order of value than invertebrates and plants, but all fossils ıre protected by law. Futhermore, should the geologic feature be on the Iational Register of Historic Places, or be eligible for nomination, a ;tatement describing the action (in this case, coal leasing) must be subıitted to the Advisory Council on Historic Preservation for comment. This .s known as a "Section 106 Statement" and must be submitted as directed in ;ection 106 of the Historic Preservation Act of 1966, Public Law 89-665.

(e) Archeologic Values

An archeological survey of the lands to be ıined should have been made before coal exploration began. If this has ·een done and all archeological values have been inventoried, tested, stu-.ied and evaluated, and if needed, excavated, the only remaining mitigation 'ould be to situate the mine in a location that would impact these values east and avoid them if possible. An archeologist commonly has a certain ·roblem to be solved or a particular area to explore in search of a certain et of information. He then will select the most appropriate site to surey or excavate, and publish his findings. Often an archeologist will com-·ine several seasons of work to prove or disapprove, modify, or develop an ntirely new theory in archeology. Salvage archeology is not problemriented and only by sheer coincidence will the work contribute to solving larger problem. All archeological sites should be left undisturbed until t is determined that the excavation of those sites can provide needed information.

Continued protection of all archeological values in the immediate are of a mine should be stipulated as a mitigating measure. The lease grantir agency can modify or deny a lease if the archeological values are signifi cant to science or of great interest to the American public. Also, if th archeological values are on the National Register of Historic Places or eligible for nomination, a statement must be prepared and forwarded to t President's Advisory Council on Historic Preservation for comment.

c. Beneficiation

Beneficiation consists primarily of upgrading or washin coal. Frequently, this leaves large piles of waste or unusable material that is separated from the coal. Such material can be pumped or hauled back into the mine. In the case of underground coal mines, it can be returned to mined out areas or in strip-mines, it can be dumped with the spoils in sections that are to be covered and revegetated. If the materia is piled near the washing plant, care should be taken to insure that the fines are not allowed to wash or blow away. A dam may be necessary to con tain sediment. Dry material can be sprinkled with water to prevent the dust from blowing away. The pile should be graded, covered with topsoil, and reseeded as soon as possible to restore vegetative cover. Care must b taken to monitor the water carrying waste materials to be sure that pollutants do not enter streams. Wastewater from coal beneficiation plants can be settled and treated similar to mine drainage. Reuse of waters wherever possible reduces the consumption of water, and also reduces disposal problems. Proper construction of spoil pile dams in narrow drainages is essential. There must be an allowance and consideration of heavy local storms that could wash-out a spoil pile and cause flooding dowstream.

d. Potential Extractive Techniques

Little is known about potential extractive techniques or the possibility of any technique becoming a commercial method of extracting coal or energy. Therefore, the resulting impacts on the environment are speculative and the mitigating measures become more speculative. It has been assumed that all techniques will require a surface plant, and some will require pipelines and roads. It was also assumed that surface subsidence would result. Beyond this, additional assumptions should be held in abayance until a commercial process becomes a reality.

Air and water pollution from plant facilities can be prevented by known and approved methods. Unless some method is developed to fill the mined area as the coal is removed, the extraction site would have to be one that future land use would not be impaired by surface subsidence. For those techniques requiring a network of roads and pipelines, a systematic recovery plan would keep the number required at any one time to a minimum. As extraction proceeded around or across the area, roads and pipelines would be constructed where needed, and old roads and pipeline paths, no longer necessary could be rehabilitated. When the coal or energy extraction is completed, the plant site and waste piles or pits, if any, would be rehabilitated the same as required for any mine plant on a Federal lease.

e. Measures to Conserve Coal Through Most Complete Extraction Feasible

Close supervision of the mining of Federal coal will assure that as much coal as feasible is extracted. This in turn will decrease the

size of the disturbed area per unit of coal extracted and the impact on the environment. Also, extracting the coal as completely as feasible conserves other deposits for future use. However, in addition to recovering the coal safely and economically, the degree of completeness of extraction depends upon many related factors. The important factors include: depth and thickness of the coal seam(s), distance between seams, method of mining, condition and type of roof and floor (floor only for strip-mining), mining equipment, efficiency of operation (includes safety, supervision, and productivity), and marketability.

Each coal deposit must be considered separately to determine how it should be mined to extract the coal as completely as possible. The depth and thickness of the coal seam(s) generally determines the method of mining. With few exceptions, coal seams more than 150 feet below the surface would be mined by underground methods. Again, with few exceptions coal seams more than 1,500 feet below the surface should be considered reserves for the future, since recoverability of coal decreases rapidly below 1,500 feet.

Wherever possible in multiple seam deposits, the upper seam should be mined before the lower seam. When underground mining methods are used, this can be accomplished by keeping the workings in the upper seams in advance of the workings in the lower seams. Pillars should be superimposed in the respective seams, and none should be removed from lower seams until all have been removed from the upper seams.

Where surface mining methods are used, coal should be recovered from the upper to the lower seams as each is exposed. A surface mining plan should contain provisions to recover all marketable coal in seams above the

lowest seam mined.

Limitations for conserving coal seams of recoverable thickness include thickness of seam, distance between seams, condition or type of roof or floor, and marketability.

In underground mining, recovery completeness is lessened in seams greater than about ten feet in thickness because no safe, efficient method of mining seams to a height much greater than ten feet has been developed. When two seams are as close as 40 feet apart, generally recovery from both seams will be difficult if not impossible. Hence, in the interest of safety and economics, recovery usually is attempted from only one seam which results in the loss of the other. For a safe operation, the condition or type of roof and floor dictates the amount of coal that must remain as support. Where the roof is bad and the floor will heave or is composed of wet, soft material that will not support mining equipment, completeness of recovery will be considerably less than in a mine having a good roof and sound floor. At surface mining operations, a sound floor is also necessary. Otherwise a layer of coal must be left to support the coal loading equipment. When this is necessary, recovery is reduced accordingly.

If economics would allow, unmarketable coal could be conserved by recovery and stockpiling until methods of upgrading to marketable coal are available. Ash and sulfur removal are being researched in an effort to alleviate a part of this loss. Other limitations of recovery must wait until the technology is developed to overcome the losses.

Efficiency of operation is one way that completeness of recovery may be increased. Planning and close supervision are necessary to see that no

oal is wasted. In underground mines, all coal broken at the face should be ecovered, and spilled coal should be cleaned up. Pillars should be of ufficient size for support, but not larger than necessary. Where it is ecessary to have supporting coal in the roof and/or floor, it should be losely supervised to assure that no more or no less remains than necessary. n surface mines, keeping all loose coal pushed up to the loading face will ncrease recovery. Coal should be loaded so that recovery will not be essened by spillage en route to the tipple. Mining should be planned so minimum of coal will be left in fenders for protection of the exposed oal seam from adjoining spoil areas. Cleaning the surface of the exposed oal seam should be done with minimal waste of coal.

To prevent loss from slacking or fire at both underground and surface nes, production should be planned to minimize the amount of coal exposed the air. Loss of coal from slacking or fire can also occur if impro- rly stockpiled in a plant area.

f. Coal-Fired, Mine-Mouth, Electricity-Generating Plants

Control devices will, when functioning properly, reduce ission of particulates, greater than approximately two microns in size, meet Federal approved air quality standards.

Emission of water vapor from cooling towers and ponds can be partially tigated by using dry cooling towers. Consumption of water resources can partially mitigated by using dry cooling towers which consume 1,500 acre et of water per 1,000 megawatts per year, versus 10,000 for wet cooling th ponds or 15,000 for wet cooling without ponds.

Thermal pollution of streams, rivers, and lakes can be partially mitigated by using dry cooling towers.

Pyrite and marcasite have a high specific gravity, and most of this material can be removed from coal by various washing and cleaning procedures. The other forms of sulfur have lower specific gravities and are more intimately mixed with the coal, and consequently, are less easily removed.

Between 60 and 65 percent of all coal mined in the United States is cleaned to remove pyritic and inert material before use. However, in spite of such large-scale cleaning, the average sulfur content of all coal used in the United States is still nearly two percent.

Current efforts to reduce the sulfur content of coal and of flue gas take many forms:

(1) Much research is in progress on methods to remove sulfur oxides from flue gas. This can be done by several well-known chemical processes, and the technical problems inherent in the large-scale commercial application of chemical processes are likely to be solved in the near future.

(2) Meanwhile, the search for low-sulfur coal has been intensified, particularly in the Eastern States, and the use of lower-sulfur coal has been increased. A few older coal-burning utility plants in the Midwest have converted from high-sulfur local coal to low-sulfur Rocky Mountain coal. This substitution has required payment of transportation costs, and acceptance of the lower heat content of Rocky Mountain coal.

(3) Much research is in progress on methods to produce a high-BTU, sulfur-free gas from coal. This is also a technical possibility

soon to be realized. It has the multiple advantages of lowering the costs of long-distance transportation of energy, of eliminating the sulfur problem, of augmenting declining resources of natural gas, or reducing dependence on foreign sources of oil and gas, and ultimately permitting use of high-sulfur eastern coal.

These varied avenues of approach suggest that the amount of sulfur leleased to the atmosphere by the burning of coal will soon be greatly reduced.

V ADVERSE ENVIRONMENTAL IMPACTS THAT CANNOT BE COMPLETELY MITIGATED

This section discusses impacts that can be expected to remain despite application of mitigating measures. Included are unavoidable impacts not subject to mitigation and the net remaining adverse impacts that can be only partially mitigated.

A judgmental factor must be imposed to estimate the effectiveness of mitigative measures. It is assumed that prescribed mitigation procedures will be diligently applied.

Unmitigatible impacts are presented in two parts. The first part considers impacts on land uses, population patterns and considerations, and human-value resources. The second part considers impacts that exploration, development, and production actions have upon the natural environmental components.

A. Land Uses and Socio-Economic Values

This section describes the unmitigated impacts that coal actions have upon land uses, local populations, and human resource values for all provinces and biomes.

1. Land Uses

a. Agricultural

Rehabilitation success varies with areas and climate. It may not be possible to restore an area so it will grow the same type of crop. The productivity level also may be lowered.

b. Timber Production

Residual negative impacts during the exploration phase on timber production are generally minor and limited primarily to a temporary setback in timber production on relatively small areas. There is usually time to preharvest timber from coal fields prior to development and to rehabilitate and reforest such areas, except in cases of toxic spoil areas, saline water contamination, soil compaction or loss of redistributed soil by erosion. Rehabilitative success, therefore, varies between forest types depending upon the actions applied, and it may not be possible to entirely restore some areas to their original productivity.

c. Mining

Surface slumping or subsidence can happen after coal has been extracted despite precautionary mitigation measures. The resulting instability can make the area unsafe for the mining of other minerals.

d. Urban

Coal development would precipitate serious land use conflicts when occurring in residential, commercial, or industrial areas. Coal operations would be entirely out of character with residential land use in particular.

e. Recreation

Roads and structures associated with coal development change the character of the natural landscape. While increased access provides a beneficial impact to many recreational users (especially those using "off-road vehicles" for primary or secondary recreation purposes), the general impacts are adverse.

Coal development is non-compatible with wilderness land use by definition. Such development within areas of present wilderness quality would have a severe impact not capable of being mitigated, except over an extremely long period.

2. Socio-Economic Values

a. Social

Influx of outsiders, brought by coal mining and energy plant exploration, development, and operation will have a permanent effect on sparsely populated areas and small communities in proportion to the numbers and attitudes of the people involved. Conservative social values of traditional populations will have to change somewhat to accommodate social values brought by newcomers. Impact will be, in large measure, dependent on the ability of local populations to accept social change, and this in turn will depend on the extent of change and rate at which the change takes place. In-migration of a modest number of well-intentioned, mining-oriented people into a small community could result in their being welcomed and rapidly assimulated into the existing social fabric. On the other hand, the coming of proportionately large numbers of ethnocentric, selfish coal miners and plant workers to a community, where they were as numerous or more so than the local people, would likely have a continuing and unmitigated adverse social impact. So far as radical changes affect the social fabric, rates of delinquency, crime, personality disturbance, alcoholism, alienation, and rootlessness will be increased and the impacts of coal mining and coal energy conversion remain unmitigated.

b. Political

In-migrant populations, dependent on and oriented toward coal mining and energy conversion, and the influence of powerful busines corporations engaged in the same and related industries cannot help but threaten a heavy unmitigated impact on established political patterns. So far as changed political power is able to dominate the existing political establishment, through numbers and corporate influence, the impact on the political life of a community, county, or state will not be mitigated.

c. Economic

The impact on the ranching, agricultural, and recreatio- al aspects of local economies cannot be entirely mitigated. Lands used f mining and plant purposes, as well as attendant transportation routes, wi be removed from these aspects of the local economy. People whose economi livelihood derives from these existing uses will suffer accordingly some degree of economic dislocation and loss. Economic unmitigated impact wil be in proportion to which local populations do not derive economic benefi from the advent and expansion of coal mining and energy conversion develo ment and production.

d. Ethnic

Unmitigated impacts on native Indian groups, and to some extent on all other ethnic minority enclaves, cannot be avoided with the advent of massive coal mining and energy conversion in or adjacent to the communities. Influx of newcomers will result in some degree of ethnic di- lution, due to intermarriage. Lessening of ethnic bonds will result in a trend toward ethnic conformity and sameness. Indians, Eskimos, Hispanic- Americans, and communities of earlier settled "American ethnics" in the plains, deserts, and mountains, will all be affected to some degree.

e. Cultural/Religious

Economic, social, political, and ethnic factors of status and power in a community interact with and heavily influence cultural/religious lifestyles. To the degree that population patterns change, without positive progress to preserve existing cultural/religious patterns, the impacts on these cultures will remain unmitigated. Indian, Eskimo, Hispanic, other ethnic and nationality groups, and communities whose lifestyles are rooted in traditional ranching and agriculture and their related culture values will be impacted heavily if proportionately large numbers of in-migrants enter these areas as the result of coal mining and energy conversion activities. Increased population density itself will have an impact on restricting open space for such activities as hunting, which in the West is not only recreation, but deeply ingrained in many local Indian and non-Indian cultures. Land uses will change. The social fabric will be altered by the influx of newcomers and the cultural framework will never be the same again. What have been dominant cultures will have to change to some degree to accommodate new people and new conditions. The level of impact and what elements of it remain unmitigated will depend on the numbers and power of the newcomers, their acceptance of and sympathy for existing cultures and programs to buttress and encourage the viable continuance of these cultures. Cultural/religious impacts cannot be completely mitigated. To the degree that impacts are not mitigated, particular culture groups will suffer severe personal and group cultural loss and deprivation. Indian groups could be especially impacted in ways permitting little mitigation. Loss of cultural diversity of language, arts, lifestyle, and folklore will be unmiti-

gated impacts in the degree to which they occur. In-migration of numerous newcomers and altered economic, social and political power structures could easily overwhelm existing Indian and other cultural groups. Loss of cultural identity, for individuals and groups, is a significant factor in producing alienation from the world in which the losers live. Persons and groups suffering personality disturbance sometimes have suffered the loss of their cultural and traditional identity patterns, and loss of cultural identity can be assessed as a contributing factor to individual and group personality disturbance.

To the degree that cultural diversity is lost and evened out, the pressures for cultural sameness and conformity will result in culture loss for all Americans. Rich cultural and religious factors once evident in much of American life can be destroyed in too rapid and radical change, and once destroyed, they are often not replaced.

f. Health and Safety

Accidental deaths and injuries may take place despite safety measures. Where industry personnel are concerned, the magnitude of the problem from year to year is about directly proportional to the number of workers involved.

If proper precautions are taken (patrolling roads, signing, shutting down operations when climatic conditions warrant, etc.), to protect the health and safety of the general public, accidental deaths, injuries and health problems can be kept to a bare minimum. The hazards, however, cannot be completely mitigated.

g. Esthetics

There will be substantial unavoidable impacts on the visual environment during the operational periods of all phases of coal operations. Vegetation patterns are interrupted in all phases. Structures are placed on the landscape for varying time periods in the exploration, development, and production phases. Some movement of soil will occur in all phases. Each of these actions interrupts the natural character of the landscape and none can be entirely mitigated. The deserts and tundra will have the slowest recovery rate. The relatively high esthetic values of the desert create the greatest potential for non-mitigated esthetic damage.

h. Historic

Facets of coal exploration wherein heavy equipment destroys historic ruins, trails, and earthworks create unmitigated impacts on historic resources located on the land. Any activity, be it coal development or production, disturbing the historic surface, or subsurface in rare cases, results in loss of the tangible historical resource.

Loss of historic event sites involves the loss of one important physical avenue to enable people to understand and partly experience the past -- removing the possibility of comprehending many aspects of the historic heritage through sight, touch, and feel. Historic structures, objects, and event sites given an immediacy to the past that purely intellectual comprehension from books and graphics alone cannot supply. If the intrusion on and alteration of the historically familiar scene is radical and extensive enough, one can easily lose identification with the past -- a elling loss to individuals and groups.

Mine and plant operations located on historic sites will physically des-roy them. As an example, the circumstances of the January, 1877, Battle f Wolf Mountain will be lost if and when large areas of that battlefield n the Tongue River in Montana are strip-mined for coal where General N.A. iles defeated the famous Sioux leader, Crazy Horse and his Cheyenne allies. ne rugged hills and valley bottom river benches where the action occurred, nd which largely determined the course it took, will be altered.

Relocated historic structures also suffer loss in that removed from coal peration sites they are no longer in their historic setting. Likewise, otrusive coal operation roads, structures, and other developments adjacent o historic places will to some degree lessen their hisorical value in the easure that the scene and setting have been changed.

i. Geologic

Geological stratigraphic relationships, geomorphic fea-ures of human interest value, paleontological specimens, limestone caverns id caves, badlands areas with various colored strata exposed, hydrologic eatures of human interest such as waterfalls, and all manner of scenic eas will suffer adverse environmental impacts that cannot be completely itigated if the ground surface or the level at which they are found is dis-urbed.

Some features such as the scenic areas can be rehabilitated and the verse impacts will be somewhat mitigated, but no amount of man-made re-bilitation can restore a disturbed site to its original form with all lues as they were before disturbance. Natural features, once lost, are

one forever.

The effect of this loss will be one of a lessening in the quality of ife; a narrowing or alternatives in the paths people's lives follow uring their lifetime. This can be typified by likening if to having a ew less pretty views to enjoy, fewer caverns with stalagmites and stalatites to marvel at; like picking a flower and slowly, idly pulling off he petals until the flower has no more, and there are no more flower abund. This would demean our lives if no more flowers existed. We would ave to choose from a list of fewer alternatives to find what we sought by ılling off the flower petals. Perhaps we would sublimate our needs by lowing seeds off dandelion stems, but would this substitute act be as atisfying as pulling off flower petals? We would no longer have flowers round so we couldn't go back to pulling off flower petals and in this way ır alternatives would be diminished and also the quality of our lives. s the population has increased, so has the need for places of high human nterest value for man to visit and recreate himself.

j. Archeologic

Impacts on the archeologic environment which cannot be itigated are those associated with surface disturbance. There will be reakage and in-situ disturbance of objects during coal mining activities. nere will be a loss if archeological sites are completely excavated in a urried manner. These will be in the form of overlooking, breakage, and nsufficient present-day techniques which will be improved upon in the future. ncreased activity in the area will inevitably result in more vandalism of rcheological and paleontological sites.

B. Environmental Components

This section describes the impacts that coal exploration, development, and production have upon the components of the environment which cannot be completely mitigated.

Any human action that alters the abiotic environment or biotic community can impair ecological relationships to some degree; mitigative measures cannot be entirely effective. Despite all feasible precautions, some coal operations will upset the natural balance of ecosystems, at least temporarily. Actions or accidents which destroy vegetation, disturb soil, degrade water quality and pollute the air will cause some disruption of ecological interrelationships. In these instances, the nutrient cycle and hydrologic cycle may be interrupted until the affected area is revegetated and soil is stabilized, or until the source of pollution is removed.

Fragile ecosystems, where productivity is low and the natural balance delicate, will be most severely impacted and slowest to recover, particularly where the ecological equilibrium has been impaired by other human activity prior to coal operations. If grazing, farming, road construction, logging, mining, recreation, etc., have already affected ecological interrelationships, the added impact of coal operations may create a total cumulative effect that may not be offset by mitigative measures.

1. Exploration

Proper administration of Federal coal drilling permits by the Federal land managing agency and the Geological Survey will generally leave few unmitigated environmental impacts. Revegetation of areas disturbed by roads and drill sites require varying treatments and lengths of time depending on the climate, soil, and terrain. Enforcement of permit stipulations will ensure that drill holes are sealed and capped, including cementing if necessary to prevent interflow of water between aquifers, that trash is removed, and that access to and placement of drill sites is in accordance with an approved plan.

One aspect of drilling that cannot be completely mitigated occurs when an operator drills for coal information under the guise of the 1872 mining law. In order to drill for coal on Federal lands, one must have a valid prospecting permit or lease. The Federal government has not authorized any prospecting permits since January 1971. Before a company or individual bids on a competitive lease, he wants to know as much about the coal, overburden, soil, and other factors as possible. Since the Federal government has not recently authorized private drilling for coal data, some drillers have claimed that they were drilling for locatable minerals such as gold, lead, zinc, copper, uranium, etc. The Federal government can control drilling and all stipulations for leaseable minerals, but cannot control drilling for locatable minerals.

Whenever soil is disturbed, eroded, or removed, soil organisms will have their life cycles interrupted and populations will decline for an unknown time. There will be shifts in populations among species as food and energy sources are changed.

Whenever the natural interactions of parent material, vegetation, topography, and climate are disrupted by any action, the soils will be affected. Mitigating measures cannot immediately and completely restore soils to their former state. Soils may be stockpiled, moved, and redistributed, but to some degree, the impacts will remain until the interaction again have t to reach equilibrium. The time required for equilibrium ranges from de cades to a few hundred years in areas of high rainfall to many hundreds of years in arid climates.

Erosion processes are accelerated any time the protective cover is r moved or the soil is disturbed. Mitigating measures after major distur bances reduce erosion, but very rarely eliminate it. Productivity of t natural vegetation will be reduced if the soil is disturbed or compacte Some fill or cut back failures occur when roads, or trails, are constru ted on steep terrain. Of all exploration activities, road construction will have the maximum unmitigatible damage to the soil.

Some sediment may be produced by all except airborne exploration act ties. The sediment may adversely affect water quality. The amount of pended sediment produced after mitigation from any one action on a spec fic area will vary with conditions.

Exploration drill sites, pits, and trenches eliminate vegetation, an the semi-arid southwest, where precipitation is eight inches or less, r getation is very slow. The same is true in areas underlain at very sha low depths by materials not capable of supporting plant growth.

Roads constructed in steep terrain leave portions of the road prism denuded of vegetation. Areas denuded by roads or off-road vehicle trav in the most arid areas will remain bare.

After long narrow exploration, trenches or pits are dug and filled, pattern may disturb water runoff. The raised area may act as a dike wh a depressed area would act as a channel. If much of a coal or soil sam is removed, it will leave a depression. The larger the excavation, the more noticable will be the final appearance. Unfilled pits may collect water which may be good or bad. The water may be potable, or be acidic or alkaline.

Some aquatic vegetation will be destroyed or buried by road or trail construction at streams, marsh or lake crossings. The loss in productivity would depend on the magnitude of destruction and would be long-term in nature, unless a similar amount of vegetation could be replaced elsewhere in the ecosystem.

The destruction of aquatic vegetation caused by a massive earth slide down a stream channel cannot be reasonably mitigated in most cases after the slide occurs.

Sedimentation of aquatic ecosystems may be increased above natural levels despite all mitigative efforts to prevent it. Unavoidable sediment deposits in stream and lake habitats will result primarily from roads and trails.

While most impacts on wildlife through the exploration phase can be reduced by implementation of mitigating measures, some mortality, displacement, and temporary habitat loss may be unavoidable.

Cross-country ORV travel; exploratory road, trail, and drill site construction; movement of exploration equipment; and test-trenching operations may cause some direct wildlife mortality. These losses will be relatively small and primarily involve bird nests, young birds, rabbits, burrowing rodents, reptiles, and invertebrates.

Displacement and disturbance of animals will still take place, but it

can be mitigated to the extent that it would take place in the least disruptive manner possible and during the less crucial times of year.

The immediate impacts of relatively small terrestrial habitat losses cannot be mitigated. Rehabilitation of sites damaged by cross-country vehicle use and earth moving activities will mitigate the long-term effects. If roads and trails are not closed to public use during and after rehabilitation, habitat damage may be relatively permanent.

Despite mitigative measures during exploration, increased soil erosion and sedimentation of surface waters will occur from roads, drilling sites, trails, ORV travel, and test excavations. Some damage to aquatic resources and fish habitat will occur, the magnitude depending upon variables such as soil types, terrain, climatic conditions, and degree of development.

2. Development

Surface mining leaves a change in the topography and hydrology despite mitigation measures. There will be spoil pile mounds in areas that were once nearly level. The spoil cannot entirely be replaced in its original location in steeper topography. Actions which change the topography of an area also change the surface drainage patterns.

Stream crossings will inevitably produce suspended sediments. The act of constructing adequate stream crossing structures and fords will increase suspended sediment during the construction phase. Unexpected, or unusual, peak flows may cause stream crossing structures to fail. These climatic events may also cause coal pits to overflow and the contents to enter stream channels. Failure of earthworks which contain settling ponds during heavy rains may allow sediment or toxic material to reach streams, lakes, and marshes.

Geophysical data may be misinterpreted and shallow, or narrow, groun water aquifers may be overlooked and subsequently disrupted by stripping or mine preparation.

There is a possibility of physical damage to the boundary limitation c an aquifer due to explosions. Should this actually occur, it would repr- sent an adverse impact which would be virtually impossible to rectify by any mitigating measures.

The original natural soil arrangement cannot be reconstructed after is moved, compacted, or altered during construction of coal mining or po r plant facilities. The losses in soil productivity and vegetation cover y be minimal where the precipitation exceeds eight inches and severe in ar s receiving less than eight inches. In these semi-arid areas, especially the southwest, vegetation is sacrificed where construction of buildings, roads, and railroads, and spoil areas occur. The sites of utility poles or towers would also suffer unmitigated impacts on vegetation.

The impacts on wildlife from mine facility development cannot be mig gated in the immediate area of the facilities during the life of the mine During construction, the wildlife and wildlife habitat will be displaced or destroyed. Small sedentary animals are more prone to destruction whil larger animals such as some big game species and predators will leave the area. Mitigation through habitat rehabilitation cannot be accomplished u- til the facilities are removed, usually after 30 to 40 years. Impacts on some species may be permanent depending upon the type of rehabilitation employed and the land uses after mining.

The displacement of animals such as elk and others which are intolerant of man's activities cannot be mitigated until these activities cease.

Hazards to wildlife from roads, fences, trains, powerlines, etc., cannot be completely mitigated. Construction of new roads even with high engineering standards, has a residual impact on wildlife never fully erased. Some animals may be killed despite efforts to reduce loss.

The hazards of aquatic life from sediment pollution cannot be completely mitigated. After the initial facility construction period, erosion control measures and revegetation of unused areas will decrease the accelerated erosion. Sediment loads from the original construction will already be moving downstream and sediment from road drainages, poorly revegetated areas and new construction activities will continue to cause some sediment pollution.

The long-term ecological effects of sedimentation of streams, ponds, and lakes are often of greater consequence to aquatic species than are immediate short-term effects of direct mortalities.

3. Production

The major underground mine effect that cannot be completely mitigated is subsidence or caving. Degree of subsidence depends upon mining methods, thickness of seams, and depth from the ground surface. Old or even new workings may collapse, changing the character of the surface. It may affect the water table, crack foundations, open cracks or pits on the surface, and cause roads or structures to sink. This is a major concern under towns or developed areas. It is not always possible to predict the rate of subsidence, when it will occur or how large an area will be affected. Subsidence will be minimal if all the mitigating measures are fully implemen d.

The waste material brought to the surface from underground mines may cover existing vegetation or fill a valley or drainage. It may cause a d or alkaline leaching to enter drainages. It may set up unstable soil c -ditions on steep slopes or on waste piles. It may cause dust problems l -fore surface cover is reestablished. These problems cannot be complete mitigated.

Potential extractive techniques causing subsidence would have similar unmitigated impacts.

Underground coal fires occur despite mitigating measures. Coal burns to scoria which changes the geology.

Even with good cooperation by the coal industry, application of all feasible mitigative measures and careful observance of operational rules and regulations, there will continue to be some impacts upon air quality

Strict enforcement of air quality standards cannot entirely eliminate atmospheric pollution by coal operations. Air quality will inevitably b degraded, at least temporarily and locally, by engine emissions and dust arising from road, drilling site, and pit construction as well as from movement of surface vehicles. Accidental coal fires will occasionally add toxic vapors and particulates to the load of noxious materials alrea y in the atmosphere.

During coal mining, subsurface material with higher concentrations of certain soluable elements than are found in surface materials is transpo te to the surface. Introduction of these elements into the surface environ er -- water, air, plants, animals, and man -- changes interrelationships in varying degrees from what they were before.

The reduction in ground water resources when ground water is used in coal operations is an impact that cannot be avoided. In areas with substantial water resources, this impact will be of little consequence, but in water deficient areas, it may be of greater concern.

Accidents during production may contribute additional sediment to streams and lakes. The long-term effects of excessive sedimentation are often more serious to aquatic plants in shallow water habitats than short-term effects from a single pollution kill.

Stream crossings or other activity which introduce suspended sediment into bodies of water which contain aquatic organisms is going to cause some damage to these populations. Leakage of toxic substances into these waters can occur through failure of containment structures. Damage to aquatic populations may occur through the discharge of hot water into a body of water even though the discharge may otherwise be of good chemical and physical quality. Failure of a well-designed sewage disposal system may allow effluent to reach streams, lakes, marshes, or estuaries.

Steeper slope gradients along spoil banks' periphery, as well as remnants of high walls will be a source of accelerated erosion.

Some properties of topsoils are not restored until equilibrium with the environment is reached. Nutrient recycling, profile development, and organic matter cycling are examples of items not completely mitigatible.

Roads, railroads, building sites, and waste disposal sites are areas on which impacts on soils continue for the life of the facility, rehabilitation measures are only the first step in a chain of natural processes that

must continue for a long time before former equilibriums are restored.

In areas of less than eight inches annual precipitation, sites occupied by waste piles and settling ponds will be denuded of vegetation.

4. Coal-Fired, Mine-Mouth, Electricity-Generating Plants

Even in compliance with air pollution control standards, it is inevitable that small quantities of pollutants will go into the air when coal is burned to generate electricity.

Emission of particulates of less than two microns in size, which impair visibility and cause breathing problems, can be reduced only slightly.

While technological advances will reduce the amount of sulfur dioxide emitted within the next few years, some will remain.

Removal of carbon dioxide and oxides of nitrogen to lower levels will require additional research.

The magnitude of such impacts may be significant only locally and temporarily. However, there may be some cumulative effects on the upper atmosphere (and hence on the earth's general climates) which are not yet fully understood, (Maunder, 1969).

With the best of mitigation, 1,500 acre-feet of water per 1,000 megawatts per year will continue to impact air and climate as vapor and therefore will not be available for other uses.

Synergistically toxic effects of emitted oxides of nitrogen and sulfur on vegetation cannot be mitigated. Water pollution from airborne oxides of sulfur and nitrogen cannot be mitigated, except by reducing the quantities reaching the water courses.

Damage to biota directly or through reduction of its resistance to disease by concentration of emitted gases and particulates, as during periods of little air movement, cannot be mitigated.

No techniques exist to control emissions of some trace elements -- beryllium, mercury, cadium, chromium, nickel, selenium, arsenic, and manganese -- that may be hazardous to human health if in sufficient quantity

VI RELATIONSHIP OF FEDERAL COAL LEASING TO LONG-TERM PRODUCTIVITY AND MANAGEMENT OF THE LAND

Coal is mined because it provides a needed source of energy to enhance the human environment. When burned in stoves and furnaces, it releases energy, stored for millions of years, to heat homes and factories. Its energy can be converted to steam and electricity for domestic and industrial heat and power. Coal can be chemically converted to a myriad of useful products.

These environmental values must be weighed against the environmental impacts of the coal mining process. Similarly, the value of the land before coal was mined must be compared to the values of the land after mining. Sometimes, post-mining land values exceed pre-mining values. Usually, they do not. Any losses of value to the mined land must be compared to the environmental enhancement elsewhere that resulted from the use of the coal.

A. Values of Coal and Coal Mining

1. Economic

In 1972, total coal production in the United States amounted to 590 million tons. Production under Federal leases amounted to 10.2 million tons or 1.7 percent of the total. The mine-mouth sale price received by the Federal lessees was $53.4 million. Income to the Federal Government in 1972 from coal leasing was $2.3 million.

By the yea^r 2000, it is estimated that the nationwide need for coal will increase threefold, but that it will be necessary for production of Federal coal to be increased 17 times the 1972 level. Therefore, by the year 2000, a total of 175.8 million tons of Federal coal, with a mine-mouth value of

$920 million, will be needed each year. Based on present rates, the revenue from royalties on Federal coal would amount to $144 million annually, of which the States where Federal coal was mined would get 37.5 percent or $54 million (based on the formula in effect in 1973).

Assuming that 85 percent of the Federal coal produced in 2000 would be extracted by surface mining methods, about 31 surface mines -- each producing five million tons per year -- and ten underground mines -- each producing two million tons per year -- would be required.

A surface mine producing five million tons of coal per year requires about 610 employees and a capital expenditure of about $40 million. Thus 31 surface mines would provide permanent employment for 18,910 people and require capital investment of $1,240 million. Ten underground mines would provide about 5,000 permanent positions and require capital investment of $240 million. Total for both types of mines would be 23,910 jobs and capital investment of $1,400 million (National Petroleum Council, 1971).

The projected increase in Federal coal production can in part be attributed to two characteristics of major Federal coal deposits which add value to them. Most Federal coal can be classed as low in sulfur content, and most is recoverable by surface mining methods. These factors make Federal coal preferred for power generation, gasification, and liquefaction. Federal coal in Wyoming and Montana, for example, is competitive with locally produced private coal in the Midwest for use in population centers around Chicago and St. Louis.

Plans are being formulated to build new gasification and liquefaction plants, using Federal coal primarily, to produce gaseous and liquid fuels

These products can be substituted for natural gas and oil used in some powerplants.

Powerplants without coal burning equipment can be converted so they can use coal, and new powerplants can be designed to burn coal as well as oil or gas.

To the extent that coal is substituted for oil and gas, imports of those products from other countries can be reduced, with a subsequent improvement in the United States' balance of payments.

The abundance of and accessibility of Federal coal makes it an important fuel reserve for national security. The fact that most Federal coal can be mined by surface methods, which can be operational more quickly and with smaller investments and less personnel than underground mining, enhances its value for defense purposes.

The steel industry of Utah and California uses coking coal of high unit value mined in the Uinta region of Utah and Colorado. The role of coking coal is important in the western States' economies, even though the reserves are small in comparison with other supplies that can be used for power generation or direct conversion to other forms of energy. Shallow deposits of privately owned coking coal are being rapidly depleted, so future supplies will be almost totally from Federal lands.

2. Social

Coal mining provides work for many thousands of people; men who identify with a role in life that has a certain set of expectations to be met and rewards to be collected. A coal miner might know another by his language. Gob, bone, tipple, highwall, long wall, roof bolts, and parting are common words with a special meaning when applied to coal mining.

Meaningful employment for workers in the coal mines, along with wages paid, has been a stabilizing social, cultural, and political factor.

Coal represents a large segment of this Nation's wealth and as such influences political, social, and economic thinking and actions. Steady employment at a good wage for the miners of coal and a profitable operation for the coal mining companies provide local, state, and Federal governments with a tax base which can be used to finance the social, community, and government services for the benefit of the country. Social welfare, old age benefits, community and national health programs, education, and cultural facilities and programs such as libraries and theater groups can benefit from the revenues derived from a coal stimulated and sustained economy.

Mining communities often reflect strong ethnic concentrations in their populations. The existence and subsequent mixing of these people with the dominant culture group is a positive value for its horizon-widening effects on the country's sensitivity to cultural diversity. A Cinco de Mayo celebration in Trinidad, Colorado, a Yugoslavian Tamburitza Band at a Pennsylvania County fair; or an Italian wedding in a mining community in Utah will expose Americans to ethnic values other than their own and will deepen their understanding that this country is made in many parts and people from all over the world and that this is part of the Nation's strength. Cultural and ethnic mixing cannot help but produce the hybrid vigor we recognize as the distinct American Culture.

The enormous private and Federal coal reserves in the Northern Great

Plains and Rocky Mountain Coal Provinces unquestionably will provide the basis for the establishment or enlargement of permanent communities. With proper cooperation in comprehensive regional and community land use planning, there is every reason to believe that population centers will provide social, cultural, and educational advantages that depend on stable industries and steady employment. Employees of modern coal companies typical of those operating in these coal provinces are highly skilled equipment operators, scientists, engineers, and managers. Well paid and well educated, they can build the kinds of communities they prefer, with all the advantages similar communities elsewhere. The key to achieving desired amenities in expanding communities is early and foresighted planning by coal companies, municipal leaders, officials of the State and Federal agencies, and the residents themselves who can rely on the stability of their community because of expanding demands for the energy provided by the coal they mine.

America was built by the bounty of its resources and the industry and talents of its diverse peoples, and similar opportunities still prevail -- particularly in the coal fields of the West.

B. <u>Loss of Non-Coal Values</u>

The length of time that coal exploration, development, production, and rehabilitation alters the prior environment and modifies other uses will vary from a few years in the wetter provinces and biomes to many years in the drier ones where revegetation progresses more slowly.

Topography will be permanently changed in varying degrees. This could preclude production of vegetation over the long-term if the new topography is more susceptible to erosion than the old. Active erosion makes vegetal establishment more difficult as well as reducing the productive capacity of the soil. On the other hand, more regular and gentle slopes, once re-vegetated, would erode less.

Loss of long-term productivity due to subsidence into underground mines and the accompanying earth tremors will be localized, but cannot be predicted. Subsidence may affect long-term productivity of surface and subsurface water resources, soil, vegetation, wildlife, various land uses, and human value resources. Soil productivity loss and that of soil-dependent resources usually is greater in steeper terrain.

Air pollution, including carbon dioxide from coal fired plants, added to those produced by man's other activities could modify local climates, (MacDonald, 1971).

Surface water flow will be changed until drainage patterns can be reestablished, generally in three to five years. Surface water quality and quantity may be adversely affected by sedimentation and greater fluctuations in surface runoff until the predisturbance density of ground cover is reestablished. Long-term productivity will be reduced where the sediment originates as well as where it is deposited, especially if the sediment contains toxic substances.

Long-term productivity based upon pre-existing quality of groundwater aquifers may be reduced if aquifers are contaminated or mixed as a result of improper plugging of drill holes and mine tunnels. Where pressure of an aquifer is reduced, reduction of dependent productivity will be permanent. Complete disruption of subsurface aquifer flow by either surface or underground mining may permanently affect water availability.

Waste piles and settling ponds concentrate minerals in new locations in the environment.

Trace elements in fly ash deposited in the vicinity of coal-fired plants have some effects on the productivity of the affected area, dependent upon the quantity and toxicity of the deposits.

Use of water by coal-fired, mine-mouth, generating plants will reduce or enhance productivity of other water using activities -- recreational, agricultural, municipal, manufacturing, etc. -- proportional to the amount of water used by the generating plants and the change in temperature of the watercourse receiving plant discharge. Water used in the cooling process at coal-fired plants will be warmed. Warmed water will be less productive for some organisms, but more productive for organisms requiring warm water temperatures.

A net loss in aquatic production because of less total water available for the habitat is predictable.

The natural soil will be disturbed, eroded, compacted, or mixed with spoil during mining. Severity will range from slight compaction to destruction of the soil's productivity. Reductions in long-term productivity of vegetation will vary with climate and the degree of soil disturbance, compaction, or intermixture with spoil.

Steinbrenner, 1963, listed several soil factors which were significantly correlated to productivity, expressed in terms of site index, of Douglas-fir in the Pacific Northwest. Site index was defined as the total height to which a dominant tree grew in an arbitrary period, in this case, 100 years. His findings show the importance of the entire soil profile (surface soil, subsoil, and weathered parent material) to productivity. They are applicable in varying degree to soils everywhere:

1. Total Soil Depth

A linear relationship exists between total soil depth and site index. A soil that is 20 inches deep has a site index of 90. A 40-inch-deep soil has a soil index of 106. Thus, each inch of total soil depth over 20 inches is responsible for 0.8 foot of site index.

2. Gravel Content

Course rock fragments in the soil lower site index, but more and more fragments lower site index less and less. Gravels and stones do not retain available water for plant growth and the available water capacity of the site is decreased. Also, the capacity to supply plant nutrients is decreased. An increase of coarse fragments from 0 to 20 percent reduces site index by 20 feet. If coarse fragments comprise from 20 to 40 percent, site index is reduced an additional ten feet. Forty to 60 percent coarse fragments only reduce site index an additional three feet.

3. Depth of Surface Horizon

The surface soil layer is very, very important to plant growth. It is literally the plant nutrient producing factory. It is biologically, chemically, and physically the most active portion of the soil profile. Most feeder roots are located in the surface horizon. It is where the all important, active, organic soil fractions are located as well as the plant nutrients. The surface horizon is the first soil layer that is eroded, disturbed, or cast aside.

Most soil where Douglas-fir grows have surface horizons that are between our and ten inches thick. The data show that each inch of surface horizon n this range is responsible for five feet of site index. Site indexes were 09 and 140 for four-and ten-inch-thick surface horizons, respectively.

The importance of these site differences is shown by the yield tables rom Bulletin 201 (USDA, 1950). At age 100, the normal yield tables at a ite index of 140 show 62,800 board feet (Scribner). At site 135, with a oss of one inch of topsoil, the yield drops to 57,600, a reduction of ,200 board feet.

Sindelar, et al., 1973, also showed that depth of topsoil was signifi- ant to productivity. They reported that 16.18 grams per square meter of egetation grew where there was 0" of top soil and 32.35 grams per square eter grew where there was four inches of topsoil over the spoil.

4. Texture of Subsoil Horizon

There is a positive curvilinear relationship between site and lay content of the subsoil horizon. The positive effect drops off when he clay content becomes great enough that root penetration is impeded.

Site index increases seven feet as clay content in the subsoil increases rom 10 to 20 percent. Site increases six more feet as clay content goes rom 20 to 40 percent. The positive relationship almost ceases at 45 per- ent clay.

This relationship exists because an increase in clay content increases he available water holding capacity of the soil. Also, most cation changes ccur in clay and organic matter and that process affects soil fertility.

5. Macroscopic Pore Space

The importance of macroscopic pore space lies in air and water movement within the soil. When pore space is high, there is a straight line, negative relationship between site and percent macroscopic pore space in the subsoil horizon. Site index decreases 20 feet as macroscopic pore space increases from 10 to 30 percent. This is one foot of site for every one percent increase in pore space. This is explained by the fact that available water holding capacity and nutrient reserves decrease because percent macroscopic pore space increase.

When macroscopic pore space is low, an opposite positive relationship is true.

Root penetration ceases at a macroscopic pore space less than six percent. Roughly, site drops from 126 at six percent to 90 at five percent. This is what happened when the soil is compacted.

Steinbrenner (1953) reported that one pass with an HD20 tractor with blade and crawler arch reduced the macroscopic pore space from 18 to 11 percent on a wet soil. Infiltration rate in cubic centimeters per minute decreased from 83 to 12 on the same samples.

In the wetter, more favorable biomes, vegetation can be reestablished within a few years. In the most arid areas, vegetation may not be produced in predisturbance quantity and quality for several centuries.

Wildlife dependent on natural conditions will be affected by loss or reduction of water supply, food, and cover, including solitude, for short periods in wetter provinces and biomes to centuries in the driest. The seriousness of impacts on populations will depend on the scarcity of the habitat components affected and species involved.

If the entire habitat of a threatened species of wildlife were to be lestroyed, the species would become extinct. That this might happen is [uite unlikely, however.

Agricultural production will be eliminated during site occupancy for :oal production. It may subsequently be reduced in quantity and quality ›ecause of soil disturbance. For example, land capable of producing high ʼields of corn may for some time produce only low or moderate yields of ʼheat or grass for pasturage. In other cases, low-producing, rough lands ıay be smoothed and converted to improved pastures.

Timber production may be delayed only during the time sites are actually ccupied for coal production. Or it may be set back further, if young imber with no merchantable value is removed and a new stand must be planed. In any case, depending on the degree of soil disturbance, production ill be modified because of changed conditions.

Livestock forage production will be lost during the occupancy period for oal mining and the period required for the revegetation. The quantity nd quality following mining will depend on the success of revegetation.

Wild horse and burro populations will move from the area during occupany, and return as soon as forage is again available.

Recreational pursuits will be modified during mining operations. For xample, hunting may be diminished, but the mining operation itself may rovide considerable recreational interest.

In areas with sufficient water resources, recreation may be enhanced ollowing rehabilitation, if water bodies suitable for fishing and other ports are created where none existed before.

Prior to disturbance, historical and archeological evaluation should be undertaken to minimize losses. Most of the value to mankind from learning of his past can be salvaged. However, something of value will unavoidably be lost in all cases. Only conscientious historians and archeologists can determine when the quantity of information gained will be nearly that which would have been gained had there been unlimited time for evaluation and study.

The esthetic qualities of coal-mined areas will be changed most drastically in steep topography, and areas with six inches or less of precipitation. Before commitment of an area to coal mining, other developments proposed for adjoining or nearby areas must also be considered. Coal mining may disturb relatively small areas at any one time if rehabilitation is done as soon as possible. However, for example, gypsum mining may take place to the north. Breaking of virgin ground for grain production may occur to the south. Timber harvest may commence to the west. An interstate highway may go through on the east. If sagehen strutting grounds and habitat are diminished, the number of sagehens will decrease. If the solitude required by elk is eliminated over the area, elk will depart. In combination with environmental impacts from other sources, the added impacts from coal mining could be more serious than if they were the only ones on the landscape.

This summary of environmental losses (which have been described in more detail earlier in the statement), indicates that certain losses of non-coal values can be anticipated when coal is mined. Placing dollar values on such environmental losses is difficult in most cases and impossible in others. However, before any dollar values can be calculated, it must first be known which and how many acres are effected. The precise nature of impacts and their dollar values can be determined only when a specific mining proposal is precisely examined. That step is taken by interagency, interdisciplinary teams making environmental analysis in connection with applications for prospecting permits and preference-right coal leases, in consideration of prospecting and mining plans, in determining the feasibility of competitive coal leasing, in developing requirements to be incorporated in coal leases, in administering coal leases, in directing rehabilitation measures, and in assessing any un-mitigated impacts that remain after all requirements have been met and leases are terminated.

Impacts which cannot be mitigated must be weighed against the values the land has following rehabilitation and the benefits derived from the coal that was mined. The $2,347,636 which the Federal Government was paid in 1972 for Federal coal represents only a small fraction of the total converted value of the 10,222,411 tons extracted.

According to 1973 estimates, there are 21,995,000,000 tons of recoverable coal in 1,075,992 acres under Federal coal leases and preference-right coal lease applications. That represents about 20,000 tons of recoverable coal per acre. If as predicted, production of Federal coal nearly quadruples by 1975 to 38,900,000 tons per year, the Federal land mined each year can therefore be expected to be about 2,000 acres per year.

Rehabilitation costs vary widely, from several hundred to several thousand dollars per acre. Assuming that rehabilitation costs $5,000 per acre, the total annual cost to the lessees for rehabilitating 2,000 acres of Federal land mined would be $10,000,000. That is more than four times the

Federal income in 1972 from coal leasing, but less than one-fifth of the mine-mouth value of the coal mined that year.

If rehabilitation costs average $1,000 per acre, the cost for 2,000 acres per year would be $2,000,000, or less than four percent of the mine-mouth selling price of the coal.

Accurate estimates are not possible, but the difference in value of the land before mining (excluding coal values), and after rehabilitation would represent the non-coal losses in value attributable to mining. There are wide ranges in land values, of course, but if for example land valued at $100 per acre suffered a 25 percent loss in value, the loss would be $25 per acre. Applied to 2,000 acres mined annually, the loss would be $50,000, or less than one-tenth of one percent of the mine-mouth value of the coal.

Lands with depreciated values caused by mining tend to regain their former values as unmitigated environmental impacts ameliorate with the passage of time. This complicates a direct comparison of the land's long-term value with the present worth of the coal when mined, plus the residual long-lasting benefits derived from the coal. Suffice it to say that carefully located and planned extraction of Federal coal, with accompanying rehabilitation, generally produces values in excess of the immediate loss of non-coal values plus the long-term loss in productivity of the rehabilitated land.

C. <u>Land Uses Following Coal Mining</u>

Under the terms of a Federal coal lease, the United States of America, the lessor, through the Bureau of Land Management, grants coal mining privileges and the lessee agrees to certain conditions, including the provisions of regulations of the Secretary of the Interior applicable when the lease is issued and all revisions thereafter.

Among the standard conditions of a coal lease (Form 3130-1, October 1967), is the agreement of the lessee "to the extent deemed necessary by the lessor to fill any sump holes, ditches, and other excavations, remove or cover all debris, and so far as reasonably possible, restore the surface of the leased land and access roads to its former condition, including the removal of structures as and if required." Federal resource management agencies with administrative jurisdiction over lands to be mined prescribe specific conditions to be incorporated in Federal coal leases to protect the purposes for which the lands are managed.

Among such stipulations are those designed to achieve rehabilitation of the land to accomodate the planned uses of the land following mining. In most cases, the uses of Federal land after coal is mined will be similar to the uses prior to mining.

Most of the Federal coal is in the Rocky Mountain and Northern Great Plains Coal Provinces. The dominant surface uses, acreage-wise, of Federal lands in those two provinces are for livestock forage production, wildlife habitat, as watersheds, for wide-ranging recreational activities, and for timber production.

In Montana, Wyoming, Colorado, New Mexico, and Utah there are 138 million acres of Federal land. Half of that land is managed by the Bureau of Land Management and half by other Federal agencies.

Disruption of prior uses of Federal lands in those states by coal mining each year is very small, acreage-wise, about one-thousandth of one percent.

Consequently, the impact of mining on other land uses is proportionately very small as a whole. However, on the acres where mining occurs, the impact is very important, particularly since effects of impacts remaining after rehabilitation may be evident for several to many years thereafter.

With appropriate rehabilitation, Federal lands from which coal has been mined can again be devoted to other uses.

Rangelands formerly used for livestock and wild horse forage production and as habitat for wildlife of various species can again be used for those purposes. The quality of the rehabilitated rangelands will depend on several factors. These include the condition of the surface soil, season and amount of rainfall during the first several years following revegetation, management of use by livestock, appropriateness of the plant species and fertilizers used in revegetating the area, re-entry of other native species, wind and water erosion, and maintenance treatments.

The use of lands as watersheds continues during mining operations as well as after. Even in areas of relatively high rainfall, such as in Ohio and western Washington, it has been demonstrated that erosion during surface mining operations can be controlled so that water leaving the disturbed area is clear. This is accomplished through design of the mining operation, drainage management, use of flocculants, settling basins, and the filtering effect of growing vegetation. In some water-short areas, the land is intentionally denuded to produce greater runoffs from watersheds. Consequently, the water management objectives in each locality must be considered in planning for the quality and use of water from areas that are being or have been mined. Water management measures can be applied in most cases to produce the desired results. Timely enforcement of water management stipulations in coal leases is essential.

Opportunities for enhancing recreational interests sometimes result from coal mining operations. Road and utility distribution lines built to serve coal mining operations sometimes can be used for recreational activities, particularly if they were planned with that in mind. Such facilities also may be useful for range or forest fire control or for other aspects of resource management, particularly in remote areas. Since many areas have a shortage of water-oriented recreation, there are instances when planned excavation and site improvement can provide for boating, fishing, and improvement of wildlife habitat. Spoil piles can be shaped to provide attractive recreation sites. In some instances mounding provides topographic variations and interest in an area of uninteresting relief. Mining excavations, both during and after mining operations, provide recreational interests, even though the former esthetic quality of the area may have been altered. In mountainous areas, particularly, roads to former mines can be converted to hiking trails if rehabilitation has insured that the mined areas are safe for hikers.

In the Rocky Mountain and Northern Great Plains Coal Provinces, surface mining on Federal lands will occur mainly in non-forested areas. On the other hand, forested terrain is generally such that if coal is mined, it will be by underground methods. Consequently, except for areas disturbed at mine portals and plant sites, the principal effect on existing forests will be from subsidence. Future forest production will depend on the nature of the residual stands. In other coal provinces, which support coniferous stands like those on the Pacific Coast or hardwood stands as in the Eastern, Interior, and Gulf Coal Provinces, production of future stands of merchantable timber on Federal lands where coal has been mined is a distinct probability. Though the acreages of Federal coal lands in those provinces is quite small, opportunities are good for various other land uses following mining, also.

VII IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES IF FEDERAL COAL IS LEASED

Some irreversible and irretrievable commitments of resources occur if Federal coal is leased, followed by exploration, development, production, and rehabilitation. These include coal extraction and use, changes in land use, alteration of wildlife habitat, and modification or destruction of certain human-value interests. Some such consequences may remain after maximum mitigation efforts.

A. Coal Extraction

The principal commitment in the Federal coal leasing program is for the extraction of coal from the ground. Since coal is a non-renewable resource, once it is mined and has been used, it is gone and cannot be replaced. The commitment to mine coal involves not only the coal that is mined, but the coal that is wasted in the process. An average of about 85 percent of the coal resource can be recovered when the area strip-mining method is used. In contrast, only half of the coal, on the average, can be saved in underground mining. Especially when seams are thick, coal must be left to support the ground above the seam being mined. Otherwise, recoverable coal in seams above may be lost because of disruptions caused by subsidence.

Cumulative production of Federal coal from 1780 through 1972 amounts to 277,973,915 tons. From 15 to 50 percent in addition may have been wasted in the mining process. In 1972, Federal coal production was 10,222,411 tons, which was 1.7 percent of the total production in the United States.

B. Loss of Non-Restorable Surface Values

1. Ecological Interrelationships

Occasional situations occur in which the natural ecological balance is damaged beyond repair by coal mining. One example is the exposure of bedrock by mass soil movement, where restoration of a life-sustaining abiotic environment can be accomplished only be natural processes operating over a period of geologic time. Loss of the soil mantle would mean loss of vegetation, which would affect wildlife using it for habitat.

2. Geology and Topography

The major irreversible impact on the geology of the area from coal mining would be the possibility of subsidence or earthquakes, which also would alter the local topography.

3. Climate and Air

Theoretically, properly conducted coal operations should have no irreversible or irretrievable impacts upon the atmospheric resource. Mitigating measures required by coal lease terms should reduce adverse effects to a level within the natural capacity of the atmosphere to purify itself. In the interim, operating equipment will consume oxygen, and carbon dioxide and other gases will be released into the atmosphere.

4. Hydrology

Extraction of coal by either underground or surface methods may disrupt groundwater hydrology. This is particularly true where a coal seam functions as an impermeable layer which prevents the percolation of water through it. If such an impermeable layer is ruptured during mining, water formerly held could drain through to lower strata and not be available for former uses. Thus, mining may drain trapped underground pools with the result that wells dependent on them would go dry. Similarly, when normal underground watercourses are disrupted, dependent springs and streams also are altered or may cause to flow.

Surface reservoirs may suffer loss of storage capacity if sedimentation results from uncontrolled erosion caused by mining.

Groundwater aquifers might suffer loss of water quality if contaminated with pollutants.

If overlying strata subside into underground coal mines containing aquifers, the aquifer could be lost. This could affect adjacent areas which are dependent upon that aquifer for water supply.

If water is committed to coal production and utilization processes, it then becomes unavailable for other former uses. Since the supply of water varies from place to place, its commitment to mining is of variable importance to other uses. Water that evaporates or is otherwise used during mining or conversion operations in such a manner that it is not returned to normal watercourses, is no longer available for former purposes.

5. Soil

Soil organisms will recover following soil disturbance to the degree that the soil in which they live is rehabilitated. Erosion irreversibly reduces the habitat.

Any action which results in landslides or soil erosion has a permanent impact on the soil. The magnitude of the loss depends upon the severity of the erosion. A permanent commitment of the natural soil is made in areas where roads, railroads, structures, and waste disposal sites exist.

6. Vegetation

Areas surface mined may remain bare of vegetation for prolonged periods of time. Required revegetation measures, in conjunction with natural recuperation, can be expected to restore sites in the more moist areas. Disturbed arid areas are incapable of regenerating plant life except over long periods of time. The long time frame for restoring vegetation in some areas is evidenced by the fact that segments of the Salt Lake City to Los Angeles wagon trail used in the mid-1800's, is still devoid of vegetation. Arid areas receiving less than six inches of precipitation annually may be devoid of normal vegetation of hundreds of years.

Potential extinction of endangered species such as the Joshua tree or the bristlecone pine would be irreparable damage. Loss of vegetative production, be it corn, grass, or trees, during the time the area is out of production is irretrievable.

Loss of groundwater aquifers could permanently dry up aquatic habitat resulting in an irretrievable loss of aquatic vegetation in small springs or lakes, especially, in the arid and semi-arid areas.

The natural process of the conversion of standing water habitats to land masses is accelerated by various actions of coal operations that contribute to sedimentation. Massive earth slides are the most drastic events in localized areas, but the cumulative effect of increased sediment from other actions can cause the greatest offsite effects on aquatic plants.

Aquatic vegetation destroyed by road and railroad construction at water crossings would generally constitute a minor irretrievable loss of vegetation if plants could not be reestablished.

7. Wildlife

The loss of any endangered species constitutes an irreversible and irretrievable commitment. Small, non-mobile species dependent on a micro-site, or other limited habitat with only local distribution, such as the Siskiyou Mountain salamander, are especially vulnerable. Other more mobile species, such as the northern spotted owl and Columbian white-tailed deer, could be eliminated from an area for a long period of time.

Discovery of coal and subsequent mining operations may result in permanent urban development. The loss of habitat and attendant human activity could result in the loss or displacement of major game species and the larger predatory birds and animals.

Heavy industrial and domestic use of water may lower water tables, draining marshes and other wetlands. Waterfowl, other birds, amphibians, and small mammals formerly inhabiting these wetlands may be displaced to other areas or permanently lost.

Vegetation removal and soil disturbance associated with coal operations can cause siltation of bays and estuaries, permanently damaging the habitat for birds, marine animals, and invertebrates, if erosion prevention requirements are violated.

Excessive sedimentation in violation of lease terms could cause irretrievable changes in aquatic habitat when stream channels, lakes, marshes, or reservoirs become filled with sediment. The habitats would no longer be capable of producing the quantities of fish they once did, unless the sediment is physically removed, which is generally considered impractical.

While other activities in watersheds may contribute to increased sedimentation, coal mining operations might accelerate sedimentation of surface waters. Massive earth slides caused by activities in steep terrain are the best illustration of the adverse effects of heavy sedimentation in a localized area. Aquatic habitat lost to sedimentation is seldom restored by natural processes. Loss of productive area in estuaries due to accelerated sedimentation is another example of an irreversible commitment of aquatic resources.

Extermination of an endangered species or subspecies of fish is an irretrievable or irreversible action. Most endangered fish species in the western United States are found living in sometimes harsh, isolated, small habitats. These endangered species could be made extinct through direct eradication by loss of water supply or groundwater contamination. In these cases, the habitat could recover in time, but the species would be lost. Endangered fish could also be lost by habitat changes that the species could not adapt to, such as extensive sedimentation of a small spring or pond.

8. Land Use

Coal mining operations have their greatest impacts in areas which are in a natural or near natural condition. Natural ecosystems can be altered in the immediate area to the extent that restoration is either completely impossible, or not feasible. In any case, restoration to precisely the original situtation is imposssible. The significance of the loss depends on the uniqueness of the area or resource areas. Recreational activities that depend on the uniqueness of a site or area would be irreversibly eliminated.

Urban land uses resulting from coal mining nearby will establish enduring patterns and trends.

9. Population Patterns and Considerations

Community life and social patterns are altered by population increases and economic growth caused by coal mining operations. Although prior economic environments might return after operations ceased, if no new economic activity developed during coal mining activities, it is doubtful that social aspects would ever revert. Generally, most cultural, ethnic, and religious values are durable features that transcend such localized impacts as coal mining.

10. Human Value Resources

a. Esthetics

If properly planned and carried out, careful mitigation and rehabilitation measures should be able to nearly restore esthetic values in many areas. The length of time necessary for restoration would vary greatly. Certain areas of the desert and tundra require long periods to recover -- to the point where esthetic value losses could be considered irretrievable for all practical purposes. Other areas, such as steep slopes where earth slides occur during operations, may never be retrieved.

b. Geologic

Coal mining may represent an irreversible or irretrievable commitment of geological values of human interest. Massive surface disturbance could eliminate small, fragile geologic features such as natural archways, etc., if those areas are not excluded from mining.

c. Archeologic

Archeological excavation represents a use that alters the resources as it is excavated and salvaged. If archeological exploration hastily precedes coal mining, there is the chance that maximum values of more deliberate work would not be attained. No archeological study would result in complete loss of values from that source.

d. Historic

Historical structures and sites are each unique and irreplaceable. Once destroyed or impaired, such structures and sites are never really the same and the more they are impaired, the less reality they protect for the visitor. Impairment can be a cumulative thing so that after a long period of time nothing really original or authentic exists. Much of the understanding of what happened in the past is related to the present similarity of the site to its appearance at the moment of historical importance. Restoration and reconstruction are effective measures, but it must be recognized that those approaches are not completely real.

VIII ALTERNATIVES

This section will focus on the environmental impact of alternatives to the Federal coal leasing program. These alternatives are broken down into three general groupings: substitute energy sources; administrative modifications in the existing program; and conservation of energy. Most of these alternatives are not mutually exclusive and can be carried out in conjunction with, or in place of the current coal leasing program to help meet projected energy needs.

A. Energy Alternatives to the Coal Leasing Program

The coal leasing alternatives set forth in this part can be viewed as possible energy sources to help offset the loss of production from any reduction or elimination of the Federal coal leasing program. Many of these alternatives such as oil and gas leases are current conventional practices whose contribution would involve increased production while others such as the use of winds or tides to generate energy are more in the nature of long-term future sources. Nonetheless, they represent in total, the constantly changing mix of energy sources, both in magnitude and make-up.

If this mix were altered by the elimination of the Federal coal leasing program, then measures would have to be taken to offset, in part or in total, the production loss, assuming that current energy production levels are to be maintained. Other than the supply implications of a no coal leasing program alternative, the major adverse impact would be on the segment of the public who are dependent either directly or indirectly on the program for their economic livelihood. While the possibility exists for some shifts of the labor force, particularly if alternative energy source measures were brought to bear, it can be expected that the net impact would be to increase unemployment, and reduce the gross national product. At the same time, the beneficial impact of such a no program action would be to preclude the occurrence of the unavoidable, long-term productivity, irreversible and irretrievable impacts of the coal leasing program as described in the body of this statement.

In considering the numerous alternative sources of energy that possibly could be utilized in the advent of the modification or elimination of the current program, it is important to investigate the ability of one source of energy to substitute for another in various uses. Since different energy sources presently being used differ widely from coal, oil, and gas, to electricity produced in a variety of ways, the question of one being able to substitute for another is complex and a matter of degree. Substitutions can be made by the large power producer at generating plants, substitutions can be made in the home by the consumer, both affecting the total energy demand, and there are many areas where no substitutions can be made; for example, coal cannot be used in nuclear powerplants.

To simplify the discussion of the question of substituting one energy source for another, different categories of energy will be considered. First, electrical power generation will be considered, allocating all energy consumption to the production of electricity only. Secondly, substitutability in sectors other than power generation will be discussed.

a. Substitutability in Electrical Power Generation

Electric utilities presently consume about 25 percent of the primary energy consumption and are projected to increase that share to become the largest consuming sector by 1985.

The ability of different sources of energy to substitute for each other in power generation is dependent upon cost, plant and equipment design, geographic location and availability of fuel, lead time, and consideration for environment. These variables will be discussed separately to assess the effect on the substitution of one energy form for another.

Cost

Economic considerations are of paramount importance in considering a different fuel's ability to substitute for another fuel. Although technical feasibility to substitute one fuel for another may exist, costs may easily prevent substitution. Transportation costs of Western low sulfur coal to the East Coast, for example, prevent this substitution for oil and gas in Eastern boilers. Although higher costs can be passed on to the consumer, it is unlikely, that rising coal and fuel oil prices eliciting greater supplies, would allow them to replace natural gas if price alone were the only consideration in substitution.

Plant and Equipment Design

When considering substitutability of energy sources as related to electric power generation for the short-term, we are confined to substitutions among oil, gas, and coal. Nuclear plants require lead times of 10 - 12 years to build and cannot be converted to burn fossil fuels. Geothermal steam equipment is also specialized, consisting of low pressure turbines unsatisfactory for conversion to some other fuel type.

Although nuclear power will increasingly substitute for fossil fuels, short-term substitutability of fuels for power generation is limited to gas, oil, and coal. Most boiler fuel powerplants can convert from coal to oil with a lead time of six months or more if: (1) the equipment is available; (2) there is room in the plant to install the new equipment; (3) enough BTUs are generated by the fuel substitute to efficiently heat the boiler; (4) adequate resources are available to warrant changing over to handle new fuels, and (5) it is economically feasible.

Many Eastern powerplants are equipped to burn both oil and coal. For such plants conversion to 100 percent coal or 100 percent oil would only involve a matter of 1 - 2 weeks. Many other plants, however, are desiged to run only on coal. For these plants, extensive modifications involving six months to a year would be necessary to make the conversions.

The trend in new generating units is to move towards steam electric units with high substitutability of fuels. Coal fired units are less flexible, but can be producing electricity with less lead time than nuclear plants. With environmental concerns, the trend has been to use oil instead of the higher sulfur producing coals. Plants designed for all-coal fuels cannot readily convert to use oil or gas.

<u>Geographic Locations and Availability</u>

In some locations one energy source is easily adaptable and more preferable than another. For example, it is not likely that a fossil fuel plant would be built at Geysers California where geothermal steam has been developed. Availability of low cost coal in "coal competitive" areas is a function of transportation costs.

Substitutions of one form of energy for another by producing power from coal, for example, at mine mouth coal-electric plants and sending the power across the country to substitute for hydroelectric power in New England, is a function of distance and can run up transportation costs. In this example, producing power from a locally cheap and abundant fuel and sending it long-distances would not constitute an economic substitute due to high electrical transmission costs. Although direct current transmission is cheaper, it is not widely accepted yet, and involves some efficiency loss in conversion to AC. Therefore, substitutability is affected by geographic locations and what fuel sources are close enough to allow economic transportation to the point of use.

Lead Time vs. Changeover Time

Lead time and changeover time are important considerations in whether one energy source can replace another. Substitution of one fuel for another in existing plants involves changeover time where production would cease to exist for a particular unit. Lead time is the time lapse between any initial action to obtain new energy production and the resulting new production. Long changeover times could prevent substitutions entirely if high demand required a particular power unit to stay in production. The above conversions are not necessarily reversible. After being idle for long periods of time, rusty or deteriorated equipment cannot always be reused. In addition, changing price structures of fuels, and environmental considerations as to the amount of sulfur in the fuel add to the difficulties inherent in any decision for changeover in fuels. In 1973, impending oil gas shortages have prevented the option of wholesale conversion to these fuels.

Environmental Considerations

Environmental considerations are becoming increasingly important in considering substitutability for fuels. As shown in Table 1, powerplants are responsible for only about 12 percent of the estimated nationwide total pollutants in 1968, although they were the largest contributor of sulfur oxides in the air.

Table 1 - Estimated Nationwide Discharges of Airborne Pollutants, 1968

(Million tons per year)

	Carbon Monoxide	Part Matter	Sulfur Oxides	Hydro- Carbons	Nitrogen Oxides	Total
Powerplants............	0.1	5.6	16.8	Neg.	4.0	26.5
Other fuel combustion in stationary sources.	1.8	3.3	7.6	0.7	6.0	19.4
Transportation.........	63.8	1.2	0.8	16.6	8.1	90.5
Industrial processes...	9.7	7.5	7.3	4.6	0.2	29.3
Solid waste disposal...	7.9	1.1	0.1	1.6	0.6	11.2
Miscellaneous..........	16.9	9.6	0.6	8.5	1.7	37.3
Total.........	100.2	28.3	33.2	32.0	20.6	214.2

Note: Sulfur oxides expressed as tons of sulfur dioxide and nitrogen oxides as tons of nitrogen dioxide.

Source: Air Pollution Control Office, Environmental Protection Agency

New environmental legislation to limit powerplants intake fuel to 0.7 percent sulfur would greatly reduce Eastern air pollution, but many plants now using 2.5 percent sulfur fuel would be forced to make substitutions to a lower sulfur fuel, if available or in some cases abandon their operations entirely. Mine mouth plants in remote Eastern areas are an example, since they are faced with the geographic dilemma of high transportation costs as a result of transmission distance, coupled with a diminishing supply of oil and gas at any price, and a changeover time of six months or a year to make a conversion.

Since substitutability for practical short-term purposes is limited to fossil-fuels in the power generating sector (presently accounting for over 70 percent of generation capacity), it deserves attention in the study of the energy problem. Substitutions, however, are not strictly confined to the power generating sector. Numerous individual consumers and industries have considerable latitude in substituting one form of energy for another.

b. Substitutability in Sectors of the Economy Other Than Power Generation

To examine all uses of energy and their substitutability would involve lengthy categorizing and study; however, only a few of these contribute significantly to total energy consumption. Therefore, examining substitution in these energy uses would give a fairly complete picture of total energy consumption, Table 2.

Table 2 - Total Energy Consumption by Use
(The Potential for Energy Conservation, 1972)

	Percent of Total
Transportation (fuel; excludes lubes and greases)	24.9
Space heating (residential, commercial)	17.9
Process steam* (industrial)	16.7
Direct heat* (industrial)	11.5
Electric drive (industrial)	7.9
Feedstocks, raw materials (commercial, industrial, transportation)	5.5

Table 2 - (Continued)

Water heating (residential, commercial)	4.0
Air conditioning (residential, commercial)	2.5
Refrigeration (residential, commercial)	2.2
Lighting (residential, commercial)	1.5
Cooking (residential, commercial)	1.3
Electrolytic processes (industrial)	1.2
Total	97.1%

If we allocate electric utility consumption discussed earlier to the following four sectors of the economy, Residential, Commercial, Industrial, and Transportation, and compare the distribution of total energy consumption by source over the last three decades, we have the following:

Table 3 - Percent Distribution of Total Energy Consumption, By Sector and Source
(Patterns in Energy Consumption in the U.S., 1972)

	Coal	Natural gas	Petroleum	Hydro and nuclear	Total
Household & Commercial					
1950................	8.5%	4.8%	8.9%	a/	22.2%
1960................	2.3	9.5	10.9	a/	22.7
1970................	0.6	10.7	9.2	a/	20.5
Industrial					
1950................	17.4	10.9	7.7	a/	36.1
1960................	10.9	14.0	8.2	a/	33.1
1970................	8.1	15.3	7.4	a/	30.7
Transportation					
1950................	5.0	0.4	19.9	a/	25.2
1960................	0.2	0.8	23.1	a/	24.1
1970................	--	1.0	22.9	a/	23.9
Electric Utilities					
1950................	6.5	1.9	1.9	4.7	15.1
1960................	9.5	4.0	1.3	4.0	18.7
1970................	11.4	5.8	3.3	4.1	24.7
Total Energy					
1950................	37.8	18.0	39.5	4.7	100.0
1960................	23.2	28.2	44.6	4.0	100.0
1970................	20.0	32.8	43.0	4.1	100.0

a/ Not shown since only aggregate electric energy deliveries can be allocated to end uses

Substitutability almost invaribly requires large capital investment and cannot be justified on only cost savings of one fuel substituted for another, this being just one of the factors considered. Cleanliness and controllability are also primary factors in preference for a fuel type.

Another important factor to be considered, particularly important in view of energy shortage is the technical efficiencies of various fuels. By observing the different quantities of energy needed to accomplish the same task, a direct comparison in substitutability potential for various sources of energy in each use sector can be made.

Energy consumption is growing in all sectors of the economy, some more rapidly than others. In addition to the factors, influencing substitutability in the power producing sector, the remaining four sectors, residential, commercial, and industrial, are also influenced by individual preference. It is unlikely, for example, that the transportation sector will soon begin to substitute natural gas or coal for gasoline, although it is a possibility that people today, might choose a gas space heater over an oil one, if they are certain of its features. Present substitutability of fuels therefore, can be either an economic question or preference question on the consumer level.

There are more widespread uses for gas and coal, but fewer applications than for electricity. Gas use in refrigeration and air conditioning has declined, replaced by electricity. Small appliances are almost entirely electric; whereas such appliances as irons for clothing were once heated on coal stoves. Many industrial processes are locked into the use of gas where substitutes would not be satisfactory. Transportation uses over half of the petroleum products and except for this use, oil is more limited than gas. Over 80 percent of the residential and commercial consumption of petroleum (excluding the transportation sector), is used for space heating. In the future, perhaps solar energy can substitute for oil in space heating applications and other experimental energy sources will substitute for present modes of energy consumption.

Short range substitutions of energy are largely confined to oil-gas powerplants in the power generation sector, and uses as space heating with gas or electricity in the commercial-residential sectors. Environmental consideration is reflected in electricity costs and is an increasingly import factor in the cost of substitution of any energy form. Substitution by electricity from an energy consumption point of view must consider the source of fuel used to generate the electricity.

Future substitution between the fossil energy forms, nuclear, geothermal, hydroelectric, and other experimental forms is a certainty. The extent of this substitution will basically reflect the needs of the times, the supply and demand functions of the energy sources, technology and the legislation controlling them.

By considering different trends in the uses of coal, oil, and gas, projections in consumption for the various fossil-fuels have been made. Coal will be a negligible source of energy by year 2000 in the residential and transportation sectors. Gas will diminish slightly in the electrical power sector to be replaced with nuclear power. Petroleum products will continue strong in the transportation sector, although substitutions will eventually bite into the demand, particularly late in the century. If by the year 2000, we had complete substitution for forms of fuel resulting in an all-gas, all-oil, all-coal, or all-electric fuel economy, different amounts of energy would be required to satisfy the demand.

Further studies are being made by the Department of the Interior and other energy-related agencies on the substitutability of fuels. A few of the models that have been or are being developed for this purpose are: oil, gas, and coal supply allocation models, Bureau of Land Management; refinery location model, Office of Emergency Preparedness; and superport location oil transportation model, Department of Transportation.

Speculation as the extent of substitutability by the year 2000 is largely academic. Technological breakthroughs in a number of energy alternatives as well as stringent environmental legislation could considerably accelerate the substitution of one fuel for another.

1. Imports

a. Oil Imports

Oil imports play an important role in fulfilling the United States demand for petroleum. The following table shows the expected demand for petroleum, the expected domestic production and supplemental supplies that will be required to fulfill demand. Through 1980, if domestic production is not stimulated, these supplemental supplies will come in the form of increased imports. After that time, incremental production may be possible from some synthetic sources (oil shale, tar sands, etc.), but imports will still provide the predominant portion.

Table 4 - Total U.S. Petroleum Demand Domestic Production and Supplemental Supplies Through 2000 (Million barrels/day)

	1971	1975	1980	1985	2000
Total Petroleum Demand	15.1	17.4	20.9	25.0	35.6
Total Domestic Production	11.3	11.0	11.8	11.6	10.6
Supplemental Supplies	3.8	6.4	9.1	13.4	25.0

In the past, the United States has received much of its imports from Western Hemisphere sources. Because of increasing domestic demand in these countries, it does not seem likely, however, that they will be able to meet the future U.S. need for imports. In 1960, the Western Hemisphere was able to essentially maintain a balance in the supply and consumption of petroleum. This balance was almost achieved again in 1965.

The availability of Latin American oil was a major factor in reaching these balances. In the future, however, the increases in Latin American consumption are expected to be greater than increases in production. This factor combined with the great increases in United States consumption will cause larger and larger deficits in the Western Hemisphere petroleum supply-demand balance.

Future increases in oil imports will come primarily from the Middle East and North Africa. It has been estimated that almost 80 percent of the non-communist world oil reserves lie in these two areas. Problems with the security of supply, balance of payments, and United States off-loading terminal capacity could arise due to an increase in imports from this region.

In 1985, waterborne imports are projected to rise to 10.7 million barrels/ day, (National Petroleum Institute). This increase in throughput and ship traffic can only be met through some type of expansion of U.S. port capacity.

One of the key factors that will determine the changes that will be required in U.S. port facilities, is the size of tankers delivering the oil. Since 1965, tanker construction has been directed almost exclusively toward vessels larger than 65,000 DWT. The development of a successful single point mooring system which allows the unloading of deep draught tankers, and the closing of the Suez Canal in mid-1967, gave impetus to the construction of Very Large Crude Carriers (VLCC's) ranging from 250,000 DWT to 425,000 DWT (presently under construction). A tanker of more than 700,000 DWT has been ordered and a 1,000,000 DWT vessel is in the preliminary planning stage. The major attraction of large tankers is the reduction in unit transportation costs that they provide.

The possible reduction in ship traffic is also obvious if larger tankers are used. By using tankers of 100,000 DWT instead of 29,000 DWT, the number of vessels that would have to be unloaded each day could be reduced from the equivalent of 53 to the equivalent of 15. By using a 200,000 DWT average, the number of unloadings required each day could be reduced to the equivalent of 7.5.

Because of the savings in transportation costs, the reduction in ship traffic and the lack of new small tankers, it seems inevitable that the United States will be forced to use tankers larger than 100,000 DWT. The problem is that the U.S. does not have any ports capable of handling tankers larger than 100,000 DWT. The East Coast, which requires the greatest amount of imported petroleum, has only one port capable of handling a tanker larger than 55,000 DWT. The study done for the Department of Commerce's Maritime Commission shows that it is neither environmentally nor economically feasible and in some cases physically not possible to dredge existing ports to the depth necessary to allow large tankers to enter.

Several potential alternatives for importing the increased quantities of petroleum were examined in the Maritime Commission's Study. Some of these are: (1) lighten the loads of the VLCC's, offshore of existing ports; thereby reducing the drafts of the vessels sufficiently to allow them to enter the ports and complete the unloading. (This procedure is presently being used to a limited extent in Delaware Bay and New York Bay); (2) develop a fleet of shallow-draft large tankers which could use the present, or moderately deepened, port channels; (3) make use of conventional designs such as building a deep-draft terminal in Maine or in Lower Delaware Bay, or using single point mooring system offshore; (4) transfer the oil to the U.S. in small tankers from deep-water terminals being built in Canada and the Bahamas; and (5) make use of offshore deep-water ports, serving an entire region by a transfer system of pipelines and/or feeder vessels (U.S. Department of Commerce).

NVIRONMENTAL IMPACT

The consideration of environmental impacts in this analysis primarily elates to additional ship traffic and oil handling associated with the ncreased level of imports.

Potential Oil Pollution

Three factors are considered in analyzing possible oil pollution related to tanker shipment of imports: (a) intentional discharge, (b) accidental discharge, and (c) casualty analysis.

Intentional Discharge

The two primary sources of intentionally discharged oil are shoreside ballast treatment facilities and underway tank cleaning operations (USDI, 1972). Any development of ballast treatment facilities would be accomplished at the loading end of the system. It may be assumed that all intentionally discharged oil in U.S. waters from this alternative will come back from tank cleaning operations.

Accidental Discharge

In the restricted waters surrounding harbors and ports, the 1970 experience indicates that about 0.00009 percent of the oil handled is accidently discharged (U.S. Coast Guard, 1972). This would indicate spills of 3.7 barrels/day in 1975, 5.5 barrels/day in 1980, and 9.6 barrels/day in 1985.

Casualty Analysis

The worldwide tanker casualty analysis indicates that an insignificant amount of the total volume of oil transported is spilled, exclusive of transfer operations (USDI,1972). The environmental impact could be nominal where small spills are involved or where the spill occurs in such a manner as to have little impact on coastal or restricted water areas. By contrast, a single catastrophic incident such as the breakup of the Torrey Canyon can have disastrous results. The oil spill problem is a subject involving considerable study effort. The first report of the President's Panel on Oil Spills presents considerable details relative to the subject.

In analyzing future refinery requirements for oil imports, a maximum case can be identified. The maximum case would be to meet demand for petroleum products with crude oil run through the U.S. refineries. Crude runs in 1980 would be about 20.9 million barrels/day, and in 1985, 25.0 million barrels/day. This would mean an increase in crude runs of 10.0 million barrels/day in 1980 and 14.1 million barrels/day by 1985 over the actual 1970 levels.

The minimum refinery requirement would be to provide just enough capacity to process domestic production. In this case, all imports would be in the form of petroleum products and petrochemical and SNG feed stocks. Crude runs would be 11.8 million barrels/day in 1980 and 11.6 million barrels/day in 1985. Both of these figures are less than 1972 total capacity, but greater than actual crude runs in 1970. The retirement of old and obsolete facilities would require the construction of some new capacity through 1985.

To assess fully the impact of the tank cleaning operations, three separate analysis are necessary. While the overall average discharge rate in 1969-1970 was 0.074 percent of cargo, uncontrolled operations averaged 0.46 percent, load-on-top (LOT) averaged 0.027 percent, and the IMCO standard proposed in the 1969 amendments to the 1954 International Convention for the Prevention of Pollution of the Sea by Oil was 0.0067 percent (one part in 15,000). Oceanborne imports in 1975 are expected to be 4.1 million barrels/day; in 1980, 6.1 million barrels/day; and in 1985, 10.7 million barrels/day. The following table shows the expected oil spill levels under the three conditions:

Potential Intential Oil Spill Levels (thousand barrels/day)

	Oceanborne Imports	Uncontrolled Operations	L.O.T. Operations	IMCO Standards
1975	4,100	18.9	1.1	0.3
1980	6,100	28.1	1.6	0.4
1985	10,700	49.2	2.9	0.7

Increased Tankers and Terminals

Increased petroleum imports will require an increase in the number and/or size of tankers. The heavily populated Northern Atlantic coastal region will be the primary destination of petroleum shipments with the Gulf Coastal region being the secondary location. If the use of conventional ports continues, tankers will generally be restricted to 60,000 DWT or less. As shown earlier, the continued use of these small tankers will require a significant increase in the number of tankers to be unloaded each day. This added congestion would increase the risk of collision and subsequent oil pollution. The transfer of oil from VLCC's to small tankers at foreign ports would also cause substantial increase in ship traffic. The problem of port congestion could be alleviated through the use of large tankers making deliveries directly to U.S. terminals.

The environmental impacts of a terminal to handle large tankers will be determined by its location. Enlarging the channels and harbors of existing ports would require dredging which could endanger sensitive estuarine areas. These areas are important as nursing grounds for many species. Extensive dredging also presents the danger of penetrating freshwater aquifers and causing contamination of a major city's water supply. Expansion of existing port facilities in populated areas could cause conflicts with existing or planned land uses.

Offshore terminals would greatly reduce the dangers of dredging and port congestion. The determinig factor would be the facilities' distance from shore. Terminals which are sited closer to shore will generally require a greater amount of dredging. Such a facility could, therefore, cause some danger to estuarine areas as a result of dredging and from oil spills which could reach shore before dispersing or being cleaned-up. A terminal further offshore could obviate the need for dredging and allow spills to disperse or be cleaned-up before reaching sensitive areas.

The construction of a breakwater or island will permanently eliminate from productivity the area of seafloor and volume of water it occupies. Some of this loss will, however, be offset by fish havens formed by the rubble mounds and structures. A deeper offshore setting would again be preferable because it would effect fewer species. A breakwater could reduce wave action at the shoreline and thereby reduce erosion of the beach. This could lead to the deposition of suspending sediments and accretion of the beach. Continued accretion could cause the development of a sand spit, which may ultimately extend to the offshore structure. If this accreion were located at the upper end of the beach system, the normal supply f sand would be cut-off and erosion of the beach would occur. Generally, f the distance from shore is more than twice the length of the structure, he effect on the shoreline would be minimal, (Maritime Commission).

Pollution Potential at Loading Site

The increased movement of petroleum will also result in increased oil spills at the loading end. These spills will, at the receiving end, result from intentional and accidental discharges and tanker casualties, such as collisions, groundings, etc. In some exporting countries, pollution control standards may not be as stringent as United States standards, and thus there may be a greater potential for pollution at some loading sites.

b. Natural Gas

Domestic production of natural gas will have to be supplemented in order to fulfill demand and will come in the form of synthetic gas from coal and/or liquid hydrocarbons or as imports. Natural gas imports could come into the United States via pipeline from Canada or Mexico or as tanker-borne liquefied natural gas (LNG) from other countries, and will therefore be discussed individually in the parts that follows.

Pipeline Natural Gas Imports

Pipeline imports of natural gas into the United States have come from the two bordering countries of Canada and Mexico. In 1971, 0.9 trillion cubic feet were imported, via pipeline, from Canada, while 0.025 trillion cubic feet came from Mexico. There is little prospect for increased imports from Mexico. A relatively small proven natural gas supply base and policy of "self-sufficiency in energy" indicate that potential new gas will probably not be available for export. Present contracts expire in 1982; thus if no new supplies of gas are released for export, significant natural gas imports from Mexico could cease at that time, (Federal Power Commission, 1972). Future increases in pipeline imports of natural gas will, therefore, have to come from Canada.

Based on actions by the Canadian National Energy Board (NEB), it appears that future increases in natural gas exports from Canada may be limited. In November, 1971, the NEB dismissed three applications for licenses to export nearly 2.7 trillion cubic feet of gas to the U.S. The NEB rejected the applications because "--the Board decided that there was no surplus of gas remaining after due allowance had been made for the reasonably foreseeable requirements for use in Canada--" (Federal Power Commission, 1972).

If projected gas supply exceeds projected supply requirements, an exportable surplus results. FPC calculations based on the historical finding rate of 3.5 trillion cubic feet per year, show that supply could fall 23.4 trillion cubic feet short of these requirements.

Recent discoveries in the Arctic Islands, Mackenzie Valley, and Atlantic offshore regions will eventually, however, result in larger reserves additions. The NEB will not consider these new discoveries in its reserve calculations until they have been developed sufficiently to be within economic reach. If the discoveries continue and are developed, major surppluses may become available for export by the end of this decade.

ENVIRONMENTAL IMPACT

While the construction of pipeline facilities has the potential for causing unfavorable environmental effects, the employment of good construction techniques can minimize or even eliminate most of these effects. Farming or grazing lands can usually be restored to near original condition within two or three years, by the replacement of topsoil and the replanting of grass or crops. The esthetics of wilderness areas can be preserved by using existing rights-of-way or minimizing the width of new rights-of-way, by replacing grass and shrubs on the rights-of-way, and by using such techniques as feathering and screening or deflecting entrance-ways. Any displacement of wild animals will occur only during the construction. Banks can and should be stabilized to avoid erosion during construction. Access and service roads should be maintained with proper cover, water bars and appropriate slope to avoid soil erosion. Compressor stations and other aboveground facilities can be located in unobtrusive sites and planted with appropriate trees and shrubs to enhance their appearance; location, planting and exhaust design can be used to abate excessive noise associated with operation of the compressor stations. Treatment plants can be located and equipped with devices to minimize any adverse effects upon air quality and suitable means, e.g., evaporation ponds or disposal wells, can be found for preserving the water quality of the surrounding area.

Liquefied Natural Gas (LNG) Imports

Because of the growing shortage of domestic gas supplies, plans are now being made by the gas industry for baseload LNG imports under long-term contracts. LNG imports cannot, however, simply be increased to meet the demands for greater supplies of natural gas. Large-scale shipping of LNG is a relatively new industry and the United States does not yet have facilities for receiving baseload shipments. The FPC recently approved two projects which together call for deliveries of the equivalent of more than 1 billion cubic feet/day of LNG. Several other projects have been proposed and are pending approval. Future import levels will, therefore, be dependent on the rate of buildup of the United States' LNG industry.

In 1971, non-Communist natural gas proved reserves were estimated to be 1,033 TCF and production was 138 TCF. The estimate of future discoveries reserves was 6,167 TCF. It appears, therefore, that sufficient supplies of natural gas will be available for export to the United States.

ENVIRONMENTAL IMPACT

Tankers

Any seagoing vessel may be involved in collision or other mishap. However, escape of LNG to the environment would not necessarily result in significant impact. Since LNG remains liquid only at -259° F at atmospheric pressure, any spilled LNG would immediately begin to vaporize, and, although it would pollute the air, would have little impact on land or water resources. Studies on the possibilities of explosions resulting from LNG spills are inconclusive. Tests indicate that under certain conditions small-scale explosions result when the LNG is poured onto water. These results can not be extrapolated to predict the result of a large-scale spill on open water (USDI, 1972). Another study concluded that there was little danger of normal LNG exploding when spilled on water, and that a vapor explosion could result only after the methane content of the LNG had reached 40 percent. Since the normal methane content of LNG is 80-90 percent or more, and the boil-off rate is 0.2 percent per day, a reduction to 40 percent is not likely with present-day shipping practices (Enger, 1972). Worldwide experience to-date in the handling and shipping of LNG has resulted in no serious explosion or fire. Since commercial delivery of LNG by tanker began in 1961, there have not been any accidents at sea. However, LNG spills have been reported; they have not been serious.

Transfer and Storage

Each regasification plant will require facilities to permit the transfer of LNG from tankers to storage areas. Available methods require initial dredging, and possibly continued dredging, causing increased turbidity of the water and disruption of marine animals, especially in the case of bottom dwelling organisms. In most cases, this disruption would be temporary, but care would have to be taken to avoid, as much as possible, commercial fishing areas. The potential for fire or explosion is always present during the transportation, transfer, or storage of LNG. Since spilled LNG would not vaporize instantaneously, the release of the equivalent of several million cubic feet of gas, for example, might cause a fire which could continue until all the LNG had vaporized. An early LNG plant was destroyed by a disastrous fire in 1944 due to the failure of a storage tank, with a loss of more than one hundred lives. Since then, many improvements have been made in the technology of storage and handling of the LNG and increased attention has been given to proper safety precautions. The recent explosion of a Staten Island storage tank, killing more than 40 men, shows that there is still, however, an element of danger involved in the storing and handling of LNG.

Regasification

The construction of regasification plants will have an impact on land resources. The extent and duration of the impact will depend on the size and location of the plant. For example, the plant proposed for Cover Point, Maryland, would produce initially 650 million cubic feet per day and require a 1,022 acre tract of land; another plant proposed for Savannah, Georgia, would produce initially 335 million cubic feet per day and require 860 acres, or 1.5 to 2.5 acres per mmcf capacity. During construcion, there will be some disruption of the land surrounding the plant, and some damage to animal habitats. This damage will be permanent only in the area occupied by the plant and supporting facilities.

Since natural gas or water will be used to regasify the LNG, very few pollutants will be released to air or water. Plants using water to regasify LNG will release the water at a lowered temperature. In the case of the Savannah plant, water temperature will be lowered 5° F before being returned to the river.

A regasification plant could have an impact on the scenic and recreational resources of an area. The choice of the plant site is an important factor in minimizing the impact on scenic qualities and recreational activities. The increase in ship traffic could have no effect on water-oriented recreational activities.

Impact of Combustion and Transportation

Since natural gas is a relatively clean burning fossil fuel, the impact on air quality would not, therefore, be significant. LNG imports will require the construction of new pipelines. The impact of this construction has been discussed earlier in relation to domestic production of natural gas.

2. Outer Continental Shelf Production

This alternative would require increased exploration, development and production of crude oil fro m offshore areas. Supplies equal to all, or a significant part, of any reduction in Federal coal production would have to be developed and produced in addition to those supplies that are projected to be produced from OCS resources under the present leasing schedule during the same time frame.

Even though there is a demonstrated need for development of petroleum resources in offshore areas, development has not progressed to the extent required to meet projected production requirements. In response to the President's June 4, 1971, Clean Energy Message, which called for accelerated OCS leasing, a tentative schedule for leasing oil and gas resources on the OCS setting forth sales through 1975 was published. The schedule proposed an average of two major sales per year, double the previous rate. Both traditional OCS leasing areas in the Gulf of Mexico and virgin areas such as the Atlantic and Alaska OCS are included.

Implementation of the schedule was delayed after the first sale by a court injunction which precluded the completion of the December, 1971 general lease sale offshore eastern Louisiana. Although no commitment to hold a sale off the Atlantic coast has been made, opposition to such a sale already has been voiced.

Assuming that the OCS Lease Sale Schedule is continued at the rate of two sales per year in the Gulf of Mexico, the government might be able to offer sufficient additional favorable acreage to provide for increased production by leasing in frontier areas and beyond 200 meters. Leasing in frontier areas is necesssary to obtain the additional production since the Gulf of Mexico alone is not expected to be able to provide the incremental production in addition to the extended leasing rate for that area.

It should be recognized that the inevitable move into deeper water operations will impose greater capital needs and consequent need for more rapid payouts than the usual twelve to sixteen years now pertaining in the Gulf of Mexico. It is estimated that the move from depths less than 200 meters to 1,000-foot depths of water may increase exploration costs two-times and development drilling two and one-half to three times. It becomes evident, then, why the fields in deep water must be very large to be economically exploitable.

As operations move to deeper waters and more hazardous physical environment, equipment and data needs will increase. For specific areas, more detailed wave-height, wind-force, and storm information will be needed.

Changes that could be beneficial to stimulation of additional development include price increases, subsides, tax benefits, and changes in leasing procedures. The cost and effectiveness of such changes are unknown. The timeliness and the volume of increased supplies that would result from increased incentives are also unknown. Drilling rig availability might be a major problem. Less than 100 mobil drilling rigs were operating in domestic offshore waters in 1971.

Acceleration of the OCS leasing program to obtain addtional production above that expected to come from the current leasing rate in the Gulf of Mexico is doubtful. This production probably will not be obtained during this time period since leasing beyond 200 meters will have international implications which must be considered.

Futhermore, opposition has already been expressed against leasing in frontier areas.

ENVIRONMENTAL IMPACT

The developmental and production activity of OCS leasing will result in a variety of impacts on the natural environment, on other resource uses, on air and water quality, on land use patterns, on the social order, and on the economy. Some impacts are the unavoidable result of routine operations while others are caused by occasional human error. Still other impacts are avoidable and can be controlled or avoided by safe operating practices and by regulations.

Impact on Biota of the Open Sea

Except for the impact resulting from pipeline laying across the beach and through the coastal wetlands, most impacts resulting from OCS leasing affect the plants and animals of the open sea. Impacts in the open sea ecosystem will result from accidental loss of debris, discharge of drill cuttings, sand, drilling fluids, the burial of pipelines, and the accidental spillage of oil or other toxic materials.

Impact on Pelagic Marine Life

Pelagic marine life includes a broad spectrum of organisms from all trophic levels and includes the phytoplankton, zooplankton, nekton (euphausids, shrimp, fish, squid, and marine mammals), and pelagic seabirds.

Impacts that may be anticipated to have an effect on plankton will result from accidental spills of oil (and associated use of emulsifiers), and other toxic materials, discharge of drilling fluids and formation waters, and burial of pipelines.

After an oil spill has occurred, oil which has not evaporated, been carried ashore, or cleaned-up will be dispersed as minute droplets in the water and may damage marine organisms and enter the marine food chain.

Little information has been found concerning the effect of large spills of crude oil on the zooplankton. Hufford cites one experiment which showed accelerated death of zooplankton exposed to diesel oil (0.1 percent for 5 to 60 minutes), as compated to non-exposed zooplankton (Hufford, 1971). Zooplankton have been observed to ingest spilled Bunker C oil particles, however, with no apparent effect.

Small spills of fractions of a barrel to 50 barrels probably occur on the order of a thousand times per year in the Gulf of Mexico. It is difficult to determine potential impact from chronic, low-level spillage. A few scientists have offered cautious speculation. A pessimistic view is taken by Blumer who has stated:

> "..... we are rather ignorant about long-term and low-level effects of crude oil pollution. I fear that these may well be far more serious and long lasting than the more obvious short-term effects."

Blumer (ibid.), then points out that hydrocarbons are taken up into the food chain, and can become concentrated in marine species used by man for food. He states "One consequence will be the incorporation into food of materials which produce an undesirable flavor. A far more serious effect is the potential accumulation in human food of long-term poisons derived from crude oil, for instance of carcinogenic compounds." Blumer also cautions that low-level pollution may damage the marine ecology by masking natural chemical sex attractants, interfering with chemical food sensing and enemy repulsion." (Blumer, 1969)

A somewhat less pessimistic view is taken by St. Amant who states: "Chronic pollution from offshore production sites represents an unknown factor. Daily drops and loss of small amounts of oil or other chemicals overboard do not appear to generate ecological problems because of the relative immensity of the water column. Whether such sublethal pollution will eventually accumulate and cause environmental degradation is yet to be determined. Because of this unknown factor, significant effort should be made to prevent low-level pollution." (Amant)

A still less pessimistic view is taken by Oppenheimer (Oppenheimer, 1972) that hydrocarbons have been a part of the natural environment since life began. Also, that ".....except for the commercial concentrations of oil in our geosphere, no recognizable concentration of specific molecules have persisted in the aquatic environment other than tar balls, as micoorganisms are ubiquitous in their role in mineralization or recyclying of the hydrocarbons in natural environment."

Oppenheimer continues: "There is _a priori_ evidence that hydrocarbons may in some areas be significant as a nutrient source for living organisms."

The regular discharge of formation water, "brines", could have a severe, but extremely localized impact on plankton. Although only traces of entrained oil remain, formation waters contain a heavy concentration of dissolved salts and are devoid of dissolved oxygen. It could be anticipated that the release of this water would result in a plume trailing away from the point of discharge in the direction of the current with a core of perhaps a few feet in diameter and tens of feet in length that would be harmful or lethal to the plankton.

Physiological stress would probably result from an osmotic imbalance (cells losing water to surrounding brine), and low dissolved oxygen leading to suffocation.

The remaining impacts on plankton will also be extremely localized and are all related to increased turbidity caused by the discharge of drilling fluids and drill cuttings, and the jetting of sediments during underwater pipeline burial. The effect of this turbidity on a given parcel of water usually lasts a few hours at the most. The physiological effect would be to curtail the penetration of sunlight, and therefore, depress synthesis by phytoplankton.

Nekton include all marine animals which are active swimmers and are able to migrate freely over considerable distances. This mobility, combined with their ability to sense irritation and with their natural escape and avoidance behavior, enables them to flee localized adverse conditions.

Therefore, the only significant impact that members of the nekton could suffer would result from a massive oil spill.

No information has been found on the effect of spilled oil on members of the nekton other than fish. Findings from laboratory experiments cannot be easily applied to oil spills in the ocean. Although the potential for damage to nekton is clear, the scope of actual impact remains unknown.

In the past, the injury and death of thousands of seabirds has been the obvious impact of massive oil spills. The insulating properties of oil-clogged plumage are greatly reduced, resulting in heat loss. Ingestion of oil can cause a variety of pathological conditions. Feeding may drop, causing fat reserves to be exhausted. Indirect impacts could include loss of habitat and nesting areas due to installation of onshore facilities.

Impact on Benthic Marine Life

Environmental impacts which may be expected to effect benthic life adversely will result from the discharge of drill cuttings, accidental spillage of oil (and associated use of emulsifiers), and other toxic materials, and the burial of newly constructed pipelines.

Spilled oil which has not evaporated or been cleaned-up or stranded on a beach, after being dispersed into the water as droplets, adheres to particulate matter and sinks to the bottom where it comes into direct contact with the benthos. Studies of the effects of oil on benthos have yielded only tentative and qualified conclusions.

In the Arrow spill study, lobsters appeared to be clean and normal in behavior, (Operation Oil - Report, 1970). Scallops taken near heavily oiled beaches, were cooked and eaten and had no oily taste, but chemical analysis of scallops. along with periwinkles, sea urchins, and other bottom dwelling revealed the presence of oil in the digestive tract, other organs, and muscle tissue.

Data of Sanders, Grassle, and Hampson show immediate and nearly complet mortality of many forms of benthic animals following the spill of No. 2 fue oil near West Falmouth, Massachusetts, (Sanders, Grassle, & Hampson, 1972). The bivalve molluscs (clams, etc.) seemed especially vulnerable. After a fe months, affected areas were recolonized by resistant forms. After about 10 to 20 months, the more sensitive molluscs resettled many areas.

Chemical analysis of edible shellfish species made following the West Falmouth spill revealed that the fuel oil had been absorbed or ingested and could subsequently be found in oyster bodies and scallop muscles in quantities sufficient to require the closure of shellfish beds to harvesting (Blumer, Souza & Sass, 1970).

During drilling operations, drill cuttings are separated from the drilling fluid, cleaned of any entrained oil and discharged into the ocean. A diver survey during one operation revealed that the drill cuttings could be detected over a circle 100 feet in diameter. In a small area in the center, the deposit appeared to be about four feet thick. The same survey of the cuttings deposit showed that benthic animals either migrated up through the deposit as it accumulated or colonized even as deposition continued because it appeared to be inhabited by several animals characteristic of "normal" benthic fauna.

During entrenchment of new pipelines, most, if not all, benthic fauna are either destroyed by the jetting or raised into the surrounding water and rendered completely vulnerable to predation. Although recolonization would begin immediately, the native fauna could not be fully restored until seasonal reproduction cycles had been completed by representative species from adjacent areas, which would provide a supply of larvae to settle and enter the reworked substrate.

Turbidity resulting from resuspended sediment could have an adverse impact on filter-feeding apparatus by blocking respiratory surfaces. Another possible source of impact is the resuspension of toxic heavy metals by a polluted stream of runoff. The possibility exists that these toxic materials could be ingested by lower marine life and could then be magnified through the food chain until they accumulated in serious quantities in top carnivores, including species harvested for human food.

Impact on Beach and Associated Biota

Impacts on the beach and associated biota could result from contamination by spilled oil and from disruption in the path of pipeline burial excavations. A study of three sandy beaches oiled during the Santa Barbara spill revealed no conclusive results concerning the impact on marine fauna, (Trask, 1970).

During the Arrow spill study, excavation of clams revealed oil extending down most burrows. Some mortality of clams occurred and even the live clams were unresponsive (Operation Oil - Report, 1970).

Other pollution studies for the littoral zone are concerned with rocky shoreline and their characteristic assemblages of seaweeds, barnacles, limpits, anemones, etc., and consideration of physiological stresses leading to death in oiled plants and animals. To generalize, where organisms have been covered by crude oil and Bunker C fuel oil, death is primarily blamed on smothering due to the physical coating. When the pollutant has been a lighter refined oil (No. 2 fuel oil, diesel fuel), death and stress has been associated primarily with toxic effects of the oil. It is also possible that shorebirds could receive an oiling. The results would be the same as for pelagic seabirds.

Burrowing animals and rooted plants in the path of pipeline laying operations will be killed or damaged. At least one growing season would be required for the impact to be abated.

Impacts on Embayments, Channels, Water Courses & Associated Biota

Living organisms in estuarine and inland waters could be adversely affected by spilled oil and by dredging activity during the burial of new pipelines. Oil pollution in the semi-enclosed waters of a bay system could be more serious than in the sea or along the open coastline because the pollutant would be, relatively speaking, entrapped, with tidal flushing being its only source of removal. Many species undergoing early development in estuarine waters are vulnerable to even small quantities of toxic compounds containing oil. The drawbacks of past studies have been noted by Blumer, who stated: "unfortunately, chemical analysis (of potentially contaminated edible species) has not been used to support... studies in the past and conclusions on the persistence of oil in the environment have been arrived at solely by visual inspection... Marine foods may be polluted by petroleum and may be hazardous to man, but neither taste nor visual observation may disclose the presence of the toxic hydrocarbons." (Blumer, 1971).

Impact on Wetlands

The wetlands includes the mudflats, sand flats, coastal marshes, and bay and barrier island fringing marshes. Dominant vegetation consists of spartina-type grasses and algae. Insects, worms, and protozoa are the dominant fauna. Large populations of waterfowl and wading birds are found also.

Three types of adverse impacts are possible in the wetlands environment: pollution by spilled oil, disturbance during pipeline construction, loss of habitat by lands taken for installation of onshore pipeline transfer terminals and gas treating facilities.

No information has been found concerning the effects of oil in the Gulf states wetlands. It is unlikely that a marsh spill would spread far because of the physical hindrance caused by rooted vegetation, natural stream levees, canal spoil banks, and roads.

The impact of pipeline burial in the marshes will be the physical destruction of vegetation and immobile fauna in the path of the pipeline laying operation. The impact on a narrow band of marsh in the path of the pipeline operation will probably be severe, but of short duration. In addition, new pipelines will probably result in the construction of onshore pipeline terminals or gas treatment facilities. The resulting impact will be the removal of a small amount of marsh habitat (on the order of five acres or less per facility).

Impact on Air Quality

The quality of air over the leasing area could be degraded by exhaust emissions of stationary power units and service vessels, and by accidental release of oil and gas from wild wells.

If a wild well were not burning, methane, ethane, carbon dioxide, and nitrogen would be released into the air. If the gas well were on fire, combustion would be essentially complete and the emissions would consist almost entirely of carbon dioxide (CO_2) and water; the nitrogen would remain as N_2 and any sulfurous gases would be oxidized to SO_2. The resulting impact would not be great.

If a wild oil well were releasing crude oil onto the water, the resulting impact would be substantially greater. If the oil does not burn, a significant amount of it will evaporate. A reasonable estimate of the range of emissions, assuming complete combustion, that an oil well fire could produce per 1,000 bbl. burned, might be as follows:

CO_2	:	340,000 - 347,000 lb.
SO_2	:	620 - 34,000 lb.
NO	:	660 - 10,000 lb.

(As a point of reference, during the Chevron - 1970 fire and spill, the maximum spillage rate was estimated to be 1,000 bbl. per day.)

Combustion of oil would in reality be incomplete, however, and emissions would contain somewhat less of the above compounds, but would include, in addition, such materials as volatilized petroleum, particulate carbon, carbon monoxide, nitrous oxide, sulphur monoxide, along with other altered or partially oxidized matter.

Impact on Water Quality

The natural condition of sea water may be altered and degraded in several ways during oil and gas operations. Debris and bilge will be released into waters from the many seismic vessels, crew boats, tugs, and service and supply boats used throughout the operation.

During drilling operations, drilling fluids and drill cuttings will be discharged into the sea. Most drill cuttings consist of sand and shales and therefore cause no turbidity, but settle to the bottom in minutes. The chemicals used in drilling muds have a relatively low-level of toxicity and when discharged, produce a plume of turbidity in the water near the surface. The visible plume is on the order of a few feet wide a few yards long.

The production and discharge of formation waters (oil-field brines) is also a potential source of pollution. Three properties of formation waters contribute to water quality degradation when released into the sea. First, is the small amount of entrained liquid hydrocarbons. Second, is its high concentration of dissolved mineral salts. Third, is the absence of dissolved oxygen in formation waters.

Water quality could be further degraded as the result of accidental oil spills. Part of this spilled oil would be removed by clean-up operations and some would evaporate, but the largest proportion would probably be dispersed into the water.

Another source of water quality degradation is the resuspension of sediment during pipeline construction and burial. The duration appears to be on the order of several hours at a given location.

Impact on Commercial Fisheries

The general consensus of Gulf fishermen is that underwater stubs present the greatest problem; the presence of offshore structures is a moderate inconvenience; and, the debris problem is minimal.

Removal of Sea Floor From Use by Trawlers

All shrimp and industrial bottom fish are caught by dragging a large trawl across the sea floor. Every site occupied by a drilling or production platform and its attendant service boats and barges must be avoided by trawlers. If the structure is a jack-up drilling rig or permanent production platform, the area of sea floor removed would amount to two to five acres. In deeper waters (over 300 feet), a semi-submersible drilling rig with its anchoring system would occupy up to 325 acres (assuming a 1,500 foot anchoring radius). The duration of exploratory drilling ranges from under 45 days for a single well to around six months for multiple well explorations. Permanent production platforms may remain in place for 10 to over 20 years. The probability that permanent platforms will be erected on each tract, based on past exploration success rates, is about 35 percent. It is estimated that each full tract (5,760 or 5,000 acres) developed, will average three structures.

Creation of Obstructions on the Sea Floor That Cause Damage to Trawling Nets

Obstructions that may interfere with trawling are underwater stubs, large pieces of debris, and unburied pipelines. Although Coast Guard regulations require that stubs be marked by a buoy at the surface, if located in 80 feet or less of water, these buoys are frequently found to be missing. If a trawler pulls his net across a stub, it will certainly be badly damaged or lost. Large pieces of debris, such as equipment, piping, structural members, tools, and the like, if accidently lost off a platform service boat or barge, may damage trawling nets of fishermen unlucky enough to snag them.

It has also been reported that unburied pipelines (beyond the 200 foot depth contour) pose a serious problem to the shrimp trawling operations in the Gulf of Mexico (Farrelly, 1972). A significant amount of shrimp trawling does occur in water depths where pipelines remain unburied.

Contamination of Fish by Spilled Oil

Fish which are either externally coated or internally contaminated with oil are unmarketable. It has been shown that fish that live in the vicinity of chronic spillage are likely to be internally contaminated. Oyster beds have been contaminated in the past from oil spilled in the marshes, bayous, and bays in the delta region of Louisiana, but we are unaware that contaminated catches have ever been taken in the open waters of the Gulf.

Conflict with Ship Traffic and Navigation

Despite the existence of fairways in some areas, the possibility of a collision with drilling rigs, permanent platforms, and their attendant vessels remains. Impacts which would result include loss of human life, a spill of oil, release of debris including parts of, or the entire drilling rigs, and the ship, if it sinks. The contents of the ship's cargo could pose a serious threat to the environment if it includes toxic materials such as chemicals, crude oil, or refinery products. Floating trash accidentally lost off platforms also constitutes a hazard to boats.

Impact on Recreation, Sport Fishing and Esthetic Values

Pipeline construction and burial disturbs a small area of beach (about 30 feet wide). The first high tides following burial of the pipeline will restore the beach terrain. The restoration of the beach region will take longer, most likely requiring a storm tide or high winds to obliterate the effects of the excavation.

An oil spill would directly affect water sports, such as swimming, diving, spearfishing, underwater photography, fishing for finfish and shellfish, boating and water skiing. Other activities such as beachcombing, shell collecting painting, shoreline nature study, camping and sunbathing would be unattractive where an oil spill had coated a beach.

Sport fishing would be curtailed in the vicinity and for the duration of any spill incident. However, extensive testimony and evidence indicated that overall, oil and gas operations have a favorable impact on sport fishing activities. Sports fish congregate near offshore platforms, which serve as artificial reefs. In the open sea, offshore platforms provide both food and cover in areas that are largely devoid of those essentials. Myriad forms of microorganisms in the water drift by these structures and attach themselves, soon encrusting all exposed surfaces on the platform.

Adverse esthetic impacts result from floating debris or oil washed into bays or onto beaches, temporary scars from pipeline burial, and visibility of some nearer offshore structures from the shore.

Impact on Land Use and Land Use Trends

Pipeline laying and the construction of pipeline terminal facilities temporarily disrupt a small amount of land. Since pipelines onshore are buried, there would be no permanent loss of the land for grazing, farming, etc.

Exploration and production in new offshore areas could require a marginal influx of labor and redistribution of population due to the absence of a large petroleum-based industry and a labor force with the necessary skills.

Accidents and Oil Spill Events Associated with OCS Activities

In any complex industrial operation involving heavy equipment, flammable materials, work at sea, and large numbers of employees, it is inevitable that accidents will occur.

Natural Gas Leaks Associated with Blowouts

Information furnished by the Geological Survey for the period 1956-1971 lists 30 gas leaks associated with well blowouts during OCS oil and gas operations in the Gulf of Mexico. Ten of these accidents involved fires and four were associated with oil or condensate spills. The duration of the blowouts ranged from two hours to over seven months. Several incidents included the loss of life and equipment, but none of the leaking gas resulted in environmental damage. There are no estimates available of the amount of gas lost.

3. Oil Shale

Large areas of the United States are known to contain oil shale deposits, but those in the States of Colorado, Utah, and Wyoming are of greatest potential for commercial shale-oil production. It is estimated that some 73 percent of the oil shale lands containing nearly 80 percent of the shale oil are public lands. The highest grade deposits occur over an area of 17,000 square miles (11 million acres), and contain an estimated 600 billion barrels of oil. Recovery of even a small fraction of this resource would provide significant amounts of energy adequate to supplement the Nation's oil supply for many decades.

Three retorting processes have been developed to the point of technological practicability, but none have been demonstrated and tested at a commercial production scale. The mining of the shale presents no particularly difficult technological problems as it can be done by conventional room-and-pillar underground mining or by surface mining techniques. The major process barriers to development of this alternative therefore, are the need for full-scale demonstration and testing to prove the technology and develop necessary cost and other data for determining economic feasibility.

On June 29, 1971, the Secretary of the Interior, announced plans for a proposed prototype oil shale leasing program which is designed to ".... provide a new source of energy for this Nation by stimulating the timely development of commercial oil shale development by private enterprise, and to do so in a manner that will assure the minimum possible impact on the present environment while providing for the future restoration of the immediate and surrounding area." The proposed program would make available to private enterprise, for development under lease, a limited amount of public oil shale resources. Such leases would be by competitive bonus bidding and would include assumption of certain royalty obligations to the United States.

The proposed program is in concert with the President's Energy Message of June 4, 1971, in which he requested the Secretary of the Interior to initiate "A leasing program to develop our vast oil shale resources, provided that environmental questions can be resolved." The environmental question has come under intensive review over the past three years and, in September, 1972, the Secretary released a 1,300 page draft environmental statement. That statement details the proposed program and assesses the specific impacts expected from prototype development plus development on private lands that may be stimulated by the Department's action should the program be implemented.

The proposed program depends on industry as to the timing of commercial production. It is not possible therefore, to determine the exact amount of oil that is to be expected in the future. For planning purposes, however, it is necessary to determine the maximum rate of development that may be expected. This was done for the Department's study and the estimates are quoted as follows:

> Commercial shale-oil production, under the most optimistic estimate, could begin about 1975 at a rate of about 18 million barrels per year (50,000 barrels per day), on the basis of anticipated technologic progress. The first generation technology needed for this rate of production would be improved from 1976 to 1980. This development stage will be reflected by only small increases in annual production of about 18 million barrels per year as the new technology is applied. By 1980, a productive capacity of more than 100 million barrels per year (300,000 barrels per day) could be established. More importantly, the technology probably will have been advanced to the point where large incremental increases in production could be achieved. Also, the nucleus of people, supporting services, facilities, and experience needed for this expanded effort will have been established.

After 1980, the second generation extraction-retorting systems would be expected to permit annual additions to shale-oil productive capacity of about 37 to 73 million barrels per year (100,000 to 200,000 barrels per day). The rate at which oil shale may be developed provides the framework within which subsequent calculations of the capital investments that will probably be required. Seven installations with a cumulative capacity of 400,000 barrels per day are assumed to be constructed on both private and public lands in the period 1973 to 1981. In the period 1981 to 1985, capacity is assumed to grow to one million barrels per day.

The cumulative six-plant capacity of 300,000 barrels per day by 1979 reflects the necessary construction and evaluation phase of this new technologic development. Second generation technology could be expected to be available by 1980, enabling the large increases in capacity from surface processing systems. In-situ retorting may also be advanced to the point where the first commercial operation could be initiated. By 1985, cumulate capacity is estimated at one million barrels per day from both private and public lands.

It may be possible to accelerate the rate of shale oil production through a Federal program or by incentives or subsidies for private development. Such efforts, however, would not be expected to significantly increase shale-oil production over that now expected due to the long lead time required for the physical development of this resource.

Substantial production probably could be achieved by the 1980-1985 period. Before then, oil shale might provide an alternative to the proposal to a limited extent. However, since development is now only in the pilot plant stage, oil shale probably will not be available in significant quantities before 1980 due to a combination of economic, technical and envrionmental reasons.

ENVIRONMENTAL IMPACT

Impact on Land Quality

The development of an oil shale industry would require roads, mining, plant sites, waste-disposal areas, utility and pipeline corridors, and associated services during the productive life of a lease. These activities would change the existing pattern of land use, alter the existing topography and would affect natural vegetative cover until revegetation operations began. Such disturbances would unavoidably exist throughout the life of operations, but would be temporary in the sense that restoration of surfaces to original or improved condition would be required before site abandonment. Proper restoration methods could minimize scenic impacts. The cumulative land under development or otherwise not usable would be about 4,000 acres for a 200,000 barrels per day production. Land effects will vary depending on the mining and processing systems that may be used.

Waste disposal could be deposited in canyons and gullies which would gradually be converted into flatter areas. Contouring and revegetation would restore scenic attractiveness and probably reduce erosion.

Where areas to be developed are now used for livestock grazing, agriculture, wildlife habitat, or recreation, some unavoidable changes in land use patterns would result.

Impacts would be significant in local areas, but slight for the region as a whole, because the percentage of the region's total surface area affected by development (including urbanization) would be small. However, the semi-remote character of the area would be modified and some local dislocations would unavoidably occur.

Impact on Water Quality

In order to insure dependable supplies of water from the Colorado River or its tributaries, dams and reservoirs must be constructed or water purchased from existing reservoirs.

The water diverted from all uses would have an unavoidable impact on regional water supplies. Storage, diversion, and net consumption of existing water resources would deplete natural stream flow and slightly increase the salinity concentration of the Colorado River. Other salinity influences could occur from accidental releases, surface water runoff, and water table depression.

During the period between disturbance of the surface and revegetation, high intensity rains could cause accelerated soil erosion and channel cutting and could increase sedimentation in the stream beds. The cumulative impact of this over time would be quantifiable by sediment measurements of the major rivers. Water discharged into the streams could add to the erosion factor and sediment load.

Drainage courses and channels would probably be diverted because of mine facilities and waste disposal areas. The quantity of impact depends upon the type and intensity of mining operations and control measures used.

As oil shale development proceeds, increased population in all areas would put a greatly increased sanitary waste load on regional water supplies. However, treatment and disposal facilities will mitigate adverse effects.

The disturbance of groundwater by mining operations, or by water used to return spent shale underground for disposal, could have an adverse effect on subsurface water quality, groundwater movement, water levels, spring flow, and stream flow. Knowledge of aquifer characteristics, head relations, and chemical quality distribution in the aquifers in much of the region is inadequate and the extent of this impact cannot be quantified. Specific information developed during core drilling, close monitoring of the quality of groundwater, and prompt action to change operations detrimental to water quality would help mitigate adverse effects.

Impact on Air Quality

Proper techniques already exist to adequately control emissions, including particulates, sulfure oxides, and nitrogen oxides potentially present in various fuel gases, and the dusts produced in mining and shale disposal.

It is expected that all applicable Federal and State criteria on acceptable air quality standards could be met. Residual concentrations of sulfur oxide, on the basis of a 200,000 bbl/day output, would total 12 to 40 tons per day depending on the process and nitrogen oxides would total 17 to 23 tons per day. Solid particulates in gaseous discharges to the atmosphere would be small, but unavoidable at the present state of technology. New control techniques now being developed for other industrial operations could be incorporated into this industry. Some local problems with temperature inversion may be experienced, the significance of which cannot now be established. The long-term effect of industrialization would result in a decline in general air quality of the region.

The local noise level near developed sites is expected to increase, due to mining, retorting, and other processing operations. This is an unavoidable adverse consequence of increased industrial activity in a region which is presently predominantly a semi-wilderness, and can be only partially mitigated by noise abatement devices.

Impact on Fish and Wildlife

Construction and operation would have varying degrees of direct and indirect impacts upon fish and wildlife and their habitat in the immediate vicinity of the plants and along roads, surface facilities, and pipelines. Noise and associated human activities accompanying construction and operation would have a new effect of stress and disturbance on normal behavior and activity patterns of wildlife. Species which could be affected by such disturbances include mountain lion, bear, elk, mule deer, antelope, bob cats, sage grouse, blue grouse and migratory birds. Animal species such as mountain lions, elk, and peregrine and prairie falcons, would avoid disturbed areas, which would cause them to lose up to 4,000 acres of habitat per year.

Airstrips and increases in air traffic would provide some source of aerial harassment of mule deer, wild horses, and big game, the extent of which would be dependent upon the number and location of airstrips and the volume of air traffic which would be involved.

Wildlife food and cover values of lands used for mining, pipeline and road construction, building, etc., would be at least temporarily lost. Permanence of such losses would be dependent upon the time required for and success of reestablishing useful wildlife food and cover. Such habitat loss would in turn result in lower populations of animals. For example, removal of critical winter browse would result in a corresponding reduction in mule deer numbers.

Oil shale-related drying of surface water features, such as springs, seeps, and small streams, would change the natural plant-animal complex associated with each particular water feature, including the related distribution of game, wild horses and cattle.

Coverage of roadside vegetation with vehicle-caused dust would constitute a minor, but chronic problem, since such vegetation would loss its wildlife food value until washed off by subsequent rains.

Unpredicted or uncontrollable changes in the quality of local surface or groundwater would result in accompanying impacts on aquatic fish and wildlife populations and their habitats. In the event that sediment, leached substances, saline groundwaters and/or toxic materials were released to surface waters as a result of oil shale operations, adverse impacts would be imparted to aquatic plant and animals. Unless carefully controlled, such discharge would have adverse effects on aquatic habitat of the Colorado, Green and White Rivers and other exposed water areas. Adverse impacts would also be expected in exposed aquatic habitat in the form of lowered biological productivity, physical covering of fish spawning and nursery areas.

Handling, storage, and transmission, including feeder pipelines, would exhibit some small losses of oil. Spills would follow natural drainage features and released oil would kill trees, shrubs, and other vegetation with which it came into contact. Birds, some species of both land and water mammals, and fish and other aquatic organisms would be adversely affected if they came in contact with the oil.

Oil shale-related urbanization would also create stress on regional wildlife populations. Reductions in surface water quality near population centers as a result of sewage, toxic substances and siltation, would adversely affect aquatic organisms and their habitat. Some wildlife would be consumed by buildings, roads, parking lots, etc. Additional wind and water erosion would occur. Increased ground vehicle traffic would result in more frequent road kills of deer and other game.

Increased hunting pressure would cause localized adverse impacts upon wildlife through reduction of populations of some species, including a few already scarce species such as the brown bear and cougar. Increased harvest of mule deer, elk, moose and antelope would require regulation in order to avoid undesirable downward population trends. Both development and associated urbanization would aggrevate conditions which cause some species to be classified as rare and endangered. Semi-remote hunting and fishing qualities would be lost.

4. Synthetic Natural Gas and Oil

Through hydrogenation processes, it is possible to convert coal to various hydrocarbon liquid and gaseous substitutes for natural oil and gas. Considerable research and development has been done and further R & D is being conducted by the Federal Government and private industry. While many individual units for commercial gas processes have been tested, synthetic gas has not yet been proved economical in the United States. There are presently no coal-to-liquid conversion plants in the United States. The Department of the Interior's 1972 coal research report (USDI, Office of Coal Research, 1972), describes much of the work currently in progress.

The feasibility of producing synthetic natural gas and oil from coal as an alternative depends upon the rates at which technological systems are developed, tested and proved economic, and at which commercial scale plants are built. While it is possible that substantial amounts of synthetic fuels could be produced from coal by 1980-1985, the state of technology permits no accurate forecast.

Natural gas can also be synthesized from petroleum. Such gas has been produced commercially in Europe and some 25 plants are in the planning stage for the United States. While the gasification of oil does not add to overall energy supplies, it does provide an additional flexibility in energy form.

Coal Gasification

The need for natural gas has been discussed in the section relating to

Federal Power Commission natural gas pricing policies. Because of its clean-burning characteristics, gas is the preferred fuel for use in small installations--such as for home heating--where economics preclude the installation of pollution--control equipment.

In the event of limited gas supplies, steam-electric gas powerplants will probably be the first to be denied the use of pipeline-quality gas. Coal can be converted to a clean, low-Btu gas for use under utility boilers. Although such synthetic gas can be piped short distances, it will be more economical to use it adjacent to the gasification plant.

While no coal to pipeline-gas process has yet reached commercial application in the United States, at least two companies plan to construct a commercial coal-gasification plant using the Lurgi process, which has been known for a number of years, and has been applied commercially in Europe. The earliest date for production from these projects is 1976. Since gas produced by the Lurgi process has heating value of only 400-450 Btu/cf., catalytic methanation is required to achieve pipeline quality of 1,000 Btu/cf. for American gas utility use. This step has not yet been commercially demonstrated.

The Department of the Interior and the American Gas Association are cooperating on the accelerated program for coal gasification announced by President Nixon in his Clean Energy Message of June 4, 1971. Two coal gasification pilot plants have been built and are now undergoing shakedown operation, and a third pilot plant has been authorized. In each of the plants, a unique gasification method will be tried in conjunction with different systems of gas cleanup and methanation so that a final process, combining the best features of the individual processes can be chosen by the summer of 1975. Construction of a demonstration plant is expected to follow so that a large-scale plant will be on stream by 1977.

Research over a period of fifteen years by the Bureau of Mines has culminated in the development of the "Synthane" process. In June, 1971, a contract was let to Lummus for design of a pilot plant; a contract for construction may be let in the autumn of 1972. A draft environmental statement (DES 72-3) was released on January 24, 1972. Meanwhile, a smaller pilot plant will be operated by Hydrocarbon Research, Inc., under a contract with the Bureau. The Bureau also has under review another coal gasification scheme, termed a modified Lurgi process, to use strongly coking coals for making a clean low-Btu gas.

Oil Gasification

Synthetic natural gas (SNG) can also be produced from petroleum feedstocks. Processes that are being considered include: thermal cracking in steam; thermal cracking in a hydrogen-rich atmosphere; catalytic cracking in steam; and partial oxidation.

Currently, much attention is being given to catalytic rich processes, developed by the British Gas Council. Called the CRG (Catalytic Rich Gas), it can gasify a wide variety of hydrocarbon feedstocks, though attention now is concentrated on naphtha feedstocks.

About 25 SNG projects, using naphtha feedstocks, have been announced. About half of these state that they intend to operate on imported naphtha. Estimated costs for SNG range from $1.25 to $1.75 per MM Btu.

The environmental impacts of such plants are expected to be less than those of comparable coal-based synthesis plants, because they would be free of ash and char, and sulphur oxides and particulates discharge problems.

Coal Liquefaction

Until recently, there has not been the same sense of urgency with reference to the conversion of coal to clean-burning oil as exists for pipeline gas. One reason is that imported oil has been available at cheaper prices than a synthetic crude. Also, environmental restraints have forced some electric utilities to abandon the use of coal, or to forego its use in new plants. The supply of low-sulphur coal in the East is limited, additional natural gas for electric utility use is not now available to householders and commercial users, electric utilities may soon be restricted or banned from using natural gas.

Accordingly, the supply problem relating to oil now is being viewed in a more urgent context. The situation, however, as regards the necessity for developing coal-to-oil technology is not yet escalated to an urgent program basis.

The Department of the Interior has filed a Final Environmental Statement, and will soon erect at Fort Lewis, Washington, a Solvent-Refined (SRC) pilot plant. Consideration is now being given to the conversion of Project Gasoline and the pilot plant at Cresap, West Virginia, to test a simplified version of the H-Coal process, and a Bureau of Mines coal process along with others.

ENVIRONMENTAL IMPACT

Like natural gas, synthetic (also called substitute) natural gas and oil from coal are clean-burning fuels because the sulphur has been reduced to very low values, and no particulate matter is emitted at the point of combustion.

Coal gasification and liquefaction share the same environmental problems as use of coal for boiler fuel. These begin with coal mining. One of the most pressing problems is air pollution from sulfur content of coals. These problems are discussed fully in the section on coal.

Impact on Air Quality

Plant operation, consisting of handling and transporting the coal to the process and converting the coal to gas and/or oil, will involve very large quantities of devolatilized coal, called char, which will be burned in boilers to generate process steam and power, or gasified to make process hydrogen. Major emissions that must be controlled are sulphur and nitrogen oxides and bottom ash and fly-ash from the plants generating process steam and power. Fly-ash emission boiler stacks can be controlled, and furnace-bottom ash and slag are handled routinely, without environmental problems. However, it may become desirable to locate large coal-conversion plants near large strip mines, where ash and slag from the process would be returned to the open cuts, and the ground restored in accordance with environmental considerations. The technology for controlling sulphur and nitrogen oxides from such plants is under development.

The environmental impacts of SNG plants using naphtha feedstock are expected to be less than those of comparable coal-based synthesis plants, because they would be free of ash and char, and sulphur oxides and particulates discharge problems.

Impact on Water Quality

Plant operation involves very large quantities of water for cooling and scrubbing gases. The discharge of contaminant's such as phenols, cresols, benzene, oil, and tars must be controlled. Process waste solids such as spent dolomite may present problems of surface water contamination.

Impact on Land Quality

Waste solids such as char, granulated extract, and powdered sulfur must be disposed of at approved landfill areas.

5. Onshore Oil and Gas

TECHNOLOGICAL PROCESSES

The development and final utilization of oil and gas involves a wide range of operations, wherein the oil and gas must be found in a natural underground reservoir; lifted to the surface; transported to refineries; refined into more than a thousand products; and, finally, marketed and distributed.

The first phase involves the location of petroleum reservoirs, which are generally found in porous sedimentary rocks. Favorable geologic conditions may result in a variety of traps which lead to the concentration of oil and gas.

Once the well has reached a depth sufficient to have penetrated all fresh water producing zones, a string of surface casing is set and cemented. Surface casing functions to prevent the drilling operation from contaminating natural underground fresh water supplies, and to serve as a conductor for drill stem as the hole is extended.

Following the setting and cementing of surface casing, three or more additional strings of casing may be placed in the hole. Multiple casing strings are used to prevent cave-ins, which might result in loss of the hole, to shut-off undesirable high pressure water, oil, and/or gas zones and to seal-off zones of last circulation that may develop as drilling proceeds. Successive strings of casing are made smaller than the surface casing, thereby allowing deep casing to pass through the drill string.

Final steps in the pumping procedure involves emplacing a string of production casing replete with perforations for pumping in the pay zone, installing a set of pipe called "tubing" into the well in preparation for pumping, and connecting a pumping engine, or "Christmas tree" into the tubing at the surface. The Christmas tree performs the function of controlling the flow from a well where the underground pressure in the producing formation is high enough to flow naturally. If the natural pressure at the level of the reservoir is insufficient to allow the well to flow naturally, a pump is attached to the lower end of the tubing in order to force oil up the well. Only a portion of the oil in a reservoir is recoverable by primary producing operations. Secondary recovery operations increase the recoverable percentage of oil in place by injecting gas or water into the producing zone, a procedure which exerts pressure on the oil, thereby allowing additional oil and gas to be forced up the well. Once oil is removed from the underground reservoir, it is stored in tanks near the well pending shipment to the refinery.

Throughout the range of oil and gas activities, safety and other performance standards are specified by industry, as well as state and Federal agencies.

Because crude oil and natural gas occur under similar geologic conditions, and often in the same reservoir, (one-fifth of the proved reserves of natural gas are associated with crude oil), the technology associated with the production of natural gas closely parallels that of crude oil. However, impurities in natural gas vary from those in crude oil as evidenced by the following list of nonhydrocarbon impurities in natural gas: helium, nitrogen, hydrogen sulfide, and carbon dioxide.

The advent of the use of modern geophysical prospecting methods in the search for oil and gas has brought about a marked improvement in the success ratio in petroleum and natural gas exploration. In addition to improving search techniques, significant advances have been made in drilling technology and in the automation of all phases of the development and production process. Advancements have been particularly noteworthy in the areas of fluid injections, artificial fracturing of low-permeable oil formation, and of in-situ combustion. Significant improvements have also been made in production methods and equipment.

Concerning transportation of hydrocarbons, recent technological developments have resulted in decreasing cost levels. Of particular significance has been in the installation of highly automated, large diameter, thin-walled (high strength steel) pipeline systems, as well as better protective coatings and insulation.

Technological advances in the refining phase of petroleum production have mainly come about through an increase in the use of computers. Complementing the increasing trend toward automation, recent advances in the technology of petroleum refining have resulted in increased production, reduced operating costs, and improved quality control.

RESOURCE BASE

Oil and gas reserves are located in many areas of the United States, but the largest reserves are found in the mid-continent and Gulf Coast regions.

The following table shows the Geological Survey's latest calculations of proved onshore oil and gas reserves. The table also presents the Survey's estimate of recoverable resources.

Table II-1 - U.S. Onshore Oil and Gas Reserves and Resources

(Oil 1/ in billions of barrels; gas in trillions of cubic feet)

	Proved Reserves		Recoverable Resources 2/	
	Oil	Gas	Oil	Gas
Public lands	3.0	14.0	250.0	1,153.0
Non-public lands	38.3	237.6	16.0	61.0
Total	41.3	251.6	266.0	1,214.0

1/ Includes natural gas liquids.

2/ Does not include proved reserves.

Alaskan Oil and Gas Reserves

The Prudhoe Bay field currently is estimated to contain 24 billion barrels of oil-in-place. At an estimated recovery rate of 40 percent, the current proved recoverable reserves of the field are 9.6 billion barrels of crude oil (American Gas Association, 1970). These reserves alone make the Prudhoe Bay field the largest ever discovered on the North American continent. Nevertheless, the 9.6 billion barrel estimate may be a conservative indication of the crude oil potential of the field and the Arctic Slope province.

The current reserve estimate for the Prudhoe Bay field is for unextended pools and assumes primary recovery only. With further developmental drilling and application of secondary recovery techniques, it is likely that at least 20 billion barrels of crude oil will eventually be recovered from the Prudhoe Bay field. This would make it the fifth largest oil field ever discovered in the world.

The Prudhoe field has large reserves of natural gas dissolved in or associated with its crude oil reserves. Recoverable gas reserves in the field were estimated to be 26 trillion cubic feet as of the end of 1970. An average of 750 cubic feet of dissolved gas per barrel for the proved oil reserves of 9.6 billion barrels would indicate reserves of approximately seven trillion cubic feet of dissolved gas and 19 trillion cubic feet of associated gas. These reserves, which, like the crude oil reserves of the Prudhoe Bay field, are subject to extension and revision, constituted 8.9 percent of recoverable U.S. natural gas reserves at the end of 1970. They also make the Prudhoe Bay field the 13th largest gas field ever discovered in the world.

The estimated reserves of the Prudhoe Bay field do not exhaust the oil and gas potential of the Arctic Slope province in Alaska. The Prudhoe Bay field is located in the Colville Basin. Geologically, this basin is classified as an intermediate crustal type (i.e., its underlying crust is intermediate to that beneath continents and that beneath oceans), the basin itself being extracontinental (located on the margin of a continent), and sloping downward into a small ocean basin. Extracontinental, downward warping basins are among the richest sources of oil and gas in the world. Examples of such basins include the Arabian platform and Iranian basin (Persian Gulf), the East Texas basin, and the Tampico embayment, (Mexico). Over half of the 119 known oil fields with at least one billion barrels of recoverable reserves are found in the 10 known basins of this type (Halbouty, 1968).

The ultimate potential of the onshore area in the Arctic Slope province is uncertain. The platform along the Arctic Coast gives considerable geologic indications of being very favorable for both oil and gas, (Gryc, 1971). Comparison with the history of similar basins indicates a high probability of further discoveries of varying size. Professional estimates of ultimate recovery for the province range from 30 to 50 billion barrels, (Cram, Schurr, 1971). Recall, here, that the Prudhoe Bay field alone is likely to supply 20 billion barrels of crude oil. Considerably higher estimates than these have been made, but the geologic evidence for them is lacking.

Similarly, the natural gas prospects of the North Slope are not limited to the Prudhoe Bay field. Several gas fields were discovered in the 1940's and 1950's on NPR-4, the largest of which was the Gubik field with 300 billion cubic feet of reserves. Geologic investigations of other parts of the North Slope have indicated a favorable potential for future gas discoveries within them as well.

ECONOMIC CONSIDERATIONS

Prices and Costs

An overview of the major factors affecting oil and gas cost-price relationships is amply provided in the National Petroleum Council report entitled "Factors Affecting U.S. Exploration, Development, and Production, 1946-1965." Highlights of that presentation include the following: (1) Federal and State policies with respect to abatement of environmental pollution, leasing of Federal and State lands, taxes, and production regulations including well spacing, prorationing of production, and unitization of properties; (2) the changing behavior of price relative to cost factors such as wage rates, and payments for oil field materials and machinery; (3) the decrease in many areas of geological opportunities to make profitable discoveries, especially the older shallow areas, and the shift to the more expensive operating areas of Alaska, and deep inland areas; (4) the changing structure of the industry which is evident in the decline in small companies and individuals and increasing concentration of operations among the large integrated companies; and (5) a decreasing proportion of total industry's revenue from oil and gas production spent on domestic exploration and drilling.

Economic factors governing the level of crude oil prices at the wellhead are established for areas and fields on the basis of oil and/or gas quality and type, market supply-demand relationships, the competitive relationship of oil as delivered to refineries compared with oil from other fields, and other factors.

The 1971 average wellhead price of crude oil in the U.S. was $3.87 per barrel, with the price of natural gas posting at 18.2¢ per thousand cubic feet. In 1971, the gross value of revenues from the production of petroleum totalled over $13 billion; the gross value of natural gas totalled about $4 billion.

A significant reversal in the trend for petroleum prices occurred after 1957. This was brought about by a combination of factors, some of which are as follows: (1) a decrease in the growth rate of petroleum demand following the initial rapid rise of petroleum in the energy market at the expense of coal; (2) growth in the productive capacity of unused crude oil following the drilling of many new wells; (3) increasing competition from low-cost foreign oil; (4) technological advancement and improved operating efficiency; (5) the rapid growth in consumption of natural gas and natural gas liquids; and (6) processing gain in refineries.

Because of the general industry attitude concerning the confidentiality of cost data, coupled with the physical properties of oil, the environment in which it is found, and the manner in which it is produced, projection of the cost for finding and producing oil is subject to considerable uncertainty. Further complicating the determination of oil and gas costs is the association of oil and gas operations. Industry cost data which is available includes the Joint Association Survey of costs incurred in drilling and equipping wells and other yearly costs of the finding, developing, and producing of oil and gas. One study has indicated that the costs of finding and producing oil and gas in the continental United States excluding offshore in the Gulf of Mexico and onshore South Louisiana is about $1.84/barrel, (U.S.D.I., Bureau of Land Management, 1970).

Industry Structure

In the United States all phases of the development and utilization of petroleum and natural gas are performed by private companies, both large and small. The primary operations performed by these corporations include: (1) the search for and production of petroleum; (2) the transportation of petroleum from producing fields to distributors; and (3) the distribution of petroleum to consumers.

Firms in the petroleum industry exhibit varying degrees of vertical integration, as they perform from a single to all of the mentioned phases. Often subsidiary companies are formed to undertake supporting functions.

Major companies operate throughout the United States, but predominate in areas requiring large investments for drilling and producing operations. Petroleum located in mature producing areas is frequently produced by small independents and individuals. Recently, many majors and large independents have expanded their operations into other energy resource fields, as well as petrochemical manufacture and other business areas.

The petrochemical industry is the Nation's third largest industry, following agriculture and public utilities. The natural gas industry is the Nation's sixth largest industry. The petrochemical industry is dominated by ten majors and the natural gas industry by five majors. Because natural gas occurs in association with petroleum, these commodities are often produced jointly.

Petroleum refineries are situated near producing areas, water transportation facilities, or large market areas. As of 1969, 20 companies controlled 80 percent of the 264 refineries in the U.S. In the natural gas industry, 90 percent of interstate sales were made by 10 percent of the producers.

Transportation

Pipelines and water carriers, including tankers and barges, are the primary modes of transport for the crude oil produced in the United States. Pipelines, alone, account for nearly three-fourths of the movement of crude oil, and all but a negligible fraction of the distribution of natural gas. So important are pipelines to the natural gas industry that recent increases in the production of natural gas can be attributed largely to major extensions of trunk pipelines. Successes in pipeline technology, including the development of high-quality pipeline steel, welding processes, trenching machines, and efficient compressors have played a significant role in spurring the growth of pipeline systems. Surface tank trucks are used to transport crude oil over short distances, with railroad tank cars reserved for the transport of higher value specialty products. Trucks in recent years have occupied a larger percentage of the transportation mix for refined products.

The domestic cost of transporting crude oil to the refinery may amount to as much as 50 to 60 percent of the delivered cost of oil. Costs for various types of petroleum transportation, including both short and long hauls are compared as follows:

Type of Transportation	Mills Per-Ton-Mile
Tanker	1.0-20
Barge	1.5-60
Pipeline	1.7-60

Tank car	20-70
Tank truck	30-50

From the above tabulation, it is evident that transportation costs bear an inverse relationship to the size of the mode of transport, and in the case of trucks, to the density of population. Conversely, lower costs reflect longer hauls and the use of large capacity carriers. Economics in the transportation of petroleum products have been achieved through increases in the scale of operations, greater use of automation, and better design and quality of materials.

Transportation of Alaskan Oil

Under the Trans-Alaska Pipeline proposal, all of the North Slope oil to be transported by that line would be delivered to and consumed in the West Coast (PAD V) within the first few years after full operation.

Deliveries of oil from other fields and by other transportation facilities are too remote and too conjectural for meaningful consideration in current planning.

Given the large size of the Arctic gas reserves and the projected shortage in other sources of domestic supply, there is high probability that this gas will be developed. Three different consortia have made proposals for gas pipelines down the Mackenzie Valley to these potential markets. However, many major uncertainties remain; for example, at this time industry experts differ in their opinions about how soon the gas caps in the Prudhoe Bay field can be tapped. Assuming 750 cubic feet per day of dissolved gas would be produced when oil production reaches a level of 2.0 million barrels per day, the additional gas required to meet the full pipeline capacity would have to come from the gas caps. The issue may not be fully resolved until several years after oil production begins, at which time empirical data on the effects of production of associated gas on the production of oil will be available. It is likely that a gas pipeline to the Midwest and lower Canada will ultimately transport gas from both the North Slope and the Mackenzie Delta region.

ENVIRONMENTAL IMPACT

Impact on Air Quality

The impact of additional petroleum production on air quality stems principally from the emission of particulates into the atmosphere.

Air quality in immediate areas of development will undergo some reduction because of removal of ground cover, from vehicle traffic, and from occasional equipment failure or blowouts. Such quality reduction is generally of a temporary nature and has a short-term effect.

Vapor venting from storage tanks and vessels, the burning of waste petroleum and chemical products, especially those containing some sulphur compounds, could result in increase of particulates in the atmosphere and objectionable odors.

It is highly unlikely that air quality reductions from operations associated with increased petroleum production would significantly alter conditions affecting the growth of flora. After termination of operations, a reversion toward original conditions would be expected.

Impact on Land Quality

The modification of land form necessary for petroleum production results in varying degrees of environmental impacts on the physical and chemical land characteristics, biological conditions, cultural factors, and ecological relationships.

Depending upon the terrain and local conditions, access to the land is normally from existing road networks, extension of these roads, and expansion of trails. For initial exploratory work, minimum alterations are made in roadway systems. After decisions are made to drill in a given area, as improved road system is required for the transportation of heavy loads. The drilling site must be cleared of vegetation which might present obstacles. Once production has been established, newly constructed roads are normally upgraded. From these operations environmental impact can result from removal of topsoil and surface vegetation to establish right-of-way corridors and location sites, and alteration of drainage patterns and watershed cover.

In the construction of roadways, surface vegetation is removed and drainage patterns are modified. As a result, erosion can occur resulting in changes in landform. Trees, shrubs, grass, and crops may also be subjected to indirect effects by modifications of drainage patterns. Soil erosion and siltation can have both direct and indirect impact upon the normal behavior and activity patterns of wildlife. Small animals and birds may not be significantly affected, although their number in the immediate vicinity of the operations might decrease in proportion to disturbances and lost habitats. The habitat may be altered beyond the life of the producing and transporting operations.

Land use and recreation activities may also be disrupted during drilling, producing and transportation operations. Esthetic and human interest factors are affected for time-frames beyond the terminations of operations. Scenic views and vistas, wilderness qualities, and physical features in some localities could undergo alterations that could be considered permanent transformations. Population density, employment, and cultural life-styles would change from drilling, production, and transportation levels. The change would be of long-term impact and not necessarily detrimental, and directly affect access, utility networks, waste disposal, and creation of additional corridors.

Perhaps the greatest adverse environmental impact from oil and gas operations results from oil, chemicals, brine, or waste material pollution. This pollution can result from spills, leaks, blowouts, human errors, or equipment failure. Although care is exercised to prevent land pollution, there are no fail-safe methods to completely protect the environment.

Land pollution, primarily from salt water and accidental oil spills, can result in soil sterilization that could be of a long-term nature and affect not only the topsoil, but underground water quality. Native vegetation and crops can be adversely affected for short and long-term duration depending upon the volume and toxicity of the pollutant, resistance of the flora, and the techniques and technology employed. Alterations of the flora in turn affect the habitat of birds and animals. Depending upon the degree of pollution, land uses such as agriculture, grazing, forestry, and wilderness can be altered for varying time-frames. In some cases large pollutant concentration could be sufficient to kill vegetation, trees or crops and disrupt wilderness areas for long-terms. Recreation in areas subjected to large pollutant concentrations can also be altered for long time-frames.

Depending upon local conditions, esthetics such as scenic views and vistas, wilderness qualities, unique ecosystems, or historical sites and objects may be altered. The degree of alterations would be dependent upon the degree of pollutant introduction and local conditions. Disruption of ecological relationships, such as food chains, salinization of soil and water resources, could result from pollutant contamination. The degree of contamination has a bearing upon the duration of the environmental impact.

In exploring and pipelining, any spills that occur normally would be small. Major spills could occur in drilling, production, and in the movement of petroleum liquids by marine transportation. The Federal Water Quality Administration (EPA) estimates that 10,000 oil spills occur a year of which 2,500 are ground spills. Most ground spills cause little ground pollution. According to the 1970 report of the Office of Pipeline Safety (Department of Transportation), on spill incidents, there was a total of 347 liquid pipeline accidents. In those accidents, spills averaged approximately 1,780 barrels of crude oil. Principal cause of over 50 percent of accidents was corrosion. Many onshore pipelines are old, dating back to 1920's, before techniques for protection against corrosion became widely used. Continued accidents can be expected from these lines. With the development and expanded use of cathodic protection of pipelines, fewer accidents in new lines would be expected, but accidents from old lines will continue to be of concern.

Impact on Water Quality

The construction of roads for access into prospective petroleum producing areas could affect water quality by disturbing drainage patterns and causing erosion. The dredging of canals could result in increased turbidity and resuspension of bottom sediments as well as saltwater intrusions.

Turbidity is considered to be of short-term duration, but may affect local flora and fauna. Siltation of water reservoirs and estuaries has long-range environmental impacts in that the shape and size of the water basin is altered. This can have an adverse impact on flora, recreation activities, esthetic qualities and perhaps disturb ecological food chain relationships.

One of the major environmental risks of petroleum production operations is the entry of foreign substances such as oil, chemicals, brine, and waste materials into the water cycle. Spills or leaks releasing these substances result from human error, corrosion of pipelines and vessels, ruptures or mechanical failures, burning pits, open ditches and blowouts.

Large amounts of saltwater may accompany oil production as oil fields age. Such water can create pollution problems from producing wells on land or freshwater-covered areas. According to a study of the Interstate Oil Compact Commission (IOCC), up to 25 million barrels of saltwater are produced daily from the Nation's oil wells.

Proper disposal of produced brines has been and continues to be of major concern to producing operators, and regulatory agencies. Subsurface disposal is strictly regulated by some state conservation agencies and disposal of saltwater is not permitted in freshwater streams.

The introduction of oil or brine into the water cycle can adversely affect vegetation and aquatic plants, birds, land animals, and fish. Sheltered lagoons and estuaries impose natural dispersal restrictions on oil spills causing the oil to remain trapped or concentrated in such areas for long periods. Major reductions in water quality that significantly disrupt the food chains by bays, lagoons, and estuaries could have long-term environmental effects.

6. Hydroelectric

Conventional hydroelectric developments convert the energy of natural or regulated streamflows falling through heads created by damaged waterways to produce electric power. Plants are classified as run-of-river or storage projects, depending on the way in which available streamflow is utilized. In conventional plants, water comes to the plant as a result of natural means.

Pumped storage projects generate electric power by releasing water from an upper to a lower storage pool and then pumping the water back to the upper pool for repeated use. During off-peak hours when project capacity is not required by the system, water is pumped to the upper pool using energy generated by other sources, usually by large modern stream-electric units. A pumped storage project consumes more energy than it generates. Its economic advantage comes from converting low-cost, low-value off-peak energy to high-value peak capacity and energy, and from the highly flexible peaking power it makes available. Pumped storage projects may be designed exclusively as pumped storage or may be included in the design of a conventional hydroelectric installation.

The total conventional hydroelectric power potential of 48 contiguous states at both developed and undeveloped sites is estimated to be about 146,000 MW of capacity able to produce about 530 mil. megawatt hours of electric energy annually. Of this total, 94,000 megawatts and 274 mil. megawatt hours remained undeveloped as of Dec. 1970. Although most available sites for economical production of hydroelectric energy have been developed, some additional capacity will be provided by new sites or expansion of existing plants. Use of hydroelectric power to service peak loads enhances project benefits, permitting consideration of possibilities which formerly were marginal or uneconomic under higher capacity factor standards. Multi-purpose benefits such as recreation, water supply, fish and wildlife enhancement, and flood control justify projects that would otherwise be uneconomic for a single purpose.

The availability of pumped storage sites largely depends on topography which allows development of a high head between two reservoirs in the same area. In many parts of the country, there are virtually unlimited physical opportunities for developing pumped storage projects. However, only a limited number of sites have been investigated.

ENVIRONMENTAL IMPACT

Impact on Air Quality

Construction activity increases the dust in the air. However, operation of the hydroelectric powerplant produces no air pollution, radioactivity, nor waste heat.

Impact on Water Quality

Construction often results in temporary increases in stream turbidity.

The newly filled reservoir usually has a low dissolved oxygen content. Reservoirs concentrate salt due to evaporation.

Impact on Land Quality

Constructon of a hydroelectric dam represents an irretrievable commitment of the land resources beneath the dam and lake. Inundation of the land eliminates wildlife habitat and precludes other uses such as agriculture, mining, and free-flowing river recreation. Some increase in erosion during construction and operation will occur.

Impact on Fish and Wildlife

Fish and wildlife habitat may be significantly changed. The reproductive habitats of anadromous fish may be severely altered by dam construction, unless elaborate provision is made for fish ladders or other means to provide safe fish passage. Significant mortalities of resident and anadromous fish in rivers servicing hydroelectric dams can be caused by gas-bubble disease resulting from exposure to nitrogen supersaturated water. Nitrogen supersaturation results at a dam when excess river flow must be passed over the spillway.

Survival studies conducted in 1971 indicate that high nitrogen levels in the Columbia and Snake Rivers pose a serious threat to the future of the salmon and steelhead resources of the region (Pacific Northwest River Basins Commission, 1971). Under present plans to expand the Columbia River Basin, hydroelectric system through 1980, the volume of spills at the various projects will be reduced. However, without additional control measures, the reduction in volume of spills will not be great enough to reduce nitrogen supersaturation to levels considered safe for fish during years of average or higher flows.

The Corps of Engineers is actively engaged in studying and testing several approaches to the situation of the nitrogen problem. Efforts have been concentrated on manipulation of storage, full use of generating units, slotted intake gates, collection and transportation of downstream migrants, and spillway modifications.

7. Nuclear

Most of the currently operating and planned nuclear plants utilize light water reactors. In such reactors, the heat energy created in nuclear fission is removed by the circulation of water through the fuel core to generate steam to turn turbine generators to produce electricity. Four high-temperature, gas-cooled reactors are also completed or on order. These utilize helium circulating through the fuel core to boil water for steam to turn the turbine generators. These reactors are all of the burner type which utilize less than two percent of the available energy from the uranium which they burn. Breeder type of reactors, which produce more nuclear fuel than they consume, such as the liquid metal fast breeder, are not expected to be available for commercial use until the mid-1980's. Breeder reactors could utilize more than 60 percent of the total energy from uranium. Thermonuclear fusion reactors are not expected to be a commercial reality much before the year 2000.

The use of nuclear power as a commercial electrical energy source is expected to increase considerably in the next 15 years. Installed capacity is currently 12,000 MW. This is projected to increase to 46,000 - 61,000 MW by 1975, 120,000 - 139,000 MW by 1980, and 198,000 - 286,000 MW by 1985. The variance in these estimates is due partly to licensing delays because of concern over environmental effects.

To-date operating experience has been limited to relatively small plants. Almost all of the reactors in operation today are of the thermal type, but considerable effort is being directed toward developing fast reactors which utilize more of the energy of the fuel material. Highest priority is now being placed on the development of the liquid metal fast breeder reactor. The first U.S. commercial fast nuclear breeder reactor is to be built near Knoxville, Tennessee.

The construction and operation of additional nuclear generating plants would require additional mining and milling of uranium ore to supply the fuel elements for these plants. As most of the known and potential reserves are concentrated in New Mexico, Wyoming, and the Colorado Plateau, the incremental mining and milling activity would be expected to occur there.

The number of plants in the planning or construction stage indicates that incentives to develop nuclear power facilities are already strong. The inability of utilities to assure long-term supplies of oil and gas has been the greatest stimulus to construction of nuclear plants. However, delays in equipment deliveries, public opposition, environmental objections, and legal difficulties have set back nuclear development.

Since planning, licensing, and construction lead times are at least six to eight years, no new additional nuclear plants could be expected to be a substitute source of energy before 1980.

Future costs of electricity produced by nuclear power are difficult to predict. Factors that tend to lower costs include technological improvements, lower fuel expenditure over the life of the plant, larger plants with economics of scale in capital and operating cost, standard components, and improved construction methods. However, because of the lead times involved, nuclear powerplants built as alternatives to the proposed program would have to be planned and built with today's technology.

Factors that tend to increase costs include longer lead time, poor labor productivity, added safety features, higher installed prices for plant equipment, and possibly higher costs of capital. Nuclear plants are expected to be competitive with fossil fuel plants in most areas of the United States.

Given the present energy-using technology, nuclear power can essentially only substitute for oil and gas used by electrical utilities and on-site heating facilities. Even here, it is not a complete substitute. Nuclear powerplants are designed primarily for base load operations; they cannot be expected to displace peaking or cycling units. Electricity produced by heating oils and natural gas.

ENVIRONMENTAL IMPACT

Impacts on Air Quality

Nuclear powerplants, unlike fossil fuel plants, do not emit the usual products of combustion such as particulates, sulphur oxides, and nitrogen oxides. Hence, air pollution problems from such emissions do not occur. However, they do produce radioactive emissions whose release must be strictly limited if adverse affects to the health of humans and other biota are to be avoided.

In the normal operation of nuclear generating units, there are small amounts of radionuclides discharged in the cooling water and gaseous plant effluents. Assuming that present standards will be maintained and enforced (these limit the release of radioactivity to no more than would expose an individual at the plant boundary to one percent of the individual maximums allowed), the effects of the amounts released are likely to be negligible, as the average additional annual dose which the affected population would receive, would be three to four orders of magnitude less than the average level of natural radiation exposure.

Impact of Water Quality

Operation of the nuclear plants will generate considerable amounts of waste heat due to their comparatively lower thermal efficiency (around 33 percent compared to 40 percent for new fossil-fueled thermal plants). Given this difference in efficiency and on the assumption that fossil fuel plants release around 15 percent of their waste heat directly into the atmosphere, a light-water reactor would release approximately 50 percent more waste heat into its cooling water than a fossil fuel plant of similar size, (Energy Research Needs, 1971). The effects of this waste heat will depend upon the cooling method used and the location of the plant.

The use of cooling ponds would produce less evaporation than wet cooling towers, but haze, fog, cloud, and ice formation would still occur during periods of sub-freezing temperatures.

Assuming a 15°-20° F temperature rise, a "once through" method of direct discharge into the original source for a 1,000 MW plant would require 270-360 billion gallons of water per year. The effects of using a "once through" method of cooling heated water depend in part on the size of the body of water into which this heated water is discharged. The effects along ocean sites, the Great Lakes, and very large rivers are likely to be modest as the heat is more readily dispersed and more easily avoidable by aquatic species. Along smaller lakes and rivers or in bays with limited circulation, the effects can be more significant. Within the affected areas, higher water temperature can produce fish kills, interfere with fish reproduction, disrupt food chains, decrease dissolved oxygen content, drive out desirable aquatic species and encourage the growth of undesirable algae which may speed-up eutrophication. However, sometimes the heat can be used for aquaculture and other beneficial uses.

Impact on Land Quality

Uranium mining is largely concentrated in relatively isolated semi-desert areas distant from large population centers. The removal of vegetative cover and the creation of overburden and waste-rock result from uranium mining. In 1970, 53 percent of production came from underground mines with most of the remainder coming from open-pit mines. Open-pit mines require considerable acreage, reducing the suitability of the area for other uses such as grazing, wildlife, and some types of outdoor recreation.

In underground mining, the extraction of ores requires some accumulation of waste-rock in dump areas. Careful planning for sequential land use, including reclamation of mined land and the backfilling of mined-out stopes and pits with rock, can substantially reduce land use problems.

Because of low concentration of U_3O_8 in uranium ore, milling the ore produces considerable amounts of low-level radioactive tailings that must be retained in well constructed tailings dams to prevent erosion and leaching. Tailings are a hostile environment for nearly all biota and are unsuitable for use as fill material where human exposure might result. To minimize erosion from aboveground storage, the tailings should be covered with gravel or dirt upon which a vegetative cover can be established. Aboveground storage of tailings requires considerable land area and displaces other uses. In the future, an increasing amount of tailings may be utilized to backfill mined-out stopes and open-pits.

Under current siting criteria, nuclear plants would be located at some distance from population centers. Assuming 500 acres per site (based upon an exclusion area of one-half miles radius around each plant), an average of three 1,000 MW units per site, the construction of 3,000 MW of additional nuclear capacity would thus require 500 acres from which other uses would be excluded. Cooling ponds require additional acreage (an estimated 1,000 - 2,000 acres per 1,000 MW unit).

Depending on the capacity of the transmission lines needed, the transmission line rights-of-way would require the use of ten to fifteen acres per mile of line. Certain types of development, such as residences, would be excluded although such land would still be largely available for other purposes, such as recreation. Additional transmission lines would disrupt some scenic vistas. However, transmission lines for electricity are required regardless of how the electricity is produced, whether by nuclear plants, hydropower, or fossil fuel.

Plant construction would present short-run environmental problems such as the erosion of excavated materials and subsequent siltation.

Control of Radioactive Emissions

Risk of Accidents

The operation of nuclear plants poses some risk of accidents. Nuclear plants are designed to minimize accidents or their adverse effects if one does occur, utilizing a "defense-in-depth" principle. This includes siting reactors far from areas of high population density and designing and constructing plants to prevent accidents and to contain the effects of accidents where they do occur. Plants are designed to withstand a design basis accident, defined as the worst malfunction considered to have a probability of occurrence high enough to warrant corrective action. For light-water reactors, the worst design basis accident considered is usually a major rupture in the primary cooling system. The maximum radiation dose which could be received at the site boundary, if such an accident were to occur is estimated for most plants not to exceed the annual dose obtained from natural radioactivity.

Transportation

The nuclear fuel cycle requires the transportation of radioactive materials by truck or rail at several stages. The transportation of spent fuel elements from reactors to processing plants and high-level waste from reprocessing plants to storage sites poses a potential hazard of considerable magnitude. Existing transportation regulations and cask designs have been developed to insure that even if accidents in transporting these materials do occur, no radioactivity will be released to the environment.

Fuel Reprocessing

Spent fuel assemblies from reactors are first partially cooled at the plant site and then transported to fuel reprocessing plants where usable nuclear fuel materials are recovered from them and radioactive wastes are separated. At present, there are two such fuel reprocessing plants and one more is under construction. Each reprocessing plant can serve 30 to 50 nuclear plants. While radioactive emissions during reprocessing are greater than those occurring during normal power generation, the estimated dose to the affected population is still two orders of magnitude below natural levels. Hence, the impact of these emissions is not expected to be significant, even though the chronic effects of such low-level radioactivity are not yet wholly known.

Radioactive Waste Storage

High-level radioactive wastes remaining after reprocessing are first concentrated and stored in solution for five years, then solidified, sealed in containers, and put into long-term storage.

An incremental capacity of 1,000 MW would produce around 8,000 to 10,500 gallons of high-level waste per year, using a cumulative storage capacity of 40,000 to 54,000 gallons. This liquid waste, when evaporated, would yield around 80 to 105 cubic feet/year in solid waste materials for each year of operation.

Because of their high concentrations of radioactive nuclides and very slow rates of decay, these waste materials must be isolated from the biosphere for hundreds of thousands of years if adverse effects to living organisms are to be totally avoided. Waste is presently being stored in below-the-surface man-made engineered storage facilities. Pilot studies of storage in salt beds are being conducted.

8. Geothermal Steam

The development of geothermal and associated geothermal resources involves the harnessing of the natural heat energy sources in the earth for the generation of electric power, and the production of commercially valuable by-products.

The use of geothermal steam as a source of energy is still, in large part, in the investigative stages. Commercial geothermal production in the United States to-date is small, existing in only one area in Geysers, California, and only since about 1960. Present exploration efforts are continuing mainly in the Imperial Valley, Morro Lake, Modoc County, California and Chandler, Arizona, on private and public lands. There is currently no existing geothermal leasing program on Federal lands although proposals are under consideration. Developments in Italy have existed since about the turn of the century. Worldwide geothermal exploration and development in 1970 was limited to six fields with present capacity of about 1,000 MW. Development of geothermal resources is similar to oil and gas production operations except that it deals with water in the gaseous and fluid state, under pressure, produced from the earth through drilled holes. Operating plants for converting the steam to electrical energy consist of low-pressure steam-turbine systems similar to those in use in the early 1920's. New technology should expand the use and adaptability of the resource beyond its current limitations.

In meeting future energy demands, the Nation must use many available sources of energy -- coal, gas, oil hydroelectric, and nuclear among the more important -- and no one source is an exclusive alternative to any of all of the other sources. In this context, geothermal energy would hopefully be a feasible means of supplementing other forms of electric power generation on the local scale. Under present technology, and economics, and resource availability, however, geothermal cannot be expected to substitute for other forms of electric generation. Even under favorable assumptions, "United States Energy Through the Year 2000" (U.S. Department of the Interior, 1972), estimates that geothermal energy will comprise less than one percent of the national electric power capacity through the year 2000.

Geothermal reservoir systems can be categorized into either a vapor dominated system with a high yield of steam and little associated water, or hot water yielding only hot water which at high temperatures can flash to steam.

Favorable areas for prospecting exist on the Western United States. In California, interest is chiefly in the Imperial Valley area and the Mono Lake - Long Valley area. Large amounts of land in Oregon, Washington, Idaho, and Montana are also classified as Known Geothermal Resource Areas (KGRA's). All of these areas are most likely hot water systems, rather than vapor dominated systems, and will require the disposal of large volumes of water creating additional environmental, technical, and economic problems before large scale development can proceed.

ENVIRONMENTAL IMPACT

The favorable impacts of geothermal power production, aside from the obvious socially desirable effect of supplying energy to the nation, include improved access and fire protection in an undeveloped country. Service roads to wells also provide access for hunters, fishermen, and for recreation in general. Fire control measures are improved such as clearing of brush and fire-fighting in many terrains and also improved feed for birds and animals is provided.

The principal objection to geothermal power development stems from the intrusion of industrial development into new areas. Nearby residents and outdoorsmen generally find the noise, odor, and disturbance of terrain and vistas highly objectionable. Such objections are understandable, and operators have been attempting to meet them by alleviating the objectionable aspects insofar as practicable. However, some impacts are unavoidable and the public will have to decide whether the impacts are acceptable.

Fish and Wildlife

Test drilling and production testing of geothermal steam resources would have varied impacts upon fish and wildlife. Most would occur on or adjacent to well sites, although water quality impacts could potentially have further influences. The magnitude of particular impacts would be interrelated with fish and wildlife and their habitat within the area of development influences, extent and duration of the entire geothermal development activities and operations, and the effectiveness of control measures. Many of the impact types lend themselves to whole or partial control.

As a specific geothermal development proceeds through test drilling and production testing, physical land modification and commotion would occur. These activities would include such things as construction of roads, ponds, drill sites, and drilling of wells which would result in loss of wildlife values.

Most areas adjacent to drilling and test operations, but outside of the immediate zones of physical modification, would retain part or all of their fish wildlife populations and habitat. Where existing public access would be restricted in order to reduce hazards to the public, there would be an accompanying reduction of hunting, angling, and camping opportunity on these lands. The importance of these losses would depend upon the capacity of other available habitat areas to absorb the pressures which are presently absorbed by the geothermal area.

Erosion from roads and the construction activities would predictably result in added siltation of aquatic habitat within the area of project influence. This would be most severe during construction phases, although some might extend into the operational stages. Harmful siltation effects would include coverage of fish spawning and feeding areas as well as shoaling of streams. The degree and extent of siltation damage to aquatic habitat within the area of influence would be dependent upon the success of erosion control measures, amount of land disturbance, and type of terrain.

Blowouts

Blowouts, in which steam or water escapes uncontrolled, potentially pose a distinct environmental hazard in geothermal drilling. The principal adverse environmental effects of such accidental releases are safety of operating personnel, waste of the resource, noise nuisance, air contamination from gaseous emissions, and possible pollution of surface and groundwater resources. Once a blowout occurs, it is troublesome to control because of the difficulty in handling escaping hot fluid. However, unlike similar problems encountered in petroleum drilling, there is essentially no fire hazard in the case of a geothermal accident. To further minimize this hazard, proper casing design is required to assure that the pressurized fluid will be confined to the well bore and can be controlled through surface shut-in equipment.

Groundwater

The groundwater regime in the general area of a geothermal field may be irretrievably altered if appropriate control procedures are not employed. A fresh water aquifer may occur above a geothermal reservoir which contains hot saline water. Tapping the geothermal strata could result in contamination of the fresh water if one horizon were not kept isolated from the other by properly cementing the casing of either production or reinjection wells. During the earlier stages of a project, suitable data must be accumulated and analyzed, and studies made to determine what steps should be taken to prevent or minimize alteration of the area groundwater regime.

Seismic Stimulation

Experience in petroleum production indicates that marked changes in reservoir pressure, whether due to pressure reduction from the production of fluids, or to pressure increase due to injection, may in certain types of reservoirs, expecially in faulted or fractured rocks, result in instability leading to earthquakes. Such instability due to production alone has been documented in the Wilmington Oil Field, California (Poland and Davis, 1969); instability due to injection was documented at the Baldwin Hills Oil Field in California (Hamilton and Meehan, 1970): at the Rangely Oil Field, Colorado (Healy and others, 1968); and in connection with injection of waste waters at the Rocky Mountain Arsenal, Colorado (Healy and others, 1970).

Similar increases in seismic activity have also been noted in association with filling or large surface reservoirs with attendant change in hydrostatic head, including Lake Mead on the Colorado River and Lake Kariba in Africa (Rothe, 1969). The role of fluid-pressure changes in triggering seismic activity is not well-known, but a causative relation has been established in many areas. In general, such activity has not proven disastrous, but the potential for a major quake cannot be ruled out. In any event, seismic activity must be counted as a potential environmental impact associated with geothermal development, and provisions must be made for seismic monitoring before and during major production. If monitoring indicates a significant increase in seismic activity particularly in intensity of motion, remedial steps to alleviate stress would have to be initiated promptly.

Subsidence

Subsidence of the ground surface over and around a geothermal reservoir can result from the withdrawal of large volumes of fluids, (Poland and David, 1969). Subsidence would reach a maximum rate during full-scale operations unless fluid is returned to the reservoir. In some instances, it may be practical to reinject the geothermal fluids after extracting most of their heat. Studies would be initiated prior to approval of operating plans to determine the existence of subsidence potential and its probable consequences. If fluids are not injected, subsidence measurements should be made during the course of a project, at intervals whether remedial action would be required.

Noise

Noise due to steam injection or expansion can be severe and can be expected to reach its highest intensity during testing operations. Such noise can range from a low-frequency to a very high frequency region. Experiments at the Otake Geothermal Powerplants located in the Aso Mountains in Japan have shown that an ordinary expansion chamber muffler is not effective for high-frequency abatement. However, a newly designed muffler used at the Geyser geothermal area effected good noise reduction, even in the high-frequency region, and it did not cause much resistance to steam flow. Venting steam under water also reduce noise effectively.

Power Distribution

Distribution of electric power involves a wide scope of environmental impacts. However, because of the small scale of geothermal developments, only the aspects of delivering electricity from the geothermal plant to existing electrical networks are properly assignable to the geothermal development. Normally, this would involve construction of lines of 69 kv to 110 kv capacity to provide connection for power generated to the nearest main transmission line. The present practice is to use overhead steel tower lines.

Electrical transmission lines are generally benign and favorable environmental impacts would be limited mainly to improved fire protection resulting from clearing of the rights-of-way and slight improvement in access as well. The principal adverse impacts are esthetic, due to the intrusion of the structure on vistas. Disturbance of the terrain is minimal except for clearing trees and brush. Transmission lines located in flyways or over nesting and feeding sites would cause some mortality of waterfowl, raptors, and other birds from collision and/or electrocution. The magnitude of this type of loss cannot be predicted, but would be expected to be minor with proper design and location of transmission facilities.

Waste Disposal

Solution to problem of waste disposal is vital to successful development of geothermal resources. Geothermal waste fluids normally contain sufficient mineral matter that discharging them into streams and lakes would be generally unacceptable. Even discharge to the ocean might be unacceptable in view of the thermal load. Disposal to otherwise usable underground waters, likewise, would generally be unacceptable. The sollution available in most situations is reinjection of waste fluids into the producing zone. This has the double advantage of providing recharge and pressure maintenance to the geothermal reservoir, as well as providing for waste disposal. It might be possible to evaporate wastes and recover minerals and salts of economic value.

The favorable impacts of waste disposal through reinjection include pressure maintenance and recharge, which would tend to alleviate potential adverse impacts of land subsidence and increasing seismicity and instability resulting from reservoir pressure decline. Other favorable aspects of not polluting surface waters are self-evident.

With proper management of reinjection works, adverse impacts would be minimal. The potential adverse impact from improper management, however, includes both the pollution of surface and ground waters as for increasing seismic activity.

The major potential impact would be upon fish and wildlife which could result from improperly planned or executed handling of geothermal fluids. If controlled releases, spills, seepage or well blowouts were to result in significant additions of toxic or highly saline geothermal waters to streams, ponds, game management areas, etc., adverse impacts would result. These impacts would include the alteration of fishery habitat and waterfowl nesting and feeding areas over the area of influence. If toxic substances, such as boron, sulfides, methane, fluoride, arsenic, and others were present in such releases, they also would exert adverse impacts. Releases of heated effluents to aquatic habitat would alter aquatic habitat and life, perhaps creating temperatures intolerable to existing fish species and stimulating growths of nuisance algae.

Use of excessive pressure in injecting waste waters could conceivably increase seismic activity, but with adequate design and monitoring of reservoir pressure, this problem should not be serious.

Another aspect of waste disposal not generally considered is that of gaseous wastes. Steam from cooling towers in some situations could bring on fogging problems, and this should be considered seriously in design and siting of such installations. Likewise, release of noxious gases with such steam also constitutes an inverse impact, but certain gases, particularly hydrogen sulfide and ammonia, can be removed from powerplant steam before release.

Other Potential Benefits

There are indications that through the combination of desalination processes with energy production, large volumes of usable water could be produced. This could be of particular value in the water-short Western States. There also is the potential of mineral production. The investigation of such potentials has only begun, so the magnitude and economic feasibility cannot be evaluated at this time. However, it could be that such multipurpose benefits would result in overall lower system costs that would further enhance the electrical generation potential of geothermal resources.

9. Tar Sands

Reservoirs of hydrocarbons that are too viscous to be recovered in their natural state and by conventional oil production methods are called tar sands or bituminous sands. Typically, reservoir energy must be added in some manner, either by direct heating, fluid pressure, or mechanical work.

Of the many known North American tar sand deposits, only a few are likely to be of major commercial interest in the next 15 to 30 years. Chief among these are the Athabasca deposits in northern Alberta, Canada, and the Orinoco deposits in eastern Venezuela (U.S. Energy Outlook, 1971). Only five deposits in the United States of 0.5 billion barrels or more are worth considering in relation to affecting United States energy supply. All of these deposits are in Utah and are estimated to contain about 17.7-27.6 billion barrels of tar sand resources in place, based on relatively few drill holes supported by outcrop data. Recovery would only be on the order of 30-50 percent of the in-place reserves, reducing these reserves to 10-16 billion barrels of recoverable oil. Another estimate of U.S. tar sand reserves, based on shallow occurrences only, range from 2.5-5.5 billion barrels of recoverable oil (U.S. Bureau of Mines, 1965).

Three states have occurrences of tar sands: Utah, California, and Kentucky. Presently, only in Utah is there any production potential, furthermore, the Utah deposits are not susceptible to mining, but more likely will be developed by in-situ methods, the technology for which has yet to be developed. In either method, a major shortcoming is a lack of an adequate water supply in proximity to the deposits.

In addition to technological problems, other legal and developmental problems exist. The Tar Sand Triangle and Circle Cliffs giant deposits are largely on Federal lands. Leasing of Federal land for "asphaltic minerals" or tar sands has been delayed pending legislation.

ENVIRONMENTAL IMPACT

Tar sand development would effect the environment in all phases of development; exploration, mining, production, and transmission of the synthetic crude.

Exploration

Standard exploration techniques are likely to have an affect on the environment. Seismic disturbance associated with initial geophysical surveys deliniating the extent of the prospective producing zones would temporarily disturb some domestic animals and wildlife in the area. Other sophisticated methods as gravity, and electromagnetics which are used to determine regional geological structure in the area would not likely disturb animal life. Exploration drilling would involve access roads, drilling sites, mud ponds, and unattractive storage areas. Soil erosion associated with this activity could effect local surface waters and the fish in time. Drilling operations could contaminate various subsurface aquifers by using certain drilling mud additives or intermixing saline and fresh water aquifers. Debris and wastes associated with any construction and drilling activity could have an impact on asthetics, especially important in tar sand areas due to interest in land use for wilderness areas, recreational areas, national parks, etc.

Mining

Once exploration has determined an area to be profitable, a choice of using mining-extraction or in-situ methods will have to be made. The mining-extraction method has the advantage of greater recovery, but the environmental disadvantage of: (a) large unsightly amounts of tailings and overburden disturbed over the ground surface, (b) excavations in both open-pit or underground mining which disrupt the surface, (c) dust and erosion problems which are often associated with tailings, (d) possible contamination or depletion of a local aquifer in a water poor area, and (e) disruption in wildlife habitat by using tailings areas, mine areas, and associated mining activity.

Although in-situ methods will not face the tailings problems, disadvantages are also present: (a) thermal pollution involved with large amounts of heat put into the ground, (b) possible contamination of aquifers, (c) surface spills due to machinery failures, (d) or possible surface subsidence with accompanying land disturbance, and (e) noise could be a problem depending on the equipment being used.

Processing

A well designed pre-refining system of processing tar sands should meet current Federal air standards. The sulfur and nitrogen removed from the bitumen could become a source of air pollution with faulty plant design. Metals removed from the bitumen and associated with the carbon residue unless adequately disposed of, could be a local pollutant. Noise, lighting, and activity associated with a plant could have a detrimental affect on wildlife and esthetics.

Development of the area to house workers and family will cause associated drains on local water supplies and destroy the natural appearance of the area.

Transporting Syncrude

In this final stage, all the impacts of the other stages will have their cumulative effect. Should any petroleum tranporting pipelines be ruptured in the dry remote areas as those particularly associated with tar sand resources, considerable time would be necessary to restore the environment. Road transportation by trucks could cause oil spills and dust problems. Rail or pipeline transportation of the syncrude would also be subject to spills through ruptures, caused by natural catastrophies or human error.

10. Hydrogen

The basic technology of using hydrogen as an alternative to fossil fuels exists and although energy intensive, it leaves the greatest obstacles to this relatively pollution free source of energy a matter of economics and timing. By passing a strong electric current through water in a process called electrolysis, water can be separated into its main gaseous components oxygen and hydrogen. The hydrogen can be piped as a gas or subsequently liquified and shipped to be used as a fuel.

Prior to 1958, liquid hydrogen was produced only in small quantities and was primarily a laboratory curiosity. The 1972 hydrogen production was more than 12 billion pounds in the U.S. alone, and is used primarily in making refined petroleum products and chemical synthesis. Only a small fraction of this total production comes from the electrolysis of water, the great preponderance being produced by much cheaper methods of breaking down natural gas, oil, and to a lesser extent, coal through various catalytic streams and partial combustion processes.

Future speculations for massive hydrogen producing facilities include great floating platforms, some miles offshore in the oceans. These platforms would house a series of big nuclear powerplants which would generate power for spot decomposition of sea water by electrolysis, the hydrogen produced could be piped ashore. The potential advantages of such a system are numerous. Hydrogen gas could be piped to its point of use at about one-eighth the cost of sending an equivalent amount of electricity through high-voltage overhead cables. Underground pipe transmission of gaseous hydrogen would eliminate unsightly overhead wires. Unlike electrical capacity which is difficult or inefficient to store, hydrogen could be stored as a gas in underground cavities or as a compressed liquid in large insulated tanks to meet fluctuating power demands. Already under development are fuel cells which convert hydrogen and oxygen directly into electricity. Advanced electrolitic cells have also begun development which work by feeding in current to catalytically separate oxygen and hydrogen at a 1/4 - 1/3 reduction in power required.

The major advances made in hydrogen technology in the last decade are largely a spin-off of rocket and space programs. Liquid hydrogen engines have powered nine astronaut crews safely to the moon and back. In the future, these engines are scheduled to play an even larger role in the space shuttle.

The economics and timing of hydrogen's first use as a fuel are complex matters. Presently, liquid hydrogen is only about 50 percent more expensive than gasoline on a btu per unit weight basis since liquid hydrogen is so much higher in energy content. Actual cost projections for the electrolytic production of hydrogen range from a low of $0.04 per pound using electrical energy from a large breeder type reactor to about $0.12 per pound for other energy sources. Presently, gasoline costs of production are about $0.02 per pound. Hydrogen gas is so light, it cannot match natural gas in heat value on a volumetric unit basis. The first hydrogen gas should enter the economy in hybrid gas mixtures that stretch natural gas supplies or may be mixed with synthetic gas products from coal perhaps before 1980. It is possible to convert present gas lines to handle hydrogen, although at considerable changeover costs. Transmitting costs of the lighter gas would double or triple, as well as the need for tigher, more carefully maintained piping systems, even though the lighter gas could move more rapidly.

With some mechanical modifications, all types of internal combustion engines can burn hydrogen cleanly. In the summer of 1972, at the Urban Vehicle Design Competition, of 63 experimental cars, the two least polluting were cars converted to run on hydrogen, one of which was the only car to exceed the 1975-76 Federal emission standards. Buses, trucks, ships, locomotives can all run on hydrogen with their present engines, although somewhat less efficiently. It can also be burned in the home for heating or cooling. In any combustion of hydrogen as a fuel, the only major waste product is water. Additional uses, as the direct reduction of iron ore, dispense with coal and coke use as is already being done at several small scale plants. Production of high temperature steam for conventional steam powerplants is also a future possibility.

With all the exciting possibilities, conversion costs remain extremely high, particularly to the consumer. Enormous investments of capital will be necessary, as well as demonstration projects to work out technical problems. It is possible that the use of hydrogen as a fuel could be substantial by the mid-1980's. Large amounts of energy needed for electrolysis could presently be provided only by fossil fuel which would not relieve supply or environmental problems.

Projections of this alternative remain highly speculative due to its largely experimental nature and its early stage of development.

11. Biological

Biological energy has attractive prospects in two major areas. One is the production of alcohol from crops, particularly unused crop surpluses, and the other involves the conversion of organic wastes into usable oil.

The efficiency of U.S. agriculture has advanced so fast that for several decades crop production has exceeded demand, except in times of international conflicts and in early 1973, when heavy international buying coupled with unusually bad weather drained surplus stores. Average farm production has increased about 80 percent in the last three decades, largely owing to better yielding seeds and greatly improved "know-how." Thus, to meet our crops needs, we plant fewer acres and require fewer farmers (New Energy Forms Task Group, 1972).

Agriculture provides the major current source of renewable energy. Forests, cultivated crops and pasture land may be used repeatedly under proper management. Agriculture production is, however, subject to weather, diseases, wind, and other natural conditions which cannot yet be completely controlled. Nevertheless, average production in excess of priority requirements for domestic food, feed and fibers is believed possible by 1985 and beyond, barring natural disasters or national emergencies. The production of cereal grains and their conversion through fermentation to usable ethyl alcohol fuel; the collection and use of such residue as straws, corncobs, hulls and shells for fuels; the growing of crops for fuel energy; and the conversion of animal by-products into fuels are all possibilities.

Agriculture fuels would normally be more expensive than such traditional fuels as coal, gas, oil and waterpower. Increasing U.S. needs for energy, requirements for pollution abatement and many other economic factors could, however, materially change the future role of agriculture as a source of industrial energy.

Of the approximately 2,260 million acres of U.S. land available, about 25 percent is classified as forest and woodland and about the same proportion is land suitable for cultivation. Most of our woodland will probably be required to meet the predicted demands for lumber, pulp and paper industries, and thus will offer only minor possibilities for contributing to additional U.S. industrial energy supplies. On an average, however, only about 60 percent of the potentially available cultivated land is now farmed for crops. Yields of cereal grains on these lands have, on an average, increased about three percent annually for the past decade. This increase has exceeded the U.S. population growth, even though the amount of cultivated land has decreased. Thus, unused acres constitute a potential source of energy for the foreseeable future.

A logical sequence of energy conversions is to use this land to produce cereal grains, which are largely carbohydrate, and then to convert these grains by fermentation into ethyl alcohol, which is a convenient combustible fuel readily usable in motors. If we assume that the 100 million acres, or about one-half of the acres not now required, are used to produce the grain for alcohol at a yield of 70 bushels per acre, this would be equivalent to about 18 billion gallons of alcohol, or over 20 percent by volume of the 86 billion gallons of motor fuel consumed in the U.S. in 1970. Since ethyl alcohol contains only 65 percent of the energy content of gasoline, on a gallon basis, the actual energy replacement would be only 14 percent.

The cost of this ethyl alcohol from fermentation would be many times higher than the cost of present motor fuel. Even so, this tremendous energy potential must be considered in any assessment of future energy sources.

In 1971, collectable agricultural residues in the U.S. amounted to over 125 million tons annually with an oil potential of 170 million barrels, roughly equivalent to 47 million tons of low sulfur coal. To produce the oil from waste, the organic material is treated with carbon and water at 250° - 400° C and 2000 - 5000 psi pressure. This oil product has a heating value of 15,000 btu per pound and the total energy potential would be on the order of 2,000 trillion btu. High collection and processing costs, incomplete technology, along with high capital requirements, prevent this energy source from being economically competitive. Presently, only one continuous unit with a capacity of 20 pounds per hour is being operated on a test basis. Although the total potential energy from organic waste is enormous and growing, economic considerations will likely prevent this source from having a significant effect on the U.S. energy picture by 1985.

ENVIRONMENTAL IMPACTS

To use crops to create alcohol is not likely to raise any more pollution, in fact, proper farming techniques would probably reduce soil erosion and increase productivity of the land.

To use animal waste for conversion to fuel would have the obvious advantages of disposing of a pollutant itself and recycling it into a useful product. Areas of high population density, produce greater wastes and would have a locally available source of fuel in proportion to thier population. Water quality problems associated with organic wastes could be alleviated. The residue would be sterile although large amounts of bulk material would still have to be placed somewhere perhaps as landfill.

The oil produced has properties varying with the type of material composing the waste. A distinct advantage in waste conversion would be to reduce demand on natural resources commensurate with the amount of oil and gas made from these wastes.

12. Solar Energy

Solar energy is a source of both heat and electromagnetic radiation and possibilities exist for both direct and indirect use of this energy. Fossil fuels are representative of solar energy stored from earlier periods in the earth's history, which, when ignited, release the energy plants and animals accumulated eons ago. An indirect way of using solar energy in more recent history would be burning fuel, wood or plants directly, while direct use would be a solid state solar cell.

Four characteristics of solar energy deserve particular notation;

- it is a diffuse, low intensity source of energy;
- the energy is spread over various frequencies (i.e., distributed over the various wave lengths of light);
- its intensity is continuously variable during the daylight hours, is zero at night, and is subject to weather and seasonal variations; and
- its availability differs widely between geographic areas.

A consequence of the diffuse nature of solar energy is that it does not naturally produce the high temperatures characteristic of combustion processes. This is a definite disadvantage since high temperatures make possible greater thermodynamic efficiency in energy conversion.

The U.S. land area intercepts each year about 600 times its total 1976 energy requirements at an intensity of radiation of 1 KW M or less, (IT & T Consultive Committee, 1972). At a 10 percent efficiency each square meter of active surface will produce not more than 100 watts of peak power.

Such heat can be used for electricity generation, space heating, cooling, and processing of industrial materials. Properties of solar radiation produce photosynthetic conversion and storage of energy in plants and other photochemical reactions which also convert and store energy.

About half the energy in the solar spectrum lies in wavelengths usable in photosynethesis. The efficiency of this half can be in the neighborhood of 50 percent, giving an overall possible photosynthetic conversion of 25 percent. In experiments, efficiencies in the usable spectrum ranged from chlorella (a green algae) at 20 percent conversion efficiencies to about two percent for sugar cane. Experiments in Japan to use chlorella have always fallen short of economical use as food. Consequently, using it for fuel with a lower unit than food would also be uneconomical. Since chlorella rates high in efficient conversion of solar energy, other plants don't appear to hold good prospects for useful conversion of solar energy.

With direct conversion of solar energy, the number and range of potential applications are extensive, but the present state of the art is such that energy collection efficiencies are low and the requirements for energy storage resulting from the intermittent nature of the source result in costs that are prohibitive for general use. A typical 1,000 MW powerplant operating in a normal solar climate would, with present technology, require 37 square miles of collector surface (assuming efficiency of conversion of solar energy to process heat is 30 percent and to electrical energy is five percent). The many square miles of collector surface that would be required for even a medium-sized power generation facility would have significant impact on the land area, its other use or resource values, and on the general environment. There would be a major esthetic intrusion in desert areas which now are generally unmarred by man's activities.

The silicon cell, developed about 15 years ago, has proved to be a reliable means for this direct conversion of solar radiation to electricity for applications to outer space. The generation of significant amounts of power, however, requires the connection of extremely large numbers of cells. The capital cost of silicon cell arrays results in power costs in the order of $2.00 to $5.00 per KWH. Thus, the cost is about 1,000 times that of conventional power sources.

Examples of other types of solar generation potential include floating powerplants which would use the solar-produced temperature differentials which exist between the upper and lower levels of Caribbean waters and the Gulf Stream. A second concept deals with the orbiting of space vehicles for the purpose of creating central power generation. Systems such as these have not yet been developed or tested, so they do not represent feasible energy source alternatives that can be considered at this time. Some application for solar heat exists in home heating using relatively inexpensive collectors costing $2.00 - $4.00 per square foot and using auxillary heating when necessary.

As a large scale source of power, expensive collector areas and low efficiencies make it unlikely that solar energy will have any significant impact within the next 30 years as the economics are unfavorable compared to many alternatives.

13. Tidal Power

Tidal power is hydroelectric energy source similar to other water power sources, except it is derived from the alternate filling and emptying of a bay or estuary that can be enclosed by a dam. The total tidal power dissipated by the earth is enormous, largely accounted for by oceanic friction in bays and estuaries around the world, although theoretically, it could be captured and converted to electric power. Despite this total potential, practical considerations have eliminated all geographic areas except where tidal behavior, range, and water displacement are extremely favorable.

Two plants are presently operating, the larger is the Rance Plant on the Rance River estuary Brittany France, which was completed in 1967, at a cost of $90 million, a capacity of 240 MW, to be increased to 320 MW. The present cost is about $350/KW. The U.S.S.R. completed its first plant on the White Sea in 1969 which has a 1,000 KW capacity. Other proposals incude the Bristol Channel, United Kingdom; San Jose Gulf; Argentina; and the western Australian Coast. The Canadian government studied 23 sites on the Bay of Fundy.

The only practical opportunities for economic development in the United States appear to be in the vicinity of Passamaquoddy Bay, Maine, and perhaps Turnagain Bay in Cook Inlet, Alaska. The higher potentials for Cook Inlet is negated by economics and distance from the market. Passamaquoddy Bay has a tidal range of 18 feet. Capital costs of as high as $1 million for the 1.8 billion KWH/year were calculated in a detailed 1964 Senate Subcommittee proposal for development. With enormous increase in demand, the significance of this contribution has lessened and the project has been determined to be uneconomical.

Some possibility exists that with better interest rates and a decline in alternate energy sources, the Canadian government will develop a portion of the Bay of Fundy before 1985. Some of this power could become available to the New England region of the United States. Assuming a maximum of 10 billion KWH from this source could be available by 1985, this would still by only two percent of the projected electrical energy required by the New England region at that time. The attraction of the renewable nature of tidal energy is a great advantage, although the total amount of energy is relatively low.

ENVIRONMENTAL IMPACT

Environmental problems would be considerable. Although no air pollution would exist, damming with alternate filling and emptying of bay and estuary areas would effect shipping, drainage, sport and commercial fisheries, wildlife, water quality, esthetics, recreation, accumulation of sands and silts, as well as numerous other uses of present bays and estuaries.

14. Wind Energy

Energy can be obtained from the wind by means of a device which will extract energy from a moving mass of air. A fixed device can capture kinetic energy by rotation about an axis and, coupled to a generator, convert it into an electrical form. Economical power generation requires an average annual wind velocity of about 30 mph, a nearly constant magnitude, and topography in which boundary - layer effects are minimal.

The advantages in using wind energy are the following: (a) the supply is inexhaustible; (b) it is available in many parts of the world; and (c) the energy is free on the site of production. Some of the practical disadvantages are: (a) the low energy density of the wind; (b) the wind velocity is unpredictable in time and magnitude; (c) the low conversion efficiencies of aeromotors; (d) the effect of icing conditions and weather on aeromotors; and (e) the high cost of money required for the capital investment.

In Denmark, between 1940-1945, when fuel oil was in short supply, 88 wind-driven installations generated 18,000 MWH for local needs.

By combining wind-driven generators with diesel standby units, continuous, small-scale, dependable power can be locally generated. This method has supplied lighthouses for over ten years at several locations, but at a capacity of less than 10 KW. Presently, there is only one major research project to harness the wind's energy at the University of Hawaii, with a budget of just over $100,000/year. If, for example, 10 billion KWH/year could be produced from a few large and numerous small generators, then it would reduce the use of conventional fuel annually by four million tons of coal or another equivalent source of energy. However, high equipment, energy storage, and backup equipment costs coupled with the intermittent characteristics of the wind, preclude a favorable cost benefit of wind energy at the present time. Small-scale use may increase in remote areas where transmission costs prevent conventional power systems, but this impact on the total power picture is negligible. Wind energy does not appear to be an available alternative to traditional large-scale energy sources at this time.

ENVIRONMENTAL IMPACT

The chief environmental advantage of this noiseless air pollution free source of electrical energy is in its elimination of conventional, polluting equivalent, amounts of energy production by fossil fuels. Secondly, transmission of either the fuel or energy over long distances could be eliminated since the wind is free on site, preferably a site close to the consumer.

The chief disadvantage would be the adverse esthetic effect of a large number of towers with assorted paraphernalia to absorb the winds energy. Associated with this would be land disruptions caused by construction and guying of large towers. Possible injury to soaring birds or damage to the devices themselves by the large number of birds is a possibility. Heavy weather, icing, and high winds could make such structures unstable and a hazard to the immediate surrounding areas.

B. Conservation of Energy Use

The United States has both the highest per capita consumption of energy and the highest per capita income in the world. Energy has provided the foundation for a continued rise in our material standard of living. Demand for energy in the U.S. has been increasing at an average rate of 3.1 percent for the last 20 years, more than twice the growth rate of the U.S. population. Higher energy use per capita compounded by populaton growth has produced unprecedented levels of energy consumption. As population growth slows, increasing per capita demand will account for a larger and larger share of increasing total demand for energy. These trends are illustrated below:

Table - U.S. Total and Per Capita Net and Gross Energy Input

Year	Gross Energy Input (Quadrillion BTUs)	Net Energy Input	Population (Millions)	Gross Energy Input/Capita (Million BTUs)
1950	34.0	29.7	152.3	223.2
1955	39.7	34.3	165.9	239.3
1960	44.6	38.2	180.7	246.8
1965	53.3	45.3	194.2	274.4

Table - (Continued)

1970	67.4	56.0	204.8	329.1
1975	80.3	65.1	216.2	371.4
1980	96.0	76.1	229.4	418.5
1985	116.6	89.7	243.3	479.2
2000	191.9	140.1	279.7	686.1

Source: United States Energy Through the Year 2000, United States Department of the Interior, Dec. 1972, p. 5.

In the past, energy growth has been little constrained by price or supply of resources. However, recognition that environmental costs should be reflected in price of energy, concern over environmental quality, and uncertainty of both immediate and long-term energy supplies have added urgency to the study and realization of energy conservation.

Energy demand growth can be reduced by slowing population growth and reducing per capita energy use. However, potential reductions in population growth are limited as fertility appears to be approaching replacement level. In addition, the most important factor in growth of energy demand has not been population growth, but higher energy per capita. In a study of electricity demand, alternative population projections showed that "the population assumption is unimportant for demand growth in the next 20 to 30 years", (Chapman, 1972).

The most promising approach to reduction in demand is, therefore, through lower per capita use of energy. The rate of growth of per capita energy demand could be reached by (1) reducing the rate of growth of demand for the goods and services produced with energy, (2) producing the demanded goods and services more efficiently, and (3) converting energy to useful work more efficiently.

The Office of Emergency Preparedness recently released a study on conservation, (Office of Emergency Preparedness, 1972). The study focuses particularly on short-term and mid-term user conservation measures and does not consider improvement in recovery techniques for primary fuels or relate government actions. The measures suggested could reduce energy consumption by 5.0 quadrillion Btu (QBtu) a year in 1975, 15.5 QBtu a year in 1980, and 33.4 QBtu per year after 1980. These energy savings represent the maximum that can be achieved if all the suggested measures were implemented. Since all of the suggestions depend on voluntary cooperation for which incentive is slight, the estimates must be regarded as the upper limit and not the most likely outcome.

OEP found the greatest potential for energy conservation in (1) improved insulation in homes; (2) adoption of more efficient air conditioning systems; (3) shifting to intercity freight from highway to rail, intercity passengers from air to ground travel and urban passengers from automobiles to mass transit and freight consolidation in urban freight movement; and (4) introduction of more efficient processes and equipment.

The following outline of specific measures directed at the four major consuming sectors - transportation, residential/commercial, industrial and utilities is taken from the study. These measures could be implemented through standards and regulations, tax incentives, and educational campaigns.

Short-Term Measures (1972-1975)

Transportation - Conduct educational programs to stimulate public awareness of energy conservation in the transportation sector; establish government energy efficiency standards; improve airplane load factors; promote development of smaller engines/vehicles; improve traffic flow; improve mass transit and intercity rail and air transport; promote automobile energy-efficiency through low loss tires and engine tuning.

Savings - 1.9 Quadrillion (Q) BTU/year - (10 percent)

Residential/Commercial - Provide tax incentives and insured loans to encourage improved insulation in homes; encourage use of more efficient appliances and adoption of good conservation practices.

Savings - 0.2 QBTU/year - (1 percent)

Industry - Increase energy price to encourage improvement of processes and replacement of inefficient equipment; provide tax incentives to encourage recycling and reusing of component materials.

Savings - 1.9 - 3.5 QBTU/year - (6-11 percent)

Electric Utilities - Smooth out daily demand cycle by means of government regulation; facilitate new construction; decrease electricity demand.

Savings - 1.0 QBTU/year - (4 percent) (already assumed in the projections)

Mid-Term Measures (1976-1980)

Transportation - Improve freight handling systems; support pilot implementation of most promising alternatives to internal combustion engine; set tax on size and power of autos; support improved truck engines; require energy-efficient operating procedures for airplanes; provide subsidies and matching grants for mass transit; ban autos within the inner city; provide subsidies for intercity rail networks; decrease transportation demand through urban refurbishing projects and long-range urban/suburban planning.

Savings - 4.8 QBTU/year - (21 percent)

Residential/Commercial - Establish upgraded construction standards and tax incentives and regulations to promote design and construction of energy-efficient dwellings including the use of the "total energy concept" for multi-family dwellings; provide tax incentives, R & D funds and regulations to promote energy efficient appliances, central air conditioning; water heaters, and lighting.

Savings - 5.1 QBTU/year - (14 percent)

Industry - Establish energy use tax to provide incentive to upgrade processes and replace inefficient equipment; promote research for more efficient technologies; provide tax incentives to encourage recycling and reusing component materials.

Savings - 4.5 - 6.4 QBTU/year - (12-17 percent)

Electric Utilities - Restructure rates for heavy uses to smooth out demand cycle; facilitate new construction.

Savings - 1.1 QBTU/year - (4 percent) (already assumed in the projections)

Long-Term Measures (beyond 1980)

Transportation - Provide R & D support for hybrid engines, non-petroleum engines, advanced traffic control systems, dual-mode personal rapid transit, high-speed transit, new freight systems, and people movers; decrease demand through rationing and financial support for urban development and reconstruction.

Savings - 8 QBTU/year - (25 percent)

Residential/Commercial - Provide tax incentives and regulations to encourage demolition of old buildings and construction of energy-efficient new buildings; R & D funding to develop new energy sources (solar, wind power).

Savings - 15 QBTU/year - (30 percent)

<u>Industry</u> - Establish energy use tax to provide incentive for upgrading processes and replacing inefficient equipment; promote research in efficient technologies; provide tax incentives to encourage recycling and reusing component materials.

Savings - 9-12 QBTU/year - (15-20 percent)

<u>Electric Utilities</u> - Smooth out daily demand cycle through government regulation; facilitate new construction; support R & D efforts.

Savings - 1.4 QBTU/year - (3 percent)

The Office of Emergency Preparedness estimates that by 1980, space heating and cooling requirements could be reduced by 20 percent through improved insulation and a nationwide education program to encourage conservation practices in the home. Thermal insulation also reduces the energy required for air conditioning, an important factor in summer peak loads of utility systems. Different models of air conditioners vary greatly in efficiency. The least efficient consumes 2.6 times the electricity consumed by the most efficient to provide the same cooling. If more efficient air conditioners were used, the annual power consumption for air conditioning in 1970 could have been reduced by 15.8 billion KWH, or about 40 percent. The connected load would have also been decreased by 40 percent, or by 17,800 MW, (Hurst and Moyers, 1972).

In his Energy Message of April 18, 1973, President Nixon told the Nation:

"To provide consumers with further information, I am directing the

Department of Commerce, working with the Environmental Protection Agency, to develop a voluntary system of energy efficiency labels for major home applicance. These labels should provide data on energy use as well as a rating comparing the product's efficiency to other similar products."

A step forward was taken in 1971, with the revision of the Federal Housing Authority's Minimum Property Standards (MPS) for single-family dwellings. The MPS establishes thermal design criteria for qualification fo residences for FHA-insured mortages. However, new homes constructed through conventional financing are not required to follow these standards. The revised FHA-MPS do not distinguish between electrically heated and combustion heated homes. A study of construction practices found that appreciable energy savings and some monetary savings to homeowners were possible through stricter insulation requirements. Wider application of these standards and additional insulation beyond the MPS requirements would afford further energy savings.

Substantial reductions are also possible in the transportation sector. The transportation of people and goods comprised 24.5 percent of U.S. energy consumption in 1970. Increase in transportation energy consumption are due primarily to growth in levels of traffic and shifts to less energy efficient modes. Below are shown the energy requirements for transport of freight and passengers. The efficiencies are typical of the mid-1960's.

Efficiency of Freight Transport BTU/ton mile	
Pipeline	450
Waterway	540

Efficiency of Passenger Transport BTU/passenger-mile	
Bicycle	200
Walking	300

Railroad	680	Buses	1,200
Truck	2,300	Railroads	1,700
Airplane	37,000	Automobile	4,500
		Airplane	9,700

Source: Energy Consumption for Transportation in the U.S., Eric Hurst, Oak Ridge National Laboratory, June, 1971.

The shift from railroads to truck and airplane in freight traffic and from railroad and buses to airplanes has caused declining energy efficiency. The trend is encouraged by preferential government policies favoring air and highway transport. Low average car occupancy, use of cars for many short trips, and disregard for congestion problems increase fuel consumption and pollution.

In order to illustrate possible energy savings through use of energy efficient transport modes, one study compared two transportation models, an actual and a hypothetical case. Comparison of the two models revealed that adoption of the hypothetical case would require only 71 percent as much energy as the actual 1970 case, (Hurst and Moyers, 1972).

Assumptions underlying the hypothetical model include the following:

(1) Half the freight traffic carried by conventional methods (truck and air) is to be carried by rail.

(2) Half the inter-city passenger traffic carried by air and one-third the traffic transported by car are to be carried by bus and train.

(3) All the urban automobile traffic is to be carried by bus.

Socio-economic factors which might inhibit shifts to the energy efficient transport modes employed in the conjectural model are ignored in the analysis. Such factors include: existing land use patterns, capital costs, changes in energy efficiency within a given mode, substitutability among modes, new technologies, transportation ownership patterns and other institutional variables.

A comparison between the actual and the hypothetical models identifies the principal components of energy use patterns and emerging considerations which may precipitate the shift towards increased energy efficiency in urban transportation. Variables influencing the current energy mix include: personal preferences, private economics, convenience, speed, reliability, and government policy. Current transportation patterns are altered by factors such as fuel scarcities, rising energy prices, dependence on foreign petroleum, urban land use problems, and environmental considerations.

The Office of Emergency Preparedness study estimated that short-term measures could produce a maximum energy savings in the transportation sector of 1.9 quadrillion Btu per year by 1975, equal to 10 percent of transportation demand. Such measures would include educational progress, establishment of government efficiency standards, improved airplane load factors, smaller engines and vehicles, improved mass transit, and improved traffic flow. Public awareness of energy conservation and alternatives would foster a clearer understanding of the energy implications of decisions. A change in public attitudes toward walking, bicycling, and mass transit, might do much to reduce demand for energy.

Another sector of great potential for energy conservation cited by the OEP study is industry. OEP projects that, with the exception of the primary metals sector, industrial demand for energy under existing technology could be reduced to five to ten percent given sufficient economic incentive (possibly price increase or an energy tax). Often less efficient equipment is chosen because capital expenditure is recovered in a shorter time. Incentive for selection of more efficient equipment could counter higher capital expenditures. Industrial energy demand can also be cut by recycling metals. For non-ferrous metals, the amount of energy required to recycle scrap metal is less than 20 percent of that required to refine the metal originally, although new low energy primary metal extraction methods are in development.

The imbalance between supply and demand for energy can be narrowed through the price mechanism. In the past, use of natural air, water, and land resources has been virtually free. If a price were put on social costs reflecting depletion of resources and damage to the environment, energy patterns would tend to shift in order to reduce demand and conserve natural resources. For example, an electric rate schedule including higher charges for peak period usage would encourage consumers to shift use to other times of day, resulting in more efficient use of existing plants and less construction of new generating capacity to service peak demand. Tax credits and penalties could encourage development of cleaner and more efficient technology. For example, an auto tax would make it more expensive to drive a car and encourage use of mass transit.

Response of energy demand to increased in prices of energy is difficult to predict. In the short-term, gradually rising prices may have negligible effects. The study cited previously in the discussion of population growth concluded that substantial cost increases and reduction in population growth will noticeably lower electricity demand growth in the 1980's and 1990's. Given the lengthy time period of response, growth reduction in the 1970's might be limited, (Chapman, 1972). The authors give the following preliminary estimates of elasticity of electricity demand for electricity prices, income, population, and gas prices.

Table - Summary of Electricity Demand Estimated Elasticities for Electricity Prices, Income, Population, and Gas Prices

	Consumer Class		
Factor	Residential	Commercial	Industrial
Average Electricity Price	-1.3	-1.5	-1.7
Population	+ .9	+1.0	+1.1
Income	+ .3	+ .9	+ .5
Average Gas Price	+ .15	+ .15	+ .15
Percent of Response in First Year	10%	11%	11%
Years for 50% of Total Response	8 years	7 years	7 years

The elasticities of demand represent the relationship of the percentage change in electricity demand and the percentage change in the factor. For example, the commercial elasticity for electricity prices of -1.5 means that a 20 percent rise in average commercial electricity price would in the long run cause demand to be 30 percent less than it otherwise would have been.

The kind of public policies that would be required to reduce demand, according to Michael McClosky, Executive Director of the Sierra Club, would include the replacement of the market system to determine how much energy shall be produced or imported and who shall consume energy, with a detailed control on the production, importation, and use of energy in all sectors and regions of the economy. In his evaluations relative to controlling energy growth, he states:

> " A short-run strategy would involve the following changes in public policy: ending or reducing the many biases in public policies which provide incentives to energy growth; maintaining and strengthening environmental constraints on energy growth; reducing energy demands by educating the public to understand the importance of conservative use of energy; encouraging intensified research and development in order to achieve greater efficiencies in energy utilization and in order to find new, more environmentally acceptable energy sources and discouraging growth in industries that are the most profligate consumers of energy. Coordination of these efforts would be facilitated through the establishment of new government agencies, specifically geared to respond to the energy problem. Each of these changes would involve efforts that would go well beyond the traditional bounds of energy policy, and all could have profound economic and social impacts. Yet changes are already beginning to occur in all these fields, and environmentalists are determined to promote them." (McClosky, 1971)

To coordinate energy programs and carry out the directives of President Nixon's April 18, 1973 Energy Message, Secretary of the Interior morton, created four new offices on energy - the Office of Energy Conservation, the Office of Energy Data and Analysis, and the Office of Research and Development. The Office of Energy Conservation will promote consumer awareness of energy conservation, develop studies on measures to reduce energy requirements, coordinate all Federal agency programs relating to energy conservation, and work to obtain Federal, State, local and industry participation in energy-saving programs.

Development of untapped energy sources such as geothermal steam, tar sand, hydrogen and solar energy, and conversion techniques such as the fuel cell and magnetohydrodynamics, and more efficient methods of energy conversion offer long-range possibilities for conservation of scarce non-renewable resources.

The environmental benefits of energy conservation depend on the energy mix that evolves. Reduced consumption of energy from one to several sources may be balanced by increased consumption of energy from other sources. Environmental benefits will vary in direct proportion to the adverse impacts that would have resulted from the foregone consumption. Environmental impacts of each individual energy alternative are discussed in the section on that alternative. For example, curtailment of oil consumption will have greater environmental benefits than curtailment of gas consumption since oil combustion produces significant adverse environmental impacts while gas is virtually clean-burning.

Appendix A

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Appendix B

GLOSSARY

Alkali Soil

A soil that contains sufficient sodium carbonate or other alkali salt to give it a pft of 8.5 or higher.

Available Water Capacity

Available water capacity refers to the total quantity of water available for plant growth that is stored in the effective root zone or the upper 60 inches of the soil profile at field capacity. It is largely dependent upon the effective depth, texture, structure, porosity, organic matter content, and coarse fragment content. In general, profiles that contain 50 percent coarse fragments by volume will only have one-half the moisture holding capacity of a comparable soil that is free of coarse fragments.

Coke

A combustible material consisting of the fused ash and fixed carbon of bituminous coal, produced by driving off by heat the coal's volatile matter. It is grey, hard and porous. Used in blast furnaces, as a fuel in the steel making process.

Coking Coal

A bituminous coal suitable for the production of coke.

Coking Characteristics

A bituminous coal that can be coked. Often blended with coking coal.

Dip

The angle that bedding plane or coal bed makes with the horizontal, measured perpendicular to the strike of the bed.

Fault

A surface or zone of rock fracture along which there has been displacement, from a few inches to a hundred feet.

Gasification

The changing of a solid or liquid into a gas. In gasification of coal, a series of reactions produce a gas that can be used for the same uses as natural gas.

Gob

Spoil material or disposed piles associated with underground or surface mining.

Highwall

The unexcavated face of exposed overburden and coal in a surface mine.

Hydrologic Groups

Soils are placed in hydrologic groups according to their potential to yield run-off. This information is used in watershed planning. Various hydrologic groups range from (A), that shed almost no precipitation to (D), that shed nearly all the precipitation.

The four hydrologic groups are defined as follows:

A. Very deep, coarse and moderately coarse textured soils that transmit water through their profile and substratum at a high rate. These soils have the lowest run-off potential.

B. Medium to fine-textured, moderately deep to very deep soils having a moderate rate of water transmission through the profile.

C. Fine-textured, deep and very deep soils that have a slow rate of water transmission through the subsoil.

D. Fine-textured, deep soils, and impervious material exposed or covered by a thin mantle of soil. These soils have the highest run-off potential.

Lenticular

Resembling a lens in shape, thick in the middle, and thinning out toward the edges.

Metallurgical Grade

Having qualities that meet specifications for special uses. Coal that is low in sulphur, phosphorous and has maybe been coked.

Outcrop

That part of a geological formation, a coal bed that appears at the surface of the earth.

Overburden

The rock, soil, etc, covering a seam of coal to be surface mined.

Props or Mine Props

Timber or steel supports for the roof. Steel props may be adjustable.

Relief

Relief is expressed as a range in the slope percentage that each soil may have.

Shuttle Car

A vehicle propelled by electric motors receiving its energy through a portable cable. Its function is to transfer coal from loading machines in truckless areas of a mine to the main transportation system.

Soil Name

Each soil series in the United States is given a name. The name identifies a specific soil just as names identify people. Soil names are correlated so that any one name applies only to a specific soil, regardless of occurrence.

Spoil

The rock, soil, etc., of the overburden after it has been broken and removed from above the coal seam.

Strike

The direction or trend that a bedding plows as it intersects the horizontal.

Syncline

A fold that forms a trough. The same beds often outcrop on both sides, whereas in the center, they are deeply buried.

Tipple

Originally the place where mine cars were tipped and emptied of their coal. Now it is generally applied to the surface structure of a mine, housing the coal breaker, screens, loading truck, and preparation plant.

Unified Classification

This is one of the two systems that classify soil material for engineering uses.

The Unified soil classification system identifies soils according to their textural and plasticity qualities, and their grouping with respect to their performance as engineering construction materials. Soil materials are divided into 15 classes; eight classes are for coarse-grained material, six classes are for fine-grained material, and one class is for highly organic material. Soils that have characteristics of two classes are designated by symbols for both classes; for example, CL or ML. Each class is identified by a letter symbol. GP identifies poorly graded gravel and mixtures of gravel and sand with little or no fines. Soils in class SM are silty sands and mixtures of sand and silt. Soils in class ML are inorganic silts of low liquid limit that are mixed with sand and clay. Soils that are predominantly silts and clays have a low liquid limit are in class CL. The symbol CH identifies inorganic clays that have a high liquid limit and plasticity.

The first letter of the class symbol indicates the grain size, for example. G stands for gravel, S for sand, C for clay, and O for organic. The modifying terms indicated by the second letter are P for poorly graded, W for well graded, M for silty, and C for clayey. The symbol L stands for low liquid limit and H for high liquid limit.