VOLUME I

-Regional Analysis-

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

NORTHWEST COLORADO COAL

DEPARTMENT OF THE INTERIOR

DRAFT

NORTHWEST COLORADO COAL

ENVIRONMENTAL STATEMENT

Prepared by
Bureau of Land Management
Department of the Interior

State Director

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FOR
REGIONAL ANALYSIS

This is Volume I of the Northwest Colorado Coal Environmental Impact Statement. It contains the Regional Analysis.

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SUMMARY SHEET

SUMMARY

(X) Draft ( ) Final Environmental Statement

Department of the Interior, Bureau of Land Management

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

2. Brief Description of Action

The proposed Federal action is the approval of four coal mining plans and one right-of-way application to construct a twenty-five mile railroad from Craig, Colorado, to Axial Basin, Colorado. The above actions are analyzed as site specifics in the report. The cumulative effects of increased coal exploration, production of private coal, additional Federal coal leasing, and right-of-way approval are analyzed on a regional basis.

3. Summary of Environmental Impacts

A. Mineral resources will be depleted.
B. Water consumption will be increased.
C. Existing water quality will be decreased.
D. Ambient air quality will be decreased.
E. Soil fertility and capability will be decreased.
F. Total forage production will be lowered.
G. Wildlife habitat will be reduced.
H. Quality of aquatic habitat will be reduced.
I. Archaeological and paleontological values will be impacted.
J. Historical values will be influenced.
K. Existing land uses will be altered.
L. Recreation demands will increase.
M. The social environment will be adversely impacted.
N. Additional transportation facilities will be required.
O. Aesthetic values will be reduced.
P. Regional population will increase.
Q. Employment levels will increase.
R. Income levels will increase.
S. Taxes will increase.

4. Alternatives Considered

A. Rejection of the proposed action.
B. No action.
C. Alternate implementation schedule.
D. Alternate mining schemes.
E. Alternate transportation modes.
F. Alternate utilization methods.
G. Alternate production levels.
H. Alternate energy sources.

5. Comments have been requested from the following

Environmental Protection Agency
United States Department of the Interior
United States Department of Agriculture
Federal Power Commission
United States Department of Health, Education and Welfare
United States Department of Transportation
State of Colorado
Routt County
Moffat County
Rio Blanco County
City of Meeker, Colorado
City of Craig, Colorado
City of Hayden, Colorado
City of Steamboat Springs, Colorado
Colorado District 12 Area Council of Governments
Colorado District 11 Area Council of Governments

6. Date draft statement made available to CEQ and the public:

P R E F A C E

PREFACE

This regional coal environmental impact statement is patterned after a statement prepared for the Eastern Powder River Basin in Wyoming. It is the second regional coal EIS in the Bureau's history and the first undertaken by the Colorado State Office of BLM. Ten (10) other regional statements have been ordered prepared by Secretary Kleppe. It is assumed that these ten statements will benefit from the experience gained from this statement, especially as it progresses from a draft to a final statement.

The reader should note that during the period of preparation of this draft environmental statement, the Department of the Interior has promulgated proposed regulations governing surface coal mine operations and reclamation. These regulations, published as proposed on September 5, 1975, were used by the preparation team in the development of a draft statement.

During the period in which this draft statement was being printed, the Department published the coal mine operating and reclamation regulations as final rulemaking. Because these regulations affect the level of impact on the environment, as well as the mitigating measures required, there may be areas in this environmental statement in which changes must be made to reflect the coal mine operating and reclamation regulations as they are published as final rulemaking. Specifically, the sections entitled Environmental Impacts of the Proposed Action, Mitigating Measures, and Adverse Impacts Which Cannot Be Avoided, as they are draft in both the regional analysis and the site-specific sections, may have to be changed to conform with the final regulations. Such changes will be made during development of the final environmental impact statement.

In response to the nation's growing need for a dependable supply of energy, interest in domestic energy resources has increased sharply. In western states this interest is being expressed in the form of new demands on Federal agencies for actions to expedite the development of the vast energy resources in the Federal estate.

In northwest Colorado, several coal-related Federal actions are pending before agencies of the U.S. Department of Interior. These pending actions include: (1) approval by the Area Mining Supervisor of the U.S. Geological Survey (USGS) of four mining plans covering the development of coal on seven Federal coal leases issued under the terms of the Mineral Leasing Act of 1920; these mining plans have been submitted by Energy Fuels Corporation, W. R. Grace and Company, Peabody Coal Company and Ruby Construction Company; (2) approval by the Colorado State Director of the Bureau of Land Management (BLM) of a 25-mile tram road right-of-way application submitted by W. R. Grace and Company for the transportation of coal via unit train; (3) offering at public auction by the Colorado State Office of BLM four tracts of Federal coal under the short-term leasing criteria established by the Secretary of the Interior: three of the tracts lie adjacent to Energy Fuels Corporation's existing mines; the fourth borders coal property being mined by Peabody Coal Company. Affirmative action on these proposals would add approximately eight million tons of annual coal production to the region's 1974 output of 3.7 million tons.

The actions outlined above pertain to specific coal operations that are in relatively advanced stages of planning. Though not as well-defined in terms of scale and timing, other coal-related developments requiring

Federal actions exist in northwest Colorado, because the area is rich in low sulfur bituminous coal, much of which is in the Federal estate.

In reference to these additional Federal actions, the Colorado State Office of the BLM has in the region 11 pending preference-right coal lease applications, 24 pending competitive coal lease applications (over and above the four that meet the short-term criteria), and thirty tracts identified for possible additional coal leasing. Some of these tracts may meet the Secretary's short-term leasing criteria in the near future, while others may be leased under a new Federal coal leasing policy currently being formulated. Either policy may allow for leasing additional Federal coal not currently covered by lease applications. Several coal-related rights-of-way applications are pending before BLM, and within the next fifteen years, 38 issued Federal coal leases in the region will be subject to renewal.

The USGS expects additional requests for approval of mining plans on the 41 existing Federal coal leases in the region, as well as on any leases issued in the future. An additional 1760 megawatts of coal-fired electric generating capacity, over and above the 1173 megawatts installed or under construction, have been proposed for northwest Colorado, and would likely entail additional action on the part of the Department of the Interior, the Environmental Protection Agency, or the Department of Agriculture.

Section 102 of the National Environmental Policy Act of 1969 (NEPA) states that every Federal agency which proposes an action that may significantly affect the quality of the human environment must prepare a statement describing the environmental impact of that action. In light of this requirement, the Secretary of the Interior determined in March, 1975, that the approval of each of the four proposed mining plans as well as the railroad right-of-way application constitutes a major Federal action. In addition it was concluded that the cumulation of the other possible coal-related decisions may have considerable effect on regional environmental values. Therefore the Secretary commissioned the preparation of the following environmental analyses. The BLM was designated the lead agency for statement preparation with assistance from the USGS.

Correspondingly, this statement is divided into six separate analyses. The first section, contained in Volume I, addresses the cumulative impacts of potential regional coal-related developments, including those involving Federal, State or private action; this section is hereafter referred to as the Regional Analysis. The remaining five sections investigate the site-specific impacts of the four mining plan actions and the tram road right-of-way action that are outlined above. Volume II contains analyses of the proposed mining plans submitted by Ruby Construction and Peabody Coal Company. The analysis of W.R. Grace and Company's proposed mine plan is in Volume III while the analysis of their proposed railroad is in Volume IV. Volume V analyzes Energy Fuels Corporation's mine plan. Volume VI contains supporting appendix material and large oversized maps are in a separate map packet volume. The time frame for all analyses is fifteen years, with projections of activities and impacts in 1980, 1985, and 1990.

All of the proposed Federal actions fall within Routt and Moffat counties and that portion of Rio Blanco County north of the White River;

this area of approximately 5.68 million acres encompasses valuable portions of the Green River and Uinta coal regions; from Landis' work (1959) it is estimated that 14.1 billion tons of recoverable coal are in the Federal estate in this region. The major communities are Craig, Steamboat Springs, Meeker, Rangely, Hayden, and Oak Creek, and the current population is approximately 26,000. For analytical purposes this area is used as the source area for coal-related environmental impacts, and is hereafter referred to as the study region.

The geographic extent of impacts varies, depending on the nature of the resource receiving the impact. For example, impacts on vegetation from surface mining are generally limited to the mined area, but impacts on water quality from increased sedimentation may extend well beyond the study region.

The general methodology for all analyses involves: (1) detailed description of the proposed action, (2) description of the present environment and where necessary, a projection of the future environment without the proposed action, (3) analysis of the environmental impacts of the action, (4) measures which would mitigate impacts, (5) determinaion of adverse impacts which could not be avoided, (6) description of short-term uses of the environment which may affect long-term productivity of the environment, (7) identification of irretrievable commitments of resources which would result from the implementation of the proposed action, and (8) description of alternatives to the proposed action which would have significantly different impacts. This manner of analysis provides the basis for a future selection of a course of action which would optimize the use of the human environment.

The reader should note that this draft environmental impact statement is a public information document which will contribute to later Federal decisions. Comments and suggestions regarding the analyses contained herein are encouraged and will be weighed in any final decisions regarding the proposed actions. Note further that the Regional Analysis provides the basis for additional environmental reporting that would be required at such time as additional specific Federal actions are identified in the study region.

Chapter I

Description of the Proposed Action

THIS CHAPTER INCLUDES A DISCUSSION OF THE VARIOUS INDUSTRY PROPOSALS TO DEVELOP COAL WITHIN THE STUDY REGION. FEDERAL ACTIONS THAT WOULD BE REQUIRED TO IMPLEMENT ALL OR PART OF THE PROPOSALS ARE ALSO IDENTIFIED AND DISCUSSED IN THIS CHAPTER.

CHAPTER I

DESCRIPTION OF THE PROPOSED ACTION

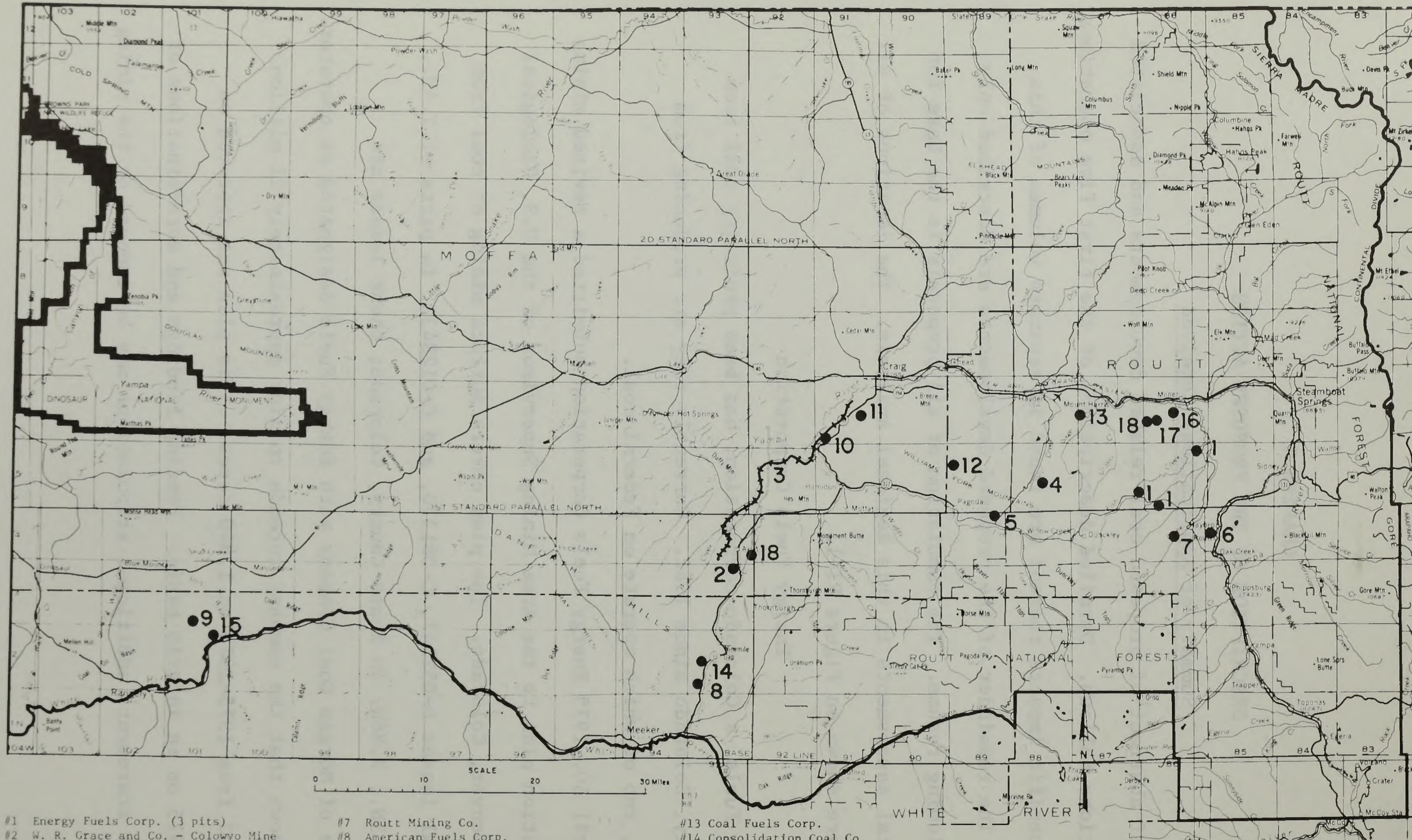
Summary of Applications Received

A brief abstract of proposed coal-related developments and associated Federal actions follows. Detailed descriptions of the first five operations and site-specific impacts thereof are found in separate volumes of this statement. The remainder of the proposed developments are described only in the following resume. The cumulation of all proposals is the base for environmental assessments in this Regional Analysis. The locations of all proposals are shown on Figure RI-1.

Energy Fuels Corporation

Energy Fuels, a Colorado corporation, has been producing coal from Routt County, Colorado since 1962. Currently they are producing from three pits, two of which operate on Federal coal.

On April 30, 1975 Energy Fuels Corporation submitted a revised mining and reclamation plan to the Area Mining Supervisor of the U.S. Geological Survey in Denver, Colorado. The plan covers surface mining of coal from Federal coal leases D-052547, C-081330, and C-0128433. in parts of T.4N., 86W. and T.5N., R.86W. in Routt County, Colorado; these leases are in the name of Morgan Coal Company with Energy Fuels designated as operator. The plan shows that the company intends to mine approximately 22 million tons of coal from 1975-1979 on 1,840 acres. This plan was approved on June 20, 1975 on an interim basis. Pending findings and determinations of this impact statement, additional stipulations may be imposed on the mining plan.



#1 Energy Fuels Corp. (3 pits)
#2 W. R. Grace and Co. - Colowyo Mine
#3 W. R. Grace and Co. - Railroad
#4 Peabody Coal Co.
#5 Ruby Construction Co.
#6 Pittsburg and Midway Coal Mining Co.
#7 Routt Mining Co.
#8 American Fuels Corp.
#9 Moon Lake Electric Asso.
#10 Empire Energy Corp.
#11 Colorado Ute Electric Association
#12 American Electric Power Service Corp.
#13 Coal Fuels Corp.
#14 Consolidation Coal Co.
#15 Midland Coal Co.
#16 Merchants Petroleum Co.
#17 Thomas C. Woodward
#18 Paul S. Coupey (2 sites)

FIGURE RI-1

Locations of proposed actions.

Three competitive lease applications, C-16284, C-20900, and C-22676, adjoining properties covered by the proposed mining plan, meet the Secretary's short-term leasing criteria. Three other competitive lease applications, C-9968, C-22644, and C-22677, have been made by Energy Fuels and would be incorporated into the company's mining plan beyond 1979. It should be emphasized that Energy Fuels does not own any coal rights covered by these six lease applications nor do they have any unique right to acquire these tracts.

In the case of Energy Fuels Corporation the proposed actions before the Secretary of the Interior are review of the 5-year mining plan approval with inclusion of any additional stipulations deemed necessary, offering at auction three competitive lease applications under the short-term leasing criteria, and offering three additional lease applications under a coal leasing policy currently under formulation.

W. R. Grace and Company--Colowyo Mine

In December, 1973, W. R. Grace and Company acquired the Colowyo Coal Company, including Federal coal lease D-034365, in Axial Basin in the southeastern part of Moffat County, Colorado. On April 30, 1975, Grace and Company submitted a revised mining plan involving a surface coal operation on D-034365, to the Area Mining Supervisor of the USGS in Denver, Colorado. The plan covers the extraction of approximately 85 million tons of coal from eight coal seams over a thirty-year period with disturbance of approximately 1500 acres. Included in the company's mining plan is production from their Federal competitive coal lease application C-22839. It should be noted that W. R. Grace and Company does not own the coal on this tract nor do they have any unique right to acquire the coal.

The company has also filed three Federal competitive coal lease applications with the BLM on properties adjoining D-034365. The area covered by these applications, C-22836, C-22837, and C-22838, is not part of the company's proposed mining plan but would be integrated into the mine operation if the tracts are offered at competitive auction and if W. R. Grace and Company is the successful bidder.

In the case of W. R. Grace and Company, the Federal actions before the Secretary of the Interior are approval of a mining plan and offering of four competitive lease applications at public auction. None of the four lease applications meets the short-term criteria. Therefore all would be offered under a leasing policy currently under formulation.

W. R. Grace and Company--Tram Road

Right-of-Way Application

On April 30, 1975 W. R. Grace and Company filed a tramroad right-of-way application (C-22673) with the Colorado State Office of the BLM for a railroad between the Axial basin and Craig, Colorado. The railroad would be approximately 25 miles long and would disturb about 400 acres.

The purpose of the proposed railroad is to transport coal via unit train from the company's proposed mine, previously described, to the Denver and Rio Grande Western Railroad spur south of Craig, Colorado. Maximum grade against loaded trains is planned to 0.8 percent, and against empty trains, 1.1 percent. Maximum curvature would be seven degrees. These criteria are subject to change upon reaching the final design stage.

Fills are designed with 1.5:1 slope while cuts are expected to vary from 1.5:1 to 0.25:1. Channelization of Milk Creek would be necessary. A 200-foot bridge would be required over Colorado State Highway 13.

The proposed action before the Secretary of the Interior is approval of a 25-mile tramroad right-of-way for a railroad to haul coal via unit train from W. R. Grace's proposed mine in Axial Basin to Craig, Colorado.

Peabody Coal Company

Seneca Coals Ltd., a joint venture between Peabody Coal Company and Western Utility Coal Company, with Peabody designated as operator, has been producing coal near Hayden, Colorado, since 1964 to supply coal to unit 1 of the Hayden station power plant. On July 22, 1975 the company filed a revised mining plan with the Area Mining Supervisor covering stripping operations on Federal coal leases C-081251 and C-081258. These two contiguous leases, designated the Seneca 2-W area, are located west of the company's existing Seneca 2 mine and south of Hayden. It is the company's intention to begin production from the 2-W area in 1980 at a rate of 900,000 tons/year. Approximately 970 acres would be disturbed by this proposed operation. The coal would be used at the Hayden unit 2 power plant, scheduled for commercial operation in 1976. Between 1976 and 1980 the company would supply the new power plant with coal from their existing Seneca 2 strip mine.

The company has also filed a competitive coal lease application, C-19885, with the Colorado State Office of the BLM. This application meets the short-term leasing criteria. The company's existing Seneca 2 mine is currently operating on State and private coal properties adjoining this 125-acre application. If the coal covered by this application is offered at public auction and if Peabody Coal Company is the successful bidder, the property would be incorporated in the company's plan for the Seneca 2 mine. It should be noted that Peabody Coal Company does not own the coal covered by this application nor do they have any unique right to acquire the coal.

In the case of Peabody Coal Company the proposed actions before the Secretary of the Interior are approval of a mining plan and offering of Federal coal at a public lease auction under the Secretary's short-term leasing procedures.

Ruby Construction Company

On December 18, 1974, Ruby Construction Company submitted a mining plan covering proposed underground coal production from their Federal coal lease, D-051698, encompassing approximately 146 acres twelve miles southwest of Hayden, Colorado. The company proposes to produce 200,000-300,000 tons/year to supply the local domestic market and other users. The operation would utilize traditional room and pillar techniques. Approximately ten acres would disturbed by surface facilities. Subsidence would disturb a substantial portion of the surface of the lease, because underground workings would cave after the coal is removed.

The proposed action before the Secretary of the Interior is approval of a mining plan involving underground extraction of coal from an issued Federal coal lease.

Other Coal-related Operations in the Study Area

Several other coal-related developments are expected to impact the study region. Some of these operations are well defined but do not currently involve Federal action. Others are less certain with respect to timing and scale but some degree of Federal action can be anticipated. The environmental impacts of all of these developments are addressed on a cumulative basis in the Regional Analysis.

Pittsburg and Midway Coal Mining Company (P & M)

This company, a subsidiary of Gulf Oil Corporation, currently operates Edna coal surface mine just north of Oak Creek in Routt county. The Edna mine currently produces about 1.2 million tons/year; annual production is expected to drop to 1 million tons in 1979 and to less than .5 million tons by 1990. The mine is expected to close in 1991. Between 1977 and 1991 the company expects to mine a total of 1.41 million tons of Federal coal from issued leases D-033327, D-021601, and D-053710, disturbing approximately 130 acres.

On August 11, 1975, P & M submitted a detailed letter of intent to the EIS task force concerning the company's plans for the remaining life of the mine. At present, 66% of P & M's coal is used by utilities, 31% by industrial users, and 3% by domestic users. However, by 1977, and continuing through the life of the mine, 35% will be purchased by utilities, 63% by industrial users, and 2% by domestic users. Over 90% of P & M's coal is sold to Colorado users; this trend will continue through the life of the mine.

In 1977 a portion of Federal lease D-041478 will be regraded and subjected to further reclamation work. Also in 1977 and continuing into 1978, an area in Federal lease D-033327 previously mined for the Lennox seam will be reworked to recover the underlying Wadge seam; further mining will occur on this lease in 1981. Beginning in 1985 and continuing through 1988, Wadge seam coal will be mined from Federal lease C-021601.

Periodically the mine will require construction of haulage roads and powerlines. It is estimated that construction of new haulage roads will occur as follows:

1975 - 6,000 ft. located on private land
1977 - 1,300 ft. located on lease D-041478
1978 - 3,000 ft. located on private land

It is estimated that powerlines will be built as follows:

1976 - 5,000 ft. located on private land
1977 - 5,000 ft. located on private land
1977 - 2,000 ft. located on lease D-041478
1981 - 8,000 ft. located on private land

in 1976 an additional shop building will be constructed in the NW 1/4 of Section 19, T.4N., R.85W., on private land. This building will be a metal structure (7,500 square feet) with a concrete floor, used for truck storage and warehouse space. Currently there are no plans for any additional major construction on the mine property.

Routt Mining Corporation

This company operates a small underground mine near Oak Creek in Routt County on Federal coal lease D-046544. The mine is in the 52-inch-thick lower series Pinnacle Bed in the Iles Formation; it supplies the local domestic market for space-heating fuel. The company has one other Federal coal lease, C-0127592, which adjoins D-046544. The company may submit a mining plan to the USGS on this lease within the fifteen year time-frame of this analysis.

<u>American Fuels Corporation</u>

This company operated a small underground mine, the Rienau 2, north of Meeker in Moffat County on Federal coal lease C-076713. In March 1975 the mine was closed by Federal coal mine inspectors because face equipment was not permissible. Although plans for reopening are uncertain at this time, production could be expected within the fifteen year time-frame of this analysis.

<u>Moon Lake Electric Association</u>

This company is considering the development of a mine mouth steam generating plant northeast of Rangely, Colorado. The generating capacity would be in the 500-1,000 megawatt range, depending upon the acquisition of purchase guarantees from oil shale companies in Colorado and Utah. At maximum power output Moon Lake Electric would produce 3.7 million tons of coal from both underground and surface developments on issued Federal coal lease C-023703, preference right lease applications C-8424 and C-8425, and competitive lease application C-22654. The applications do not meet the short-term leasing criteria. A right-of-way application for a power transmission line from the proposed plant site to oil shale tract C-a has been filed by the company with the Colorado State Office of the BLM. If the company decides to proceed, several other right-of-way applications could be anticipated.

<u>Empire Energy Corporation</u>

This firm is currently operating both an underground and a surface mine in Moffat County south of Craig. Production is expected to reach 0.4 million tons by 1980. The company has approximately 80 acres of Federal coal under two issued leases, C-056298 and C-0127865. Additionally, Empire Energy has applied for three competitive lease tracts, C-13134, C-14738, and C-21981, covering approximately 9,300 acres. These do not meet the short-term leasing criteria.

Colorado-Ute Electric Association

This firm, based in Montrose, Colorado, is considering construction of two additional units at its Craig power station, adding 760 megawatts of capacity to the 760 megawatts already under construction. If the company decides to proceed, additional rights-of-way, mine plan, and coal lease Federal actions could be expected.

American Electric Power Service Corporation

This company is considering the development of a combined underground and surface coal operation on their issued Federal lease C-012894 (640 acres) in the Williams Fork Mountains on the western border of Routt county. Development would be predicated on the acquisition of additional Federal coal. If development proceeds, the coal would be shipped to the Midwest to be used in the company's extensive power generating network.

Coal Fuels Corporation

This company, based in Rollinsville, Colorado, has made a competitive coal lease application, C-22546, covering 6,960 acres in Routt county, southeast of Hayden. The company is currently conducting a core drilling exploration program on adjoining fee lands. If Coal Fuels Corporation is successful in acquiring the applied-for lands, they anticipate starting development of an underground operation in 1977, with full-scale production at 2 million tons/year. Additional development at some later date would bring production up to 8 million tons/year. It is expected that the coal would be shipped to markets outside of Colorado.

Consolidation Coal Company

This company, a wholly-owned subsidiary of the Continental Oil Company, holds seven issued Federal coal leases, C-093713, C-245, C-1545, C-1546, C-093714, C-093715, and C-093716, covering approximately 10 thousand acres in the Ninemile Gap area north of Meeker. In the same area the company holds three preference right lease applications, C-0126997, C-0126998, and C-0126999, covering approximately 9600 acres; these do not meet the Secretary's short-term leasing criteria. The company is currently conducting a multi-year exploration program on these tracts. If the program shows minable quantities of coal, the company would consider an underground operation beginning no sooner than 1980.

Midland Coal Company

This company, a division of American Smelting and Refining Company, is currently negotiating with Paul Riebold to obtain his rights to Federal lease C-028875 and preference right lease application C-0125366, both northeast of Rangely in Rio Blanco county. The lease application does not meet the short-term leasing criteria. If successful in these negotiations, the company intends to conduct a detailed exploration program. The company may apply for additional Federal coal adjoining these tracts if the exploration program indicates minable quantities of coal.

Merchants Petroleum Company

This firm holds approximately 2500 acres of leased fee coal near Milner in Routt county; the plans are indefinite until a joint venture partner can be found. No specific Federal action can be identified at this time, although unleased Federal coal is near the fee property.

Thomas C. Woodward

Mr. Woodward holds two issued State coal leases encompassing 920 acres near Milner in Routt county. He is currently conducting an exploration program on these properties and seeking to acquire coal rights on adjoining fee lands. If Mr. Woodward's exploration and acquisition programs prove successful, he may apply for Federal coal in the area.

Paul S. Coupey

Mr. Coupey holds two State coal leases in the study region. One lease covering 280 acres is near Milner in Routt county. Mr. Coupey currently has a strip mine permit application covering this lease before the Colorado Land Reclamation Board; if approved operations would begin immediately. Reserves would be depleted three years after operations begin. Mr. Coupey's second State lease, covering 640 acres, is in the Axial Basin area of Moffat county. He anticipates start-up of a stripping operation sometime in 1976. Some Federal rights-of-way action may be required.

Total Expected Coal-Related Development

For the analysis of regional impacts it is assumed that all of the proposed Federal actions, i.e., coal leasing, mining plan approvals, rights-of-way applications, and issued lease renewals are acted upon in a positive fashion by the two Federal agencies involved, BLM and USGS. These actions would then lead to increased regional levels of coal production, electricity generation, and establishment of new transportation systems. The extent of each of these developments is described in the following paragraphs.

Coal production

Table RI-1 summarizes total expected coal production from the study region and production levels for each of the coal mining proposals previously outlined. Data are presented for each of the benchmark years. Figure RI-2 is a graphic presentation of annual projected production from both underground and surface mines, and expected production without any further Federal action. The total expected coal production level is compared to expected national levels in Figure RI-3.

The 1980 projected annual production level of 23.91 million tons represents an approximate five-fold increase over the existing rate. This production level, which is the summation of each company's "best-guess" approximation, may not in fact be realized, due to labor and equipment shortages, and to other restrictions which may be imposed by State and local authorities. The precise effects of these restrictions could not be identified, therefore the 23.91 million ton figure will be used for analysis of "worst-case" impacts.

The 1990 production level of 33 million tons includes an increment of 6.78 million tons over and above the industry's "best-guess" estimates. The addition accounts for continued increases in demand for the study region's coal consistent with the national coal production estimates made in the Project Independence Blueprint (U.S. Federal Energy Administration 1974).

The total regional projected production levels shown in Table RI-1 and in Figures RI-2 and -3 are results of the cumulation of the proposed Federal actions previously described. Because of the checkerboard pattern

TABLE RI-1

*Projected Coal Production for Specific Operations

Mine	Present	1980	1985	1990	Start Date	Present Employ-ment	Constant Employment	Underground or Surface	Market
American Fuels	11,000	300,000	300,000	300,000	Active	25	25	U	Local
Consolidation Coal	0	**	**	**	1981	0	**	U & S	Unknown
Empire Energy	200,000	200,000	200,000	400,000	Active	72	150	U & S	Midwest
Energy Fuels Corp.	2,500,000	4,500,000	4,500,000	4,500,000	Active	175	593	S	In State
Moon Lake Electric	0	1,500,000	2,300,000	3,700,000	1981	0	700	U & S	Local
Peabody (Seneca 2-W)	0	900,000	900,000	900,000	1980	0	44	S	Local
Peabody (Seneca 2)	600,000	600,000	600,000	600,000	Active	30	30	S	Local
Routt Mining (Apex)	14,000	30,000	40,000	40,000	Active	10	10	U	Local
Ruby Construction (Sun)	0	200,000	200,000	200,000	1976	0	65	U	In State
Utah International	0	2,880,000	2,880,000	2,880,000	1976	0	165	S	Local
W. R. Grace & Co.	0	3,000,000	3,000,000	3,000,000	1976	0	244	S	Unknown
Gulf Oil Corp. (Edna)	1,000,000	1,100,000	1,150,000	400,000	Active	75	75	S	In State
Coal Fuels	0	2,000,000	2,000,000	2,000,000	1977	0	290	U	Unknown
**Thomas Woodward	0	**	**	**	1980	0	**	S	Unknown
**Merchants Petroleum	0	**	**	**	1980	0	**	S	Unknown
Midland Coal	0	200,000	300,000	300,000	1981	0	46	S	Unknown
Paul Coupey	0	1,000,000	1,000,000	1,000,000	1980	0	75	S	Unknown
American Electric Power	0	500,000	750,000	750,000	1981	0	150	S	AEP System
American Electric Power	0	500,000	650,000	750,000					
	4,430,000	19,510,000	20,870,000	21,820,000					
**Aggregate total for Woodward, Merchants and Consolidation Coal:		4,500,000	4,500,000	4,500,000		0	570		
Other expected production				6,780,000		0	546		
Total		23,910,000	25,270,000	33,000,000		387	3903		

*Figures based on industry projections

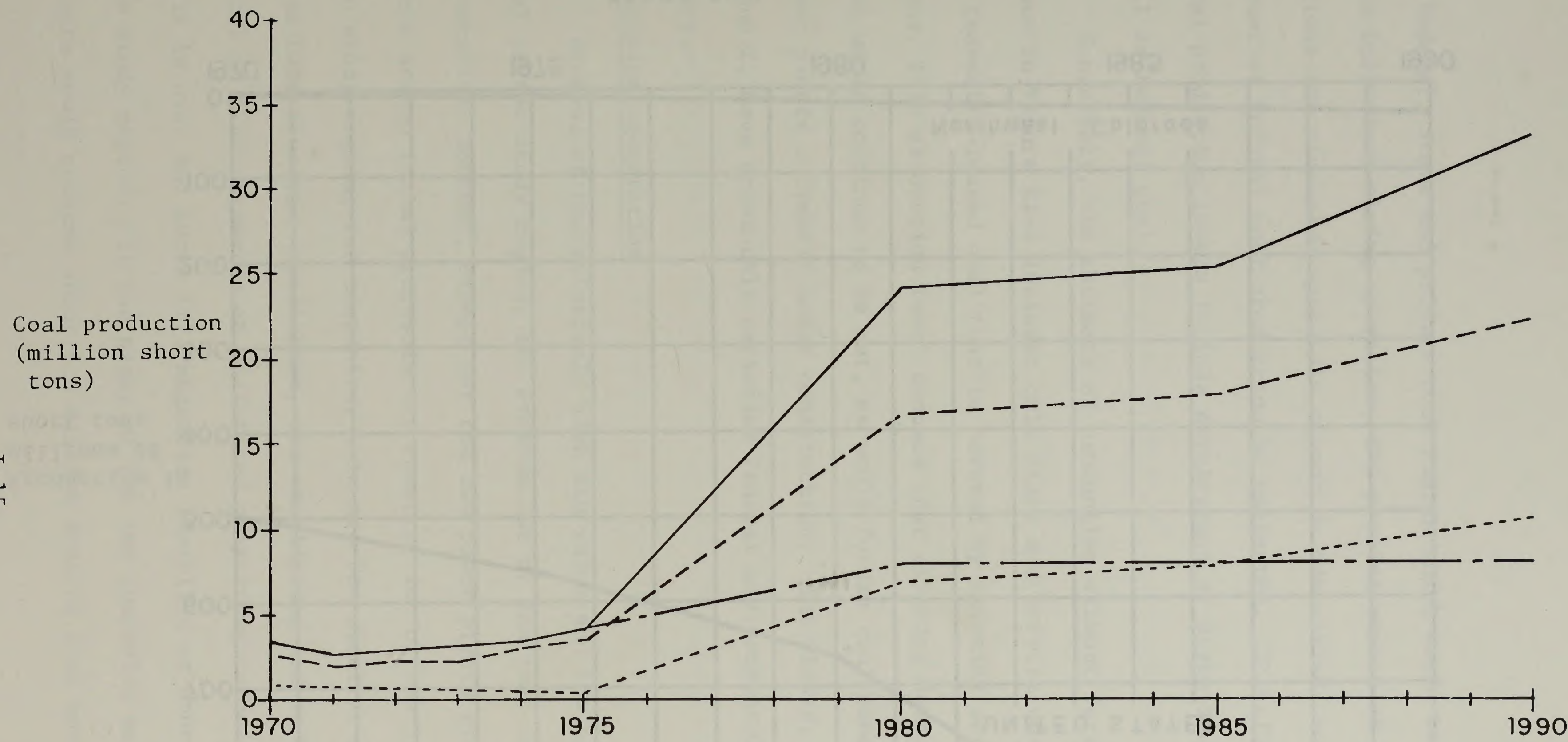


FIGURE RI-2

Historical and projected coal production from study region.

——— Total expected production
– – – Total expected surface production
- - - - - - - - Total expected underground production
-——- Expected production without the Federal action

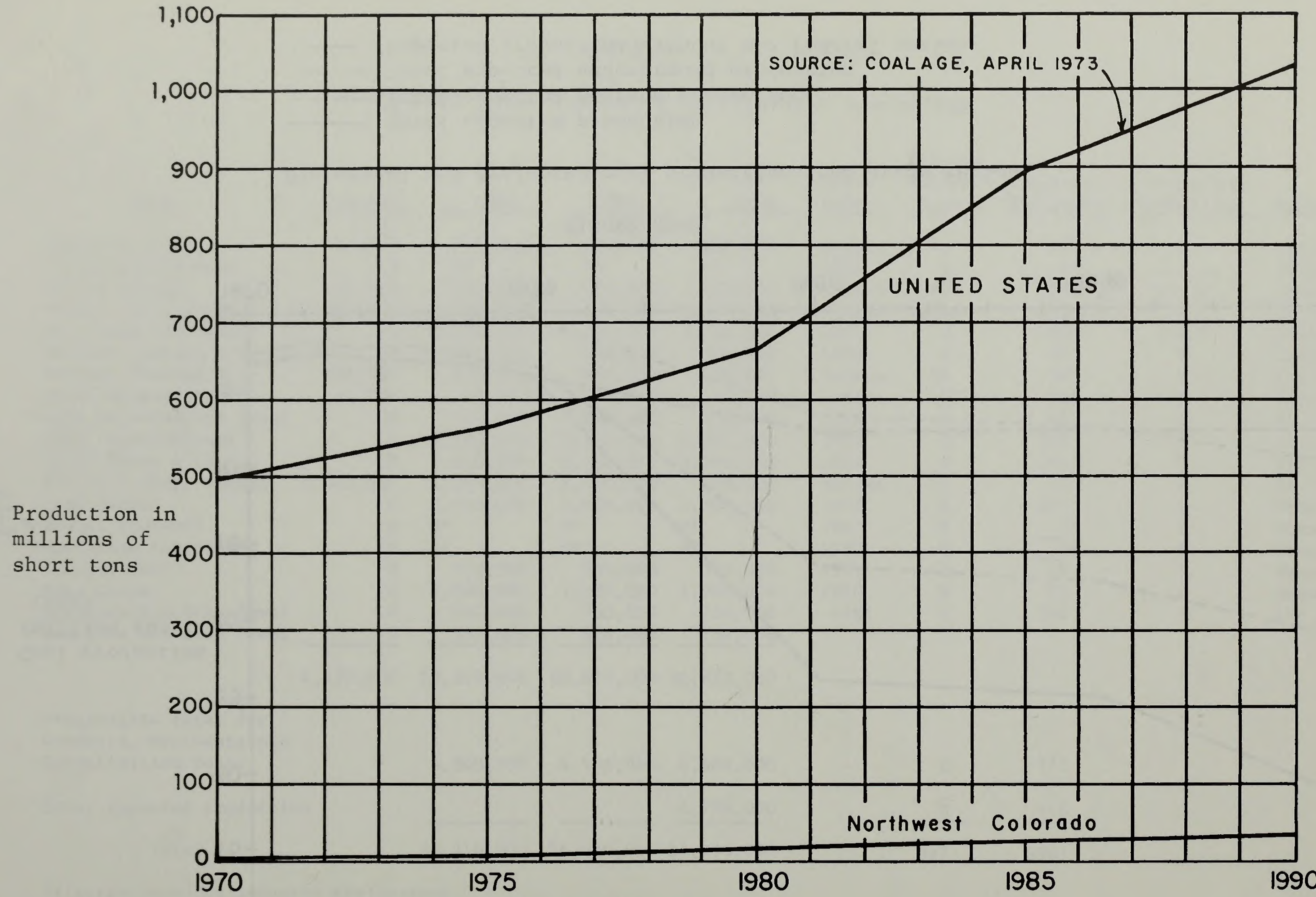


FIGURE RI-3

Projected coal production in the United States and northwest Colorado, 1970 to 1990.

of Federal, State and private coal rights which would be involved with each individual mining operation, the precise number of Federal leasing actions and mine plan approvals cannot be identified, nor can the total amount of Federal coal production be estimated. Therefore the projected total production levels include development of State and private coal as well as Federal coal.

Conversely, the estimate of production without further Federal action shown in Figure RI-2 includes only State and private coal and that portion of federally-leased coal that is covered by existing approved mining plans. This production level assumes that existing demands for regional coal would continue to be met, as would future coal needs to fuel the two power plants currently under construction. The plants, Hayden 2 and Craig 1 and 2, have previously satisfied Federal environmental reporting requirements.

Electrical generation

Because of the relatively high Btu value and low sulfur content of coal in the study region, the premium use of the coal is for electrical generation. However, except for the two power plants previously noted, there are no formal proposals for construction of new generating plants in the study region; two companies, Colorado Ute Electric Association and Moon Lake Electric Association, are considering the installation of a total of 1760 megawatts of coal-fired generating capacity in the region. This is over and above 1173 megawatts installed or under construction in the study region. If the plans of the two companies mature, the two plants would consume about 6.6 million tons of coal annually.

For the purpose of this analysis it is assumed the development of these plants would be dependent upon positive Federal actions on lease applications, and mine plans for mines that would provide coal for these projects. Additionally it is assumed that any required action by the Environmental Protection Agency and/or the Department of Agriculture through the Rural Electrification Administration would be positive.

Transportation developments

The projected eight-fold increase in regional coal production by 1990 would produce a variety of effects, dependent on the mode of transport employed for distribution of the coal. Because rapid continuous transport of coal is an essential of effective mining operations, and the bulk of the coal would be moved over long distances, the rail mode offers the most practical, efficient, and economic solution. As a result, the bulk of annual coal production would probably be hauled by unit trains over existing D&RGW RR lines from Craig to eastern Colorado and beyond. Some additional trackage, spurs, and sidings are foreseen in these proposals, and there would obviously be a considerable increase in train traffic. Increases in traffic of this magnitude necessitate improvement in management and control. Centralized traffic control (CTC) of mainline capacity is already being installed by the D&RGW for the Craig-Steamboat Springs-Dotsero branch. CTC operation obviates any need for double track and additional rights-of-way and effectively upgrades the existing branch line to mainline capacity.

For the purposes of this analysis it is assumed that, as a result of positive responses by BLM and USGS to the proposed Federal actions, a total of 35 miles of new railroad would be built by 1980, 40 miles by 1985 and 125 miles by 1990. (All new miles are over and above existing rail alinements.) This estimate allows for W. R. Grace and Company's proposed railroad to be extended from their proposed mine to Meeker, and from Meeker to Rangely by 1990.

Additionally it is assumed that the number of unit trains leaving the study region annually would increase from 500 now to 3300 by 1990, based on 75 100-ton cars/unit train, and 8.08 million tons of coal being burned at the existing and projected power plants within the study region.

Implementation of the proposed Federal actions would result in a considerable increase in worker, service, and industrial traffic over the road system of the region. New roads would have to be built also. For the purposes of this analysis it is assumed that a total of 20 new miles of road would be built by 1980, 30 miles by 1985, and 45 miles by 1990. (All new road miles are over and above existing road alinements.) These new roads would be haul roads from projected new coal mines to power plants or rail loading facilities.

The development of the two projected power plants would require new powerlines. For this analysis it is projected that a total of 75 new miles of powerlines would be installed by 1980, 200 miles by 1985, and 350 miles by 1990. (All new miles are over and above existing powerline alinements.)

Summary

Table RI-2 presents a summary of total expected coal-related development that would result if the collective proposed Federal actions were acted upon in a positive fashion.

TABLE RI-2

Total Expected Coal-related Development

	1975	1980	1985	1990
Cumulative Tons Coal Produced (millions)	--	71	194	340
Total Number of Mines	9	14 1/	17 2/	21 3/
Number of Power Plants	2 4/	2 4/	3 5/	3 5/
Installed Generating Capacity	1,173 4/	1,173 4/	2,933 6/	2,933 6/
Miles of New Railroads	--	35	40	125
Miles of New Road	--	20 7/	75	150
Miles of New Powerline	--	75	200	350

1/ Existing mines plus Seneca 2-W, Utah International, W. R. Grace, Ruby Construction, and Coal Fuels.

2/ 1980 mines plus Moonlake Electric, American Electric Power, and Consolidation Coal.

3/ 1985 mines plus Thomas Woodward, Merchants Petroleum, Midland Coal and Paul Coupey.

4/ Includes Hayden 1 and 2 and Craig 1 and 2.

5/ 1980 power plants plus Moonlake Electric.

6/ 1980 installed capacity plus Moonlake Electric and Craig 3 and 4.

7/ Including coal exploration trails.

Guidelines and Assumptions

In order that the analysis of regional impacts may proceed, certain guidelines and assumptions must be established; these are discussed hereafter.

Guidelines

Plans proposing development of Federal coal would include a comprehensive land-use plan that clearly identifies ultimate land use goals after mining, as agreed upon by the developer and the surface owner; this plan would also identify specific methods to be utilized in order to achieve these goals. Ultimate land use goals may not be the same as present land uses; therefore present land uses may be permanently impacted or eliminated in certain instances.

Reclamation schedules would vary for each mining proposal. Normally reclamation would be conducted as an ongoing program. After a surface mining operation has been in progress for two to three years, the reclamation plan should be revegetating approximately the same acreage as the mining is disturbing, on an annual basis. The following revegetation schedule will be used as a guide to proper restoration of livestock grazing land use.

1st year - reshaping, topsoiling and seeding,

2nd year - rest for seedling establishment,

3rd year - rest for plant vigor,

4th year - allow grazing with controlled management.

Table RI-3 shows several parameters regarding the manner in which surface disturbances and mine reclamation plans in the study region are projected to proceed.

TABLE RI-3

Disturbed and Revegetated Acreages in the Study Area Based on Projected Development and Acreage Requirement Units

	Period		
	By 1980	By 1985	By 1990
Surface mine disturbed	4,825	14,295	23,965
Surface mines revegetated 1/	1,434	8,962	18,558
Underground mines 2/	200	500	500
Powerlines disturbed	1,050	2,800	4,900
Powerlines revegetated 1/	420	1,750	3,640
Power plants 2/	1,000	2,000	3,000
Roads 2/ 3/	420	157	2,955
Railroads 2/	420	480	1,500
Population 2/	1,070	1,070	1,190
Mine facilities 2/	400	700	1,200
Total disturbed	9,385	23,415	39,210
Total revegetated	1,854	10,712	22,198
Total permanently removed	3,510	6,320	10,345

1/ Assume three-year lag for revegetation.

2/ Considered to be removed from production for time-frame of report, but is partially revegetated and erosion control measures taken.

3/ Including coal exploration trails.

Mine plan analysis will include all associated facilities required to fully develop the plan (i.e., powerlines, roads, railroad, power plants, and land needed to accomodate increased population). Any impacts lasting over thirty years will be considered permanent.

Because the analysis of impacts on many resource values in the study region is dependent on population increases, a projection of total population is required. This projection is shown in Table RI-4. These estimates consider the future economic environment without the proposed actions as a base scenario. The base includes the population that would result from oil shale development, Bureau of Reclamation projects, Routt County recreation developments, Hayden 2 construction, the Yampa project, and existing coal mines. Those projects considered over and above the base include all of the specific coal-related projects outlined above. The projections in Table RI-4 are consistent with the coal production projection shown in Figure RI-2.

Assumptions

The assumptions that are made in the Regional Analysis are:

1. National demands for coal will increase during the next fifteen years;
2. Coal production will increase substantially in the study area; State and private coal will be developed in northwest Colorado regardless of future Federal actions;
3. Accelerated development of other energy minerals will occur concurrently with coal development in northwest Colorado; this will include oil shale as projected in the prototype oil shale impact statement.

TABLE RI-4

Population Projection

	Moffat	Rio Blanco	Routt	Three County Region	Increases Outside Region
1975 Total Base	9,000	5,400	11,100	25,500	
1980 Total Base	10,200	11,200	14,500	35,800	
Δ Cumulative	5,000	3,800	1,900	10,700	1,600
Total Cumulative	15,200	15,000	16,400	46,600	
1985 Total Base	11,200	17,000	17,000	45,200	
Δ Cumulative	3,900	3,400	2,200	9,400	1,400
Total Cumulative	15,100	20,400	19,200	54,700	
1990 Total Base	13,500	18,500	17,700	49,800	
Δ Cumulative	4,100	3,500	2,500	11,900	1,300
Total Cumulative	17,700	22,000	20,200	61,700	

Notes: Totals may not add due to rounding.

"Total Base" is projection of population without Federal action.

"Δ Cumulative" is additional population due to Federal action. The 1990 Δ Cumulative for the three-county region includes 1,800 people that could not be allocated to any specific county.

"Total Cumulative" is projection of total population with Federal action.

Production of oil, gas, and uranium is already increasing; geothermal resources may experience local production during the time-frame of this report;

4. Mining, surface rehabilitation, and energy conversion technology will not change significantly over the fifteen year time-frame of the analysis;
5. Surface-disturbed lands can be successfully revegetated more effectively in the study region than in many other western states, due to advantageous soil and climatic conditions;
6. No national or world economic disorders, oil embargos, or major wars will occur that would distort the projected levels of development;
7. Labor and equipment shortages will not significantly distort the projected levels of development;
8. No extensive delays for obtaining environmental clearances will be encountered.

Additional assumptions regarding acreage and water requirements for various elements of projected coal-related development are presented in Table RI-5.

TABLE RI-5

Acreage Requirements for Development

Facility	Acres Required
Water-cooled power plant	1,000 per plant
Mine-buildings, shops, etc.	100 per mine
Powerline (230-kv)	18 per mile
Powerline (138 and 69-kv)	12 per mile
Roads (175' right-of-way)	21 per mile
Per 1,000 population increase	100
Railroads 100' R/W	12 per mile
Per million tons of coal mined	100

TABLE RI-5 Continued

Water Requirements for Development

Facility	Acre-feet/year
Power plant (water cooled)	15 per megawatt
Per 1,000 population increase (urban)	150

Federal Procedures

Coal Leasing

The Secretary of the Interior is authorized to lease Federal coal under the provisions of the Mineral Leasing Act (30 U.S.C. 181 et. seq.) and the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351359). The Secretary has designated the BLM the agency responsible for processing coal lease applications.

Prior to 1971 the BLM responded to industry demands for coal leasing on a case-by-case basis. After an industry application for a lease in an area of known commercial quantities of coal, auction bidding on the nominated tract would determine the competitive lessee. In unknown areas, prospecting permits were issued; if the permittee discovered coal in commercial quantities, he would be entitled to a lease by preference right. Both preference right and competitive leases were issued for indeterminable periods with the provision that terms and conditions of the lease would be subject to readjustment 20 years after the lease was originally issued.

Federal coal leasing activity in the study region has been quite extensive. At the present time there are 41 issued Federal coal leases in the study region. The coal industry's continued interest in the region's Federal coal is evidenced by the 11 pending preference right lease applications and

and the 28 pending competitive lease applications. Appendices A and D present locations and data relevant to all leases and lease applications in the study region.

The findings of a 1970 study by the Division of Minerals, BLM, entitled Holdings and Development of Federal Coal Leases, indicated that there was a substantial disparity between recoverable coal reserves under Federal lease and actual amounts of coal being produced from these leases. As a result of these findings, no leases were issued from May 1971 to February 1973. At this latter date, the Secretary of the Interior announced that issuance of prospecting permits was indefinitely suspended, and that a Programmatic Environmental Impact Statement on coal leasing would be prepared with the goal of formulating a new Federal coal leasing policy that would insure timely development of Federal coal with minimum environmental costs.

The Secretary's pronouncement additionally stated that any lease applications received by the Department prior to the formulation of the new coal leasing policy would have to meet certain "short-term leasing criteria" before any leases could be issued. These criteria are:

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

2) When coal is needed as a reserve for production in the near future; and

3) When the 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

4) When an environmental impact statement, covering the proposed lease, has been prepared when required under the National Environmental Policy Act.

As previously noted, four of the 28 competitive coal lease applications meet the short-term leasing criteria.

Future Federal coal leasing policy, although uncertain at this time, will most probably entail certain key elements. A proposed leasing system was publicly outlined by the Secretary of the Interior in Denver on January 1, 1975. The elements of this system are outlined below:

1) Nominations would be requested from industry, State and local governments and the public to indicate areas which should or should not be leased, or should be leased only with special stipulations;

2) Nominations would be considered only in areas where BLM's land-use plans are complete enough to allow analysis of the nominations in terms of possible environmental or other use conflicts. BLM's Multiple Use Land Management System analyzes possible development of all resources (including minerals) in a public land area and determines what environmental and other use conflicts could result from such developments. Land use plans are developed for each unit of public land on the basis of the analysis of possible uses and developments. These plans are intended to identify the mix of resource uses and developments that can be carried out in the area with minimum impacts on the environment and other uses. This process is carried out in consultation with local publics, other Federal agencies and with State and local governments;

3) Consultation with State and local governments will precede a decision to offer any specific tracts for lease;

4) All leasing actions will be taken only after complete compliance with NEPA;

5) New diligence requirements will be imposed to stimulate timely production and eliminate lease acquisition of excessive resources. These requirements may be in the form of advance cumulative royalties, the proposed rules (Federal Register, Vol. 39, no. 239, p. 43229) for diligent development

and continuous operation, or an absolute requirement for coal production within a specified time with relinquishment of the lease as the non-performance penalty;

6) New mined land reclamation standards similar to those envisioned in the Conference Report on S. 425 of the 93rd Congress will be incorporated in departmental mining regulations and will be applied to all Federal leases. Many of these standards have been proposed as amendments to 30 CFR 211, 216 (Federal Register, Vol. 40, no. 21, p. 4428 - 4438).

With respect to item 2) the BLM Craig District Office has recently completed two Management Framework Plans (MFP) in northwest Colorado. Both Williams Fork MFP and White River MFP identified potential coal leasing tracts where coal development would generate a minimum of resource conflicts. These tracts are shown on the surface-minerals management maps in Appendix A.

Mining and Reclamation Plan Review and Approval

Before conducting any operations on Federal lease land, (whether private or Federal surface) an operator is required by Operating Regulations 43 CFR Part 23, and 30 CFR Part 211, to submit an exploration or mining plan for approval to the Area Mining Supervisor of the USGS. An exploration plan is required to show in detail the location and type of work to be conducted, time schedule of exploration, environmental protection procedures, access and support roads, and reclamation procedures to restore and revegetate disturbed areas upon completion of operations. A mining plan must show location, method of mining and areal extent, all related activities necessary and incidental to such operations, the detailed steps to be taken to protect the environment during operations, and the reclamation methods to be used to restore and revegetate the disturbed areas.

The four mining plans submitted to the Area Mining Supervisor that are analyzed in this statement as well as any other plans that may be submitted in the future are subject to the following procedure: when new mine plans, major modifications in existing surface mine plans, or surface related change in existing underground plans are submitted to the Mining Supervisor for approval, a notice of the proposed action is posted on the Supervisor's office bulletin board the date it is received. At the close of business each week, a copy of any postings for that week is mailed to the appropriate county clerk for posting and publication. One copy of the plan is prepared so that proprietary data are excluded, and as stated in the posted notices, this plan is made available to the public for inspection at the office of the Area Mining Supervisor. A 30-day period is allowed for comment on the plan by private surface owners affected by the plan and by other interested parties. These public comments are considered in preparing the Environmental Impact Analysis (EIA) written by the mining supervisor's staff, and in approving the plan.

One copy of the exploration or mining plan is submitted to the Area Geologist of the USGS for comments on the geologic hazards of the plan. Two copies of any exploration or mining plan are sent to the BLM or other appropriate surface managing agency for their comments and recommendations for surface use, environmental protection, and restoration and reclamation aspects of the plans. These recommendations are incorporated into the Environmental Impact Analysis and are made a part of the mine plan.

For each exploration or mine plan received, the office of the Area Mining Supervisor is required to write an Environmental Impact Analysis describing the proposed action, the location and natural setting, environmental effects of the proposed action, alternatives to the proposed action, unavoidable adverse environmental effects, and either a recommendation or determination as to whether or not the action will significantly affect the environment, in light of requirements of the National Environmental Policy Act (NEPA). If it is determined that the proposed action will significantly affect the environment, an Environmental Impact Statement must be prepared; this was the case with the mine plans analyzed in this statement.

For exploration plans, or for minor modifications of existing mine plans, the Area Mining Supervisor determines whether or not the requested action constitutes a major Federal action after consultation with the BLM relative to surface protection. If the action is determined to be minor, the supervisor is then authorized to approve the plan, provided all necessary surface and environmental protection conditions have been adequately considered.

Secretarial review is required prior to approval of proposed actions determined to be major Federal actions significantly affecting the environment, and for all new or significantly modified surface and underground coal mining operations on Federal lease lands. In such case, a designated person prepares an EIA which is reviewed by the Area Mining Supervisor, and is submitted to the Regional Manager of the USGS, for determination as to whether the proposed action will significantly affect the environment. The Regional Manager forwards the mining environmental analysis with a copy of the mining plan or proposal to Washington for Secretarial review and concurrence, prior to approving the plan.

Rights-of-Way Processing

The major steps in processing rights-of-way across national resource lands are established through BLM Manuals, Washington Office Instruction Memos, and Title 43 of the Code of Federal Regulations. The procedures are fairly uniform among the BLM offices across the country and differences are considered minor. The following steps, some of which have already been completed, are necessary in processing W. R. Grace and Company's pending application for the tramroad (railroad) right-of-way. These same steps will also be required for future right-of-way applications for long-term tramroads, powerlines, telephone lines, pipelines, etc. when they are filed.

1. A right-of-way proponent telephones or contacts the appropriate BLM District Manager to arrange a joint on-the-ground inspection of the proposed route by BLM personnel and company representatives;
2. On the established date, both parties and often a qualified archeologist, county planner, and/or other agency representatives meet in the field to lay out an acceptable location for the right-of-way, and consider alternate routes available; the centerline of the most acceptable route is flagged or identified by the proponent at this time. The width of the right-of-way is determined and construction methods, construction schedules, and stipulations are discussed;
3. While the proponent is in the process of surveying the route agreed upon in the field, the District Manager directs the

preparation of an Environmental Analysis Record (EAR) including recommended stipulations, and a recommendation pertaining to the need for an Environmental Impact Statement (pursuant to Section 102 of the National Environmental Policy Act of 1969);

4. Within a short time after surveying the route, the proponent files a formal application and proper survey maps with the BLM State Office. The State Office reviews the application for completeness, notes it in their records, and after all filing requirements are met, sends the case file to the appropriate District Office. There the application and maps are examined to determine if they represent items and routes previously agreed upon in the field. The Environmental Analysis Record is reviewed to be sure it adequately considers the proposed action and its impacts. A Land Report and in some cases a Minerals Report is prepared and all reports and recommendations are sent to the State Office;

5. The State staff reviews the various district reports for technical adequacy. If an Environmental Impact Statement is not considered necessary, the right-of-way is appraised, and a rental determination is made where provided for by law. The right-of-way with appropriate stipulations is then issued by the State office subsequent to collection of the rental fee. If a statement is needed (which has already been determined for the pending tramroad right-of-way application), the application is held in abeyance until after the legal requirements

of NEPA have been met. Based on findings of the finished EIS documents and other decision-making, the application is either approved as requested, approved with certain modifications and conditions, or rejected.

The only type of right-of-way that is handled differently than the above procedures is a temporary tramroad right-of-way which is generally issued for a duration of six months and may be extended for one six-month period. Such right-of-way permits may likely be needed for railroads and motor-truck roads to be used in connection with mining. Since the District Manager has been delegated the authority to issue these permits, applications are normally processed entirely at the District level.

In situations where a right-of-way passes through lands affected by a public land withdrawal or reservation for the use of another Federal agency, the application must be cleared with that agency. Since an application which is inconsistent with the public or government interest must be rejected (43 CFR 2802.2-1(b)), the withdrawing agency must determine what impact the right-of-way would have on their government program.

Another slight deviation from the aforementioned procedures is those right-of-way applications requiring input and review by State and other Federal agencies because of the type of right-of-way and/or its location. In situations where there are overlapping responsibilities among agencies, coordination of their efforts is generally handled through the BLM State Office. Some of the other agencies involved include those listed on the following page.

Environmental Protection Agency,

Federal Power Commission,

Interstate Commerce Commission,

Federal Highway Administration,

Federal Aviation Administration,

Federal Communications Commission,

State Health Department,

Division of Wildlife,

State Public Utilities Commission.

Institutional Relationships

The BLM and the USGS have the principal Federal responsibilities for authorizing proposed development actions considered in this report. Other Federal agencies have secondary responsibilities; State and local agencies' responsibilities are significant but secondary.

Authority

Management of public lands is authorized by many laws (Public Land Law Review Commission, 1968). Some deal specifically with a resource or action; others are broad; a few of the key acts are mentioned here.

The statutory authority for leasing all Federal public domain coal deposits is contained in the Act of February 25, 1920, known as the Mineral Leasing Act of 1920 (41 Stat. 437, as amended; 20 U.S.C. 181 et seq.)

Lands excluded from the Mineral Leasing Act of 1920 include lands in incorporated municipalities, in national parks and monuments, within naval petroleum and oil shale reserves, those acquired under the Appalachian Forest Act, and those acquired by the United States under other authorities.

Land disposed of, with coal and/or other mineral deposits reserved to the United States, are also subject to the provisions of the Mineral Leasing Act of 1920. Coal is subject to disposition by leasing only, with the exception of permits for local domestic needs.

The law gives the Secretary of the Interior broad authority to make rules and regulations necessary to carry out the mineral leasing program. The Secretary has delegated his authority to issue leases to the Director, BLM, and the Director has delegated his authority in turn to the State Directors. The Secretary has also delegated his authority to administer operations conducted under leases to the Director, USGS.

Regulations governing the leasing of Federal coal, and operations under such leases, are found in Title 43 Code of Federal Regulations (CFR), Parts 23 and 3500, and in Title 30 CFR Part 211.

The Act of March 3, 1875 (18 Stat. 482; 43 U.S.C. 932-939, known as the Railroad Right-of-Way Act) grants rights-of-way for railroads to cross public lands of the United States. The statutory authority for construction and operation of a new line of railroad is contained in Section 1(18) of the Interstate Commerce Act (49 Stat. 543; 49 U.S.C. 1 (18). A certificate of public convenience and necessity issued by the Interstate Commerce Commission (ICC) is required before the start of construction. Spur, industrial team switching, or side tracks located wholly within one state are exempted from the act.

Federal Agencies

The BLM classifies and manages national resource lands and their related resources according to principles of multiple use, sustained yield, and environmental quality. In the Federal coal leasing program, the BLM 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. BLM is responsible for issuing leases and for formulating the surface, non-mineral resource protection, and rehabilitation requirements to be incorporated in them. With respect to Federal coal deposits where BLM has surface management responsibilities, and on private surface overlying Federal coal, BLM determines the adequacy of environmental protection and rehabilitation aspects of all mining operation plans. BLM is also responsible for compliance examinations 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 cadastral surveys of all Federal lands, the BLM maintains the official land status records (title records) for all Federal lands.

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

The Conservation Division of USGS 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 BLM. It approves operating plans to meet requirements of the mineral leasing acts, regulations, and lease terms and conditions, including environmental and rehabilitation stipulations. It makes compliance examinations of operations under Federal mineral leases and maintains records of operations of lessees, permittees, and licensees.

The Environmental Protection Agency (EPA) administers both the Clean Air Act and the Federal Water Pollution Control Act. The Clean Air Act requires that any entity proposing a new industrial facility (e.g., fossil fuel-fired steam generators) must obtain a permit certifying that the plant complies with EPA's new source performance standards. These standards are established separately for each category of plant. The heart of the water quality program is also a permit system which requires any entity discharging pollutants that may enter navigable waters to obtain a permit. EPA effluent guidelines and standards determine whether any specific permit may be issued.

The Department of Transportation (DOT) through the Federal Highway Administration oversees the Federal aid highway program of financial assistance to states for highway construction. In the allocation of Federal matching funds for highways, it establishes and administers standards for highway safety, design, construction, and maintenance. The Railroad Administration of DOT is concerned with safe operation of a railroad after construction.

The Mining Enforcement and Safety Administration (MESA) of the Department of the Interior enforces Federal health and safety standards in all mining operations.

The Department of Labor Occupational Safety and Health Administration is responsible for enforcement of the Employee Safety and Health Act of 1970, which applies to surface structures and facilities.

The Department of Army Corps of Engineers would have to approve plans to cross the Yampa River by railroad.

State of Colorado Agencies

The Division of Mines of the Colorado Department of Natural Resources requires the filing of a Notice of Activity for any proposed exploration or mining in the State. The Division also monitors mine safety practices in concert with the Mining Employees Safety Act; common procedure is for the State to conduct the monitoring with MESA overview.

The Land Reclamation Board of the Division of Mines issues a permit based on an acceptable plan of activity, application fee, and performance bond. The plan must comply with the Colorado Open Mining Land Reclamation Act, as amended in 1973, which sets standards, practices, time factors, and reporting procedures.

The State Board of Land Commissioners is steward of State-owned lands including surface and mineral rights; they conduct the sale or lease of rights in public proceedings.

The Water Pollution Control Commission of the Department of Health has regulatory authority over water quality and related health hazards during construction and operation phases. Standards are a matter of State law and permits are required; work is in concert with EPA.

With respect to air quality a similar role is performed by the Air Pollution Control Commission of the Department of Health.

The State Engineer has authority over water wells and other water sources, such as retention dams and mine drainage.

The Public Utilities Commission works in concert with ICC in matters involving railroad construction and abandonment. Of particular concern to PUC is the crossing of a public road by a railroad; approval is required for the location and safety features of a crossing.

The State Highway Department also is concerned with railroad crossings of State and Federal highways, and with any impingement on those road systems, including forces that will tend to significantly increase traffic volume or load tonnages.

The Occupational Safety and Health Administration of the Division of Labor issues permits to acquire, transport, and store explosives and other hazardous materials used in connection with construction or mining.

The State of Colorado requires licenses for all contractors.

County and Municipal Agencies

County and municipal governments coordinate with State agencies in matters of area development under provisions of the Colorado Land Use Act (HB 1041); counties are empowered by Colorado HB 1034 to pass regulations deemed necessary for orderly growth. Both county and municipal governments have zoning regulations and procedures and other local ordinances which are passed and enforced at the local level. For example, counties require building permits for structures, power lines, and roads. Both counties and municipalities (and private land owners) may require permission for easements and rights-of-way.

Relationships with Private Interests

Interaction between private and Federal property interests occurs frequently as the result of the historical Federal practice of conveying land to private ownership, with reservation to the United States of some or all minerals underlying the land. The Acts of June 22, 1910 (30 U.S.C. 83-85) and July 17, 1914 (30 U.S.C. 1212-124) were the earliest Federal statutes calling for this reservation. The reservations required by those acts were limited to specific minerals, most commonly oil and gas or coal. With respect to coal, the Act of June 22, 1910 provides that any person having rights to prospect for or mine the coal may enter and occupy the land for that purpose. He must first pay the surface owner for damages caused by his operation or post a bond to cover those damages.

By far the most common reservation of minerals occurs with lands that passed to private ownership under the Stockraising Homestead Act of December 29, 1916 (39 Stat 862; 43 U.S.C. 291-302). Section 9 of that Act provides that all conveyances of land under its provisions shall contain a reservation to the United States of all minerals, with the right to prospect for, mine and remove them. In addition the law spells out in some detail the relative rights of the surface owner and the holder of mineral rights. Again there is provision for posting of bond by the holder of any mineral rights (lease) for the benefit of the surface owner, if agreement with the surface owner cannot be reached. Liability of the holder of mineral rights is limited to damage to crops, including forage or other tangible improvements. Damages for reduction in the value of land for grazing can be awarded pursuant to the Act of June 21, 1949 (63 Stat 215; 20 U.S.C. 54). Bonds posted under the above acts are filed with the BLM; if amounts of the bonds are protested inadequate by the landowner, BLM must decide the proper amount.

In recent years, BLM has further protected interests of surface landowners by consulting with them when preparing stipulations for inclusions in proposed leases. Protection of facilities critical to the landowners' ranching operations is of particular concern. Similar contact and joint BLM and USGS field inspections are made when lessees' proposed mining plans are submitted.

Relationship to Other Proposals in Action Area

Oil and Gas

The earliest major oil or gas production in northwest Colorado was in 1924, from the Moffat field in Moffat County, and the Iles field about four miles southwest of the Moffat field. Production has been steadily increasing since that time with the discovery of many additional fields. Oil and gas production was recorded from 47 different fields in northwest Colorado in 1973. Production figures for the three northwest Colorado counties are shown in Table RI-6. This table indicates that all three counties, and Rio Blanco County in particular, produce a large quantity of oil and gas. In 1973 these three counties accounted for 60 percent of the State's total petroleum production and 38 percent of the natural gas

TABLE RI-6

Oil & Gas Production Statistics

County	Number of Producing Wells	1973 Production		1973 Gas Sales (Mcf)	Cumulative Production to 1-1-74	
		Oil (Bbls.)	Gas (Mcf) 1/		Oil (Bbls.)	Gas (Mcf)
Moffat	183	1,036,337	26,572,756	26,179,823	50,614,263	395,272,447
Rio Blanco	572	20,778,910	28,016,242	24,753,503	568,059,866	960,998,737
Routt	12	62,968	1,252	0	4,089,808	508,866
Total	767	21,878,215	54,590,250	50,933,326	622,763,937	1,356,780,050

1/ Thousand cubic feet.

production. Total value of this mineral production amounted to approximately 120 million dollars. This compares to the estimated value, from coal production, of 20 million dollars from the three counties in 1973.

Oil and gas lease applications and drill plans in the three northwest Colorado counties are analyzed in accordance with the National Environmental Policy Act, in the following manner:

Because of the large volume of applications received, the BLM in 1972 and 1973 prepared what are termed Umbrella Environmental Analysis Records (EARs), wherein large homogeneous areas were designated and analyzed where impacts from oil and gas drilling and production were nearly identical. Ten EARs were written within the northwest Colorado EIS study area. These EARs included a description of the impacts, as well as stipulations for mitigation of impacts. Subsequently, as oil and gas lease applications are received, and fall within the boundaries of one of the ten EARs, the leases are evaluated in accordance with the stipulations recommended in the appropriate EAR. Supplemental EARs are prepared for applications which do not fall within the scope of the umbrella EARs. These supplemental EARs outline unique impacts and include stipulations for mitigation of these specific impacts.

After obtaining a lease, a company wishing to drill for oil and/or gas must file a drill plan with the appropriate surface managing agency, and with the Oil and Gas Supervisor of the USGS. A joint field inspection with the oil company or his contractor, the surface managing agency, the USGS, and often the surface landowner is held to determine the necessary stipulations for inclusion in the drill plan approval. In the three county study area of northwest Colorado, drill plans falling within the boundaries of one of the ten umbrella EARs are assigned the stipulations outlined in that particular EAR, plus any additional stipulations that may result as a consequence of the joint field inspection.

Increased drilling and production are occurring in all oil and gas fields in northwest Colorado. The Craig District Office, BLM, is presently processing about fifteen oil and gas drill plans per month and ten-fifteen Notices of Intent to conduct oil and gas exploration per month. In 1973 there were four wildcat holes drilled which hit oil or gas, 55 development holes drilled which hit oil or gas, and 28 dry holes drilled, plugged, and abandoned. Exploration activity is expected to continue at a high level, and future prospecting should result in discovery of more oil and gas fields and producing zones. With currently producing fields, discovery of new fields through exploration, and the anticipated addition of new and better recovery methods, oil and gas operations in northwest Colorado should continue for at least another 40 years.

These extensive oil and gas operations can at times conflict with the potential coal mining operations. In several places in northwest Colorado oil or gas occurs below one or more coal beds. In such a case, simultaneous operation of a coal mine, particularly a surface mine, and a producing oil or gas field becomes difficult. Drill pads, producing well sites, and pipeline network of a producing oil field interfere with a surface mine. Drill holes could potentially interfere with an underground coal mine where the holes intersect the coal bed. Blasting and earth removal required in a surface mine could interfere with an oil or gas well. Consequently it becomes necessary to extract one resource prior to extraction of the other.

Even sequential extraction of the two resources can create potential problems for the second resource extractor. An oil or gas drill rig, drilling through unconsolidated spoil piles left from an abandoned strip mine, can encounter great difficulty in loss of circulation; drilling media would be air, rather than mud. The unconsolidated spoil would be difficult to cement; casing would be required throughout the entire depth of the spoil pile, and an adequate distance below the spoil in undisturbed rock, to prevent a blowout. Drilling into an abandoned underground mine could be potentially even more difficult. Maps of the abandoned underground mine would have to be studied to prevent drilling into an underground entry where circulation would be lost. Drilling into caved areas could also result in loss of circulation and cementation difficulties.

In cases where a mining operation followed the extraction of petroleum products, the location of the oil and gas wells would have to be obtained by the coal company. A pillar of coal, whose dimensions are determined on an individual basis, and approved by the Area Mining Supervisor of the USGS, is required to be left around all producing or abandoned oil and gas wells. Potential coal reserves would thereby be lost to the mining operator and mine planning and sequencing would be adversely affected. For these reasons it is generally more prudent to extract the coal resource prior to extraction of the oil and gas.

Map Foldout 1 in Appendix B shows oil and gas fields of northwestern Colorado as well as coal fields; there are several places where oil or gas fields are overlain by coal deposits.

Oil Shale

No proposals are on record for development of oil shale resources in the area of this statement. Oil shale does occur in large areas of northwest Colorado, and the statement area does include lands withdrawn by the Federal government as potentially favorable for oil shale development. The northernmost part of the withdrawal covering Piceance Creek basin encroaches on the statement area west of Meeker. A large withdrawn area northwest of Maybell is the Sand Wash basin, a southward extension of the Washakie basin in Wyoming. Compared to the heart of the Piceance Creek basin to the south and the Uinta basin to the southwest in Utah, the oil shale in the statement area is of low quality, and therefore does not loom large for potential development in the near future -- certainly not in the 15-year period considered in this statement.

Conflict between oil shale and coal resources is further minimized by their occurrence in different geologic units which are widely separated stratigraphically. Where minable coal occurs near the surface, rocks containing oil shale are absent; where oil shale occurs, coal is too deep to be attractive or even currently feasible for mining.

Activities related to oil shale in the Uinta basin and particularly in the Piceance Creek basin, however, are of importance to the Northwest

Colorado Coal Environmental Impact Statement. Cumulative impacts on air and water in each area are related to some extent, because both resources are dynamic and can move beyond the bounds of their impact-generating areas. Socio-economic impacts in fact overlap. An environmental impact statement concerning the prototype oil shale leasing program was prepared in 1973 by the Department of the Interior, and should be considered in conjunction with this statement on coal development.

Development of oil shale resources in the Piceance Creek and Uinta Basins is being tested currently on Federal and private lands. Tests of prototype operations recently began on two Federal lease tracts in Colorado (Ca and Cb), and two in northeastern Utah (Ua and Ub) are now combined as a single operation. These tests are of operations utilizing surface processing of mined material to extract oil.

Tests of operations that rely on extraction of oil from material in place (in situ processing) are currently being evaluated. If and when the tracts are opened for competitive bidding, and tracts are leased, an uncertain length of time will be required to formulate plans and conduct environmental evaluations, before construction and operation schedules are known. Projections at this time are so uncertain that relationships between in situ developments and coal developments cannot be evaluated in a meaningful way, except to reiterate that mineral resource conflicts are not anticipated in the foreseeable future.

Tests on private lands have been affected by the economic uncertainties of oil shale's future. Process studies have been and are underway, but plans for operation-scale tests have been sporadic. Capital investments required for full-scale operations are enormous; processes are not time-proven at operation scale, and the market value of the product is only marginally profitable at current world prices. Risks are substantial even at current costs and prices; they border on untenable, because of certainty of increased costs and threat level of decreased market prices.

Because of the program sizes, testing of oil shale extraction processes bears less significantly on the concerns of this statement than prototype or full-scale operations. Therefore consideration is only being given to projections of development on the Colorado and Utah lease tracts, and on Superior Oil's private land. Projections indicate that the construction phase on the Cb lease tract begins in 1975, and on tracts Ca, Ua and Ub in 1977; construction on the in situ process lease tracts begins later, and construction by Superior Oil begins in 1979. Operations are projected to begin in 1979 on Ca, in 1980 on Cb, Ua, and Ub, and in 1985 on Superior Oil's property. Start-up date for operations on the in situ tracts is presently unknown. The relationship between these actions and those covered by this statement are treated more fully in appropriate sections of the report.

Uranium

No formal proposals to mine uranium in northwest Colorado are known at present. Exploration activities are proceeding locally in the western part of the region and uranium is being extracted by leaching of material mined in the past near Maybell.

The potential for future uranium mining in northwestern Colorado is good at present and may get better in the future. Uranium prices have increased since the commodity recently was put on the open market in the United States. If demand increases, and this is partly dependent on the future of uranium as a fuel for power generation, prices will increase more rapidly. The result would be accelerated search for and development of uranium ore. Northwest Colorado contains known deposits of uranium that now are marginally or sub-marginally recoverable at current prices. Increased prices would make these deposits minable. The region also includes large areas of favorable ground in which there is increased likelihood that exploration will succeed in finding commercially minable uranium deposits.

For the most part, uranium in northwest Colorado is in geologic units that overly the principal coal-bearing units; therefore the chances of resource conflicts are greatly reduced. Where uranium is recoverable by surface mining methods, coal is deep enough so that it would be recoverable only by underground methods. The difference in depth is sufficient to allow underground mining of coal to precede or follow surface mining of uranium without loss of either resource. The difference in depth generally is so great that where uranium occurs near the surface, the coal is too deep to be attractive for mining in the reasonable future, particularly relative to other sources of coal in the region.

Principal areas of potential interest for uranium are near the Colorado-Utah border north of Rangely and in the area from the Wyoming border south to the vicinity of Craig and Maybell. The potential for uranium north of

Rangely is being tested currently by spot investigations by private industry. If deposits are found, most would be recovered by underground mines. The potential north of Craig and Maybell is greater because uranium was mined in the past near Maybell and the geologic conditions are similar over a broad area eastward and northward. Most deposits discovered in this area probably would be low grade and therefore would be most economically mined by surface techniques; however geologic conditions suggest that deposits could occur as deep as 500 feet.

Because any future proposals to mine uranium in northwest Colorado would be subject to many of the same constraints as coal mines, and because of the virtual absence of potential resource conflict, the relationship between the actions addressed in this statement and future proposals for uranium development is mutually exclusive except as a speculative contribution to cumulative impacts.

Geothermal Resources

Geothermal resources in the Statement area probably will not be developed to a significant degree during the next 15 years and therefore will not add to the cumulative impact on the region. Sources of appropriate dry heat are not known in the area, and thermal waters, although present, are not hot enough to generate electricity with known technology. The known thermal springs are at Juniper Hot Springs and near Steamboat Springs. Thermal waters from wells are just south of Craig and a few miles west of Steamboat Springs. Nearby thermal springs, outside the statement area (Routt Hot Springs and Hot Sulphur Springs) similarly are not hot enough for power generation. The only anticipated new uses of these thermal waters will be local and small scale -- for example, heating of a few buildings. Such uses would not significantly impact either the physical or socio-economic environment.

Water Reclamation Projects

Competition for available water will come from many sources, including proposed reclamation projects which require storage reservoirs. Several such reservoirs have been proposed which would require water from the Yampa and White River Systems. Tables RI-7 and RI-8 indicate the proposed reservoirs and accompanying statistics; the list was prepared in downstream order. As indicated in the tables the Colorado River Water Conservation District holds the decrees for several of the reservoirs, although the individual projects may have been proposed by various smaller water conservation districts.

Some projects indicated above are being pursued actively while others are inactive presently. Those in a more active status are:

1. Yamcola: funding is being sought;
2. Juniper - Cross Mountain: funding is being sought; electric power from this complex would probably be purchased by Colorado-Ute Power Company (see Figure RI-4);
3. Savery-Pot Hook: initial funding is available to the U.S. Bureau of Reclamation for this project;
4. Rangely Reservoir: Moon Lake Power Company has issued a letter of intent to purchase a block of storage from this project; the Reliable Coal Company is also committed to a block of storage.

TABLE RI-7

Proposed Reservoirs in Yampa River Basin

Reservoir	Stream	Capacity Acre-Feet	Principal Use	Decree Held By	Date of Decree
Yamcola	Bear River	6,500	Irrigation	CRWCD 1/	2/26/63
Bear	Yampa River	11,600	Irrigation	CRWCD	9/30/61
Blacktail	Yampa River	229,000	Power	RMPC 2/	1/16/66
Pleasant Valley	Yampa River	43,200	Irrigation	CRWCD	6/29/59
Wren	Fish Creek (Yampa)	2,200	Irrigation	-	9/15/69
Hinman Park	Elk River	44,000	Power	PSC 3/	8/4/64
Trout Creek	Trout Creek	23,300	Power	RMP	4/28/67
Dunckley	Fish Creek (Trout)	57,100	Irrigation	CRWCD	7/20/63
Twenty Mile	Fish Creek (Trout)	15,300	Irrigation	J.E. Lutrell	7/22/61
California Park	Elkhead Creek	36,000	Irrigation	CRWCD	8/7/62
Rampart	Fortification Creek	12,100	Irrigation	CRWCD	8/7/62
Craig	Yampa River	44,500	Power	UC & MC 4/	-
Thornburgh	Milk Creek	31,800	Irrigation	YJCD 5/	8/7/62
Juniper	Yampa River	1,080,000	Power	CRWCD	6/8/54
Cross Mountain	Yampa River	142,000	Power	CRWCD	12/-/74
Pot Hook	Slater Fork	65,000	Irrigation	CRWCD	-
Savery	Savery Creek	18,600	Irrigation	CRWCD	-
Total		1,862,200			

1/ Colorado River Water Conservation District

2/ Rocky Mountain Power Company

3/ Public Service Company

4/ Utah Construction and Mining Company

5/ Yellow Jacket Conservancy District

Note: Information contained in these tables was obtained from the Colorado River Water Conservation District.

TABLE RI-8

Proposed Reservoirs in White River Basin

Reservoir	Stream	Capacity Acre-feet	Principal Use	Decree Held By	Date of Decree
Ripple Creek	NF White River	28,000	Irrigation	YJCD 2/	11/9/53
Lost Park	Lost Creek	33,500	Irrigation	YJCD	11/9/53
Rangely Reservoir	White River	63,000	Power	CRWCD 3/	11/21/66
Total		124,500			
Powell Park	White River 1/	76,000			

1/ Would substitute for Ripple Creek or Lost Park Reservoir
2/ Yellow Jacket Conservancy District
3/ Colorado Water Conservation District

Total storage in the proposed reservoirs in the Yampa River System is 1,862,200 acre-feet, and in the White River system, excluding Powell Park Reservoir, 124,500 acre-feet. The requirements for the Yampa system, 1,862,200 acre-feet, are greater than average state line discharge for the Yampa River, 1,502,900 acre-feet for 1943-60. However, the several reservoirs will not all be constructed at the same time and will not be filled to capacity at the same time. The water will be used and reused as it flows through the system.

Recreation Designations

Currently no designated Wild and Scenic Rivers occur in the study area. Refer to Regional Analysis, Chapter IV, Present Environment Recreation

FIGURE RI-4

View looking upstream toward proposed Juniper Dam and Reservoir site.

Resources -- Recreation Water Resources, for the status of Wild and Scenic River proposals.

Refer also to Regional Analysis, Chapter IV, Present Environment -- Recreation Resources -- Primitive - natural values, for a discussion of present Wilderness and Primitive areas as well as wilderness proposals.

Refer also to Regional Analysis, Chapter IV, Future Environment Without the Proposals, for a discussion of other recreation projects or developments proposed for the region.

County Zoning and Master Plans

In the three-county study area, it is generally true that developments resulting from the major Federal actions addressed herein are subject to local land use rules and regulations set forth in county zoning resolutions. The customary zoning ordinances are intended to control population density, to regulate building and lot sizes, to set minimum building construction standards, to insure provision of adequate public works (water systems, sewage disposal, street lighting, etc.), and generally to promote the quality of life in counties.

Zoning regulations are tools by which county governments can regulate and control patterns of growth. Long-term objectives and guidance in the application of these tools are often provided by a county master plan which assesses the existing and future economic structure of a county and suggests means by which the county can accommodate its economic and social goals in an orderly manner. Such master plans are commissioned by local governments and usually prepared by a planning consultant.

Growth implies change; in the county's case it implies changing land-use patterns. These changes can be accommodated in the county planning process by careful designations of zoning districts prior to the actual demand for new land-use patterns. The development of coal resources in northwest Colorado presents a case of anticipated growth. It can be expected that this development will present difficult rezoning and zoning variance questions, especially in agricultural districts. In order to assess these potential problems, a brief discussion of each county's zoning resolution and master plan follows.

Moffat County

The Moffat County Zoning Resolution, adopted by the County Commissioners in 1962, provides for nine land-use districts. The official zoning map is filed in the County Clerk's Office in Craig. Table RI-9 presents the acreages associated with each of the nine zoning districts.

Table RI-9

Moffat County Zoning Districts

District	Acres
Agriculture	3,306,254
Rural Residence	--
Low Density Residence	262
Medium Density Residence	251
Rural Highway	144
Business	101
Industrial	115
Heavy Industrial	407
Open	394
Incorporated Towns	
Craig	1,863
County Total	3,309,791

SOURCE: Planimetric measurements of zoning map.

The zoning resolution is administered by the Zoning Enforcement Officer, appointed by the County Commissioners. It is his duty to issue building permits, including those for surface structures associated with coal mining development. Moffat County has not yet adopted the Uniform Building Code. Additionally the Zoning Enforcement Officer issues "Certificates of Occupancy" prior to the occupancy of any new building or new use of any land.

The Board of Zoning Adjustment is empowered to interpret the Zoning Resolution and "to grant variances from the provisions" of the Resolution. As a general rule variances would not be used to accommodate coal mining development.

Of the nine districts, coal mining is an identified use in two districts. The Heavy Industry district specifically allows for "coal or coke manufacture, mining or processing," while the Open Use district allows for "mines and quarries." Upon written approval of the Planning Commission, "mines and quarries..." are permitted in the Agricultural and Rural Highway districts.

Looking at coal transportation, "railroads, not including repair shops and/or switching yards" are identified uses in the Agricultural district. "Railroad facilities, including repair sheds and switch yards" are allowed in the Heavy Industry district.

In order for coal mining developments to be allowed in districts other than those mentioned above, the zoning map must be amended. The principal authority to approve such an amendment lies with the Moffat County Commissioners. Any zoning amendment proposal is first reviewed by the Planning Commission, which may require public hearings. After receiving the Planning Commission's recommendation, the County Commissioners must hold a public hearing on the issue. The amendment is adopted after a majority vote of the Commissioners.

Recognizing the changing land use goals within Moffat county, the Moffat County Commissioners have ordered the preparation of a new master plan, which is scheduled for completion in September 1975. Following the adoption of this plan, a new zoning resolution will be prepared to implement the goals of the new plan; this resolution is expected to be adopted early in 1976.

Rio Blanco County

The zoning ordinance for Rio Blanco County was adopted in 1974. Like Moffat County, there are nine zoning districts which are officially recorded in the County Clerk's Office. Table RI-10 indicates the acreage associated with each of these districts.

Administration of the Rio Blanco County zoning ordinance is the responsibility of the Zoning Enforcement Officer. However his responsibilities are limited compared to his counterpart in Moffat County. Building permits are issued by a building inspector after proof of compliance with the Uniform Building Code. Rio Blanco County does not require certificates of occupancy. The duties and powers of the Board of Zoning Adjustment are similar to those of the Moffat County Board.

With the exception of allowing "mineral research sites" in the Heavy Industry district, coal mining is not identified as a "use-by-right" in

TABLE RI-10

Rio Blanco County Zoning Districts

District	Acres
Agriculture	2,200,682
Rural Residence	-
Residential (Single Family)	1,238
Multi-Family Residential	-
Highway Business	326
Business	-
Light Industrial	1
Heavy Industrial	994
Open Use	154
Mobile Home Park	-
Incorporated Towns	
Meeker	567
Rangely	793
Rio Blanco	5
County Total	2,204,761

SOURCE: Planimetric measurements of zoning map.

any of the nine zoning districts; therefore, a conditional use permit must be obtained before any mining could proceed. Coal mining is identified as a conditional use in the Agricultural and Open districts. After mandatory public hearings, the Planning Commission makes its recommendation on the application for a conditional use permit to the Board of Rio Blanco County Commissioners. After additional mandatory public hearings, the approval of the conditional use permit is subject to the majority vote of the commissioners.

A master plan for Rio Blanco County is currently under preparation by a planning consultant and is expected to be completed by mid-1976.

Routt County

The Routt County Zoning Resolution was adopted in its basic form in March of 1972. The resolution provides for five basic zoning districts, each of which are further subclassified into combinations of 14 second-level zoning districts. Each of these 14 second-level zoning districts has distinct land use and building standards. Table RI-11 presents the second-level zoning districts, and the acreages associated with each of these classifications.

Enforcement of the resolution is the responsibility of the Building Inspector who issues building permits prior to the construction of any new building and certificates of occupancy prior to occupancy of any new building. The Board of Adjustment is empowered to interpret the zoning resolution and to authorize variances relating to mobile home regulations, sign regulations, minimum lot standards, and certain building standards.

TABLE RI-11

Routt County Zoning Districts

District	Acres
Agriculture and Forestry	1,676,024
Mountain Residential Estate	1,075
Mobile Home Residential	14
General Residential	15
Low Density Residential	570
Medium Density Residential	-
High Density Residential	203
Commercial	5
Commercial Center	-
Industrial	106
Mining	10,000
Outdoor Recreation	1,069
Flood Channel	-
Planned Unit Development	427
Incorporated Towns	
Steamboat Springs	1,841
Oak Creek	20
Yampa	5
Hayden	80
County Total	1,691,454

SOURCE: Planimetric measurements of zoning map.

Of the 14 second-level zoning districts, mining is a "use-by-right" only in the Mining district. Mining may be allowed in the Agriculture and Forestry district and the Flood Channel District after the issuance of a Special Use Permit, a temporary license for land use other than that of the zoning district. Issuance of such permits is within the discretionary powers of the Board of County Commissioners. The Commissioners must review the recommendations of the Planning Commission. Public hearings on the contemplated mining development must be held before both the Planning Commission and the County Commissioners. Before the issuance of any Special Use Permit for mining, the applicant must post a performance bond "...in an amount calculated by the County Commissioners to secure the site restoration..."

Amendments to the Zoning Map are processed in essentially the same manner as in Moffat county. Recently, several requests for coal mining zoning variances have been reviewed by the Routt County Commissioners. While the Special Use Permit may give the commissioners more management prerogatives, they have in most cases opted for amendments to the zoning map, a relatively permanent designation. A master plan for Routt County is in the final stages of preparation and is expected to be completed in the very near future.

Chapter II

Typical Development Operations

THIS CHAPTER DESCRIBES VARIOUS ACTIVITIES THAT ARE TYPICALLY ASSOCIATED WITH COAL DEVELOPMENT IN NORTHWEST COLORADO. THESE DESCRIPTIONS WILL BE HELPFUL WHEN READING LATER CHAPTERS REGARDING ENVIRONMENTAL IMPACTS AND MITIGATING MEASURES.

CHAPTER II

TYPICAL DEVELOPMENT OPERATIONS

Coal Mining

Exploration, development, production, and reclamation are the four major operations involved in coal mining. One additional operation, beneficiation, is undertaken if the coal mined contains excessive impurities and requires cleaning before being marketed. No beneficiation plants are currently operating in northwest Colorado, nor are any plans for construction and operation of such plants known.

Exploration

Exploration aims at locating economic deposits and determining their nature, shape, extent, and grade. The investigation may be divided into two parts: (1) preliminary or prospecting, and (2) final or development exploration, which often overlap. Locating the presence of a coal deposit is considered as preliminary exploration; establishing it as an economic deposit by its nature, shape (size), and grade is considered final exploration.

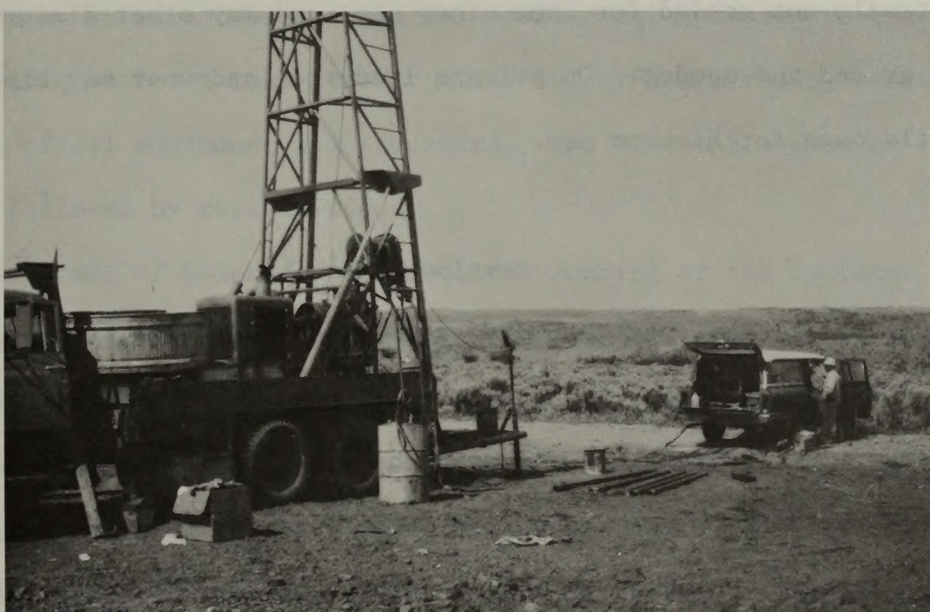
An accepted method of exploration is to first search published reports to determine the geology, previous discoveries, surface and mineral ownership, and access routes in the general area. This is followed by a geologic reconnaissance to select the logical location(s) for detailed geologic study and exploratory holes. Such reconnaissance may require the use of an airplane or helicopter in addition to walking the area. After establishing the location(s) for detailed exploration, permissions, permits, and leases must be obtained, after which detailed geologic exploratory work may begin.

The nature of the overlying strata, depth, and thickness of the coal deposit, and quantity of ground water are determined from detailed geologic mapping and drill-hole data. Coal and water samples from the drill hole are analyzed to determine the grade of coal and quality of ground water. A number of exploratory holes are required to delineate the shape of the deposit for determination of its size and boundaries.

Exploratory drilling is generally done with truck-mounted rotary rigs (see Figure RII-1 a,b); these rigs can provide cuttings or core samples, or both. In addition the hole can be electrically logged to determine coal horizons. Electric logging is a method whereby overburden and coal horizons can be determined by lowering an instrument down the drill hole to measure electric resistivity, gamma ray absorption, and gamma ray emission. Additional equipment used by an exploration crew may include water trucks, personnel carriers, a hole-logging equipment truck, and a bulldozer 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. Drill hole sites often require some leveling and other preparation with a bulldozer to accommodate the drill rig and related equipment. Drill sites average 100 feet in diameter.

Federal regulations require that all aquifers and workable coal beds encountered in drilling be protected from contamination by oil, gas, water, and other fluid substances, and that drill holes be suitably abandoned. Requirements for abandoning drill holes and protecting aquifers and coal

a



b

FIGURE RII-1

Truck mounted rotary rig.

beds are formulated by each Area Mining Supervisor of the USGS for his area. The requirements in northwest Colorado are that aquifers and coal beds be cemented off for 20 feet above and below the aquifer or coal bed. A concrete plug is required to be placed in the collar of each hole, and heavy mud, drill cuttings, or concrete in the remainder of each hole. Disposal of cuttings and reclamation of the drill site are also required. Occasionally during exploration, pits or trenches are dug with a backhoe or dozer to locate the coal outcrop. On federally owned land and/or coal deposits, regardless of the method of excavation, any exploratory pit or trench or disturbances associated with drilling must be backfilled and the surface graded and seeded.

Upon completion of exploration on federally owned land, all dozed or bladed trails not needed for some other use, and any other disturbed surfaces, must be graded and seeded. On private land the landowner may elect to keep the trails open for his own use.

Development

Development, the operation preparatory 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 development cannot begin until all necessary arrangements have been made with Federal, State, and local governments, as well as with any private owners of surface and mineral rights. Such arrangements include the obtaining of a lease and 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 in Chapter I of the Regional Analysis. Permits and licenses are requirements of State and local authorities. The Colorado Division of Mines requires, in addition to a fee, an approved mining and reclamation plan, before a permit to operate a mine is granted. The three northwest Colorado counties require a Special Use Permit if the land is zoned for some use other than mining, or a zoning amendment to change the designation to mining, prior to issuance of a license.

Obtaining access to the mine property is usually the responsibility of the lessee. The Federal Government requires that a bond be posted to insure payments of rent and royalties, and restoration of the land as mining progresses. When a coal deposit has been mined by underground methods, surface restoration involves 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 surface methods, bonding assures removal of all equipment and structures, and acceptable grading of the spoil, followed by revegetation.

The State of Colorado also requires bonding of the operator to assure reclamation of the mined land. The amount is based on the number of acres that will be disturbed in one year; the bond remains in force until the disturbed land is reclaimed.

Planning is the first stage of development; for a successful operation it must include all details of how the development work is to be accomplished, the mining method, the mining equipment, plans for restoration of the land, and prevention of air and water pollution, and a map depicting the sequence of proposed mining and land reclamation. Development drilling is often done at this stage to gain additional data.

Development of a mine includes construction of roads for access to selected sites on the mine property and to the coal deposit, utility lines, and mine plant. A mine plant might include a tipple, coal storage facilities, 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 installed on the surface at underground operations.

Construction of a railroad spur may be required depending on the amount of coal produced annually and where it is to be used. For coal that contains excessive impurities, a washing plant could be constructed as part of the mine plant. If the coal is to be mined by underground methods, the mine plant is commonly constructed near the portal of the main drift, slope, or shaft. For coal mined by surface methods the mine plant should be off the coal deposit if possible.

Access to the coal deposits at an underground operation is provided by either drifts, slopes, shafts, or a combination thereof. The coal seam is developed for further operations by driving entries with electrically powered equipment.

For surface mining, gaining access to the coal seam(s) is part of the development phase. This includes construction of main haul roads from the tipple to the mining area, secondary roads from the haul roads to the overburden removal and coal loading areas, electric powerlines from the substation to the mining area, and gasoline and diesel fuel storage facilities. It also includes the assembly of large equipment such as 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 powerlines, and constructing new roads to provide access to the working face.

Production Methods

Production is defined as the yield or output of a mine. For a mine to succeed it must operate at a profit, and this profit is gained only through efficient production. However 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 was passed to protect miners, while air and water pollution and land reclamation laws were passed for the protection of the public. In addition aesthetic values must be considered, and coal should be mined with the least possible waste of the resource. The production methods discussed in the following pages are limited to those now in use in northwest Colorado and those deemed technically feasible in the area.

Underground mining

In underground mining after the initial development has gained access to the coal seam, one of three methods is commonly used to extract the coal: room-and-pillar, longwall, or shortwall. All of the underground mines presently operating in northwest Colorado use the room-and-pillar method, as will the underground mine proposal submitted by Ruby Construction Company that is addressed elsewhere in this EIS. In any of these underground mining methods, surface subsidence may generally be anticipated; 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 later. This unpredictability could preclude some types of productive surface uses for many years. Because there are at present no firm plans to employ shortwall or longwall systems in northwest Colorado, and because impacts of all three methods on the land surface are virtually the same, no discussion of longwall or shortwall methods will be undertaken here. Refer to the Environmental Impact Statement for the Proposed Federal Coal Leasing Program for a detailed description of each of the three underground mining methods. Only a limited description of room-and-pillar mining will be presented.

Room-and-pillar mining has been used in the United States longer than any other underground method. Mining is accomplished by driving section 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. Entries are typically driven 20 feet wide; coal pillars are generally rectangular and 80-120 feet on a side.

When subsidence of the ground is permissible, the coal pillars and coal barriers between sections can often be removed, which allows the roof to collapse after the mining operation. So-called "Pillar" mining can only be done in an area where the surface use will not be seriously affected by subsidence. Where all of the pillars in the panel area can be recovered, the surface over the panel should subside uniformly. Pillar mining allows for greater recovery of the resources, lessens the potential of fire in remaining coal, and generally provides a greater area of uniformity in the subsided surface.

Subsidence is defined as "the sinking, descending or lowering of the surface of the ground" (Cummins and Given 1973). Other than the previously described mine plant facilities, subsidence is the primary source of surface disturbance resulting from underground mining. Subsidence results from the void which is created following the removal of a substantial quantity of underground material; it begins as soon as sufficient material has been removed. The roof or overlying material falls into the mine void, and cracking and caving may then progress upward, at times reaching the surface. Subsidence at the surface may result in excessive damage in highly developed urban areas; other types of land use are usually less severely affected.

The major physical factors that have been identified by Cochran (1971) which affect the amount and manner of subsidence are: (1) vertical dimension or height of void, (2) lateral dimensions, or length and width of void, and (3) depth below the surface. Other factors identified by Cochran which affect subsidence include: (1) characteristics of the overburden, including faults, joints, and lithology, (2) size, character, and distribution of support pillars, (3) amount and method of backfill, (4) surface topography, and (5) effect of ground water on subsurface rock movement.

Earth movements at the surface may result in many different types of damage. Some of these types identified by Cochran (1971) are as follows:

> Building foundations and walls may be cracked and displaced. Railroad tracks may be pushed out of alinement. Highways may crack and deteriorate, or they may subside unevenly to create a roller coaster effect. Bridges may not properly meet the adjoining roadway. Water and gas lines may be ruptured. The flow of sewage lines may be reversed. Smoke stacks may be tilted, and other industrial equipment or plants sensitive to slope may be affected. Natural drainage may be obstructed or altered to form swamps. Structural

failure may be induced in dams. Water channels such as canals may be rendered useless, and ground water supplies may be lost through subsidence-induced fracturing of the overburden.

In the three county study region of northwest Colorado, all of the current and proposed underground mines, as well as most of the potential underground mining occurs outside urban areas. Generally, because the severity of surface damage is largely dependent on the nature of surface improvements, underground mineral extraction in rural areas has only minor effects on surface values. Most of the land underlain by coal in northwest Colorado may be classified according to use: (1) cropland, with highest values, (2) grazing land, with a lesser value, and (3) forest and unused land, with least value. In the study area, forest land has not been adversely affected by mine subsidence. Damage to cropland has generally been limited to local depressions or cracks in the surface which can be either accommodated or corrected at nominal cost. However land which has been undermined may incur a loss of ground water supply; although this has little effect on forest land or cropland, it does have an impact on land used for grazing. Livestock ranches may suddenly lose their supply of water from wells, springs, and ponds. Depending on many factors, the loss may be permanent or the supply may return over an indefinite period. The loss of ground water presents two alternatives: (1) either acquire another source by drilling deeper wells, building reservoirs to store surface runoff, or transporting water from another area, or (2) let the land revert to a lower form of development - forest or unused land - with a resultant loss of value.

Because of the many variables involved, a representative recovery rate for room-and-pillar mining is difficult to calculate. Factors significantly affecting recovery percentages are: (1) extent to which a pillaring system is used, (2) top rock and conditions, (3) bottom rock and conditions, (4) marketability, (5) coalbed thickness, and (6) productivity. Lowrie (1968) determined recovery percentages within mined areas of 200 representative underground coal mines. Recovery ranged from 29-91 percent and exhibited a frequency distribution curve that was bell-shaped, or about normal. The average recovery rate was 57.0 percent.

Little or no reclamation has been applied to disturbances associated with underground mines in the past. This is no longer acceptable; Federal coal leases require reclamation of current mines when they are abandoned.

Reclamation of underground mines usually involves removal of all equipment and facilities, and regrading and reseeding of disturbed areas. All surface openings are permanently sealed and subsidence holes filled in.

Section 5 of the Federal coal lease, 43 CFR subpart 3041, and 30 CFR Part 211 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 gives the mining supervisor the authority to see that air and water pollution and land erosion are prevented, other natural resources protected; surface mined land reclaimed according to plan and maintained and protected until reclamation is complete; all surface openings and subsidence holes filled in, closed, or barriers installed; all underground openings permanently sealed; and all surface structures removed and the mine site cleaned up, including reclamation of refuse piles, before termination of the lease.

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.

Surface mining

Strip and auger mining are the two most common surface methods of extracting coal in the United States. In addition to these methods, one other is considered practical in northwest Colorado: open-pit, where numerous pitching seams lie parallel to each other.

Strip mining

Strip mining is accomplished by two techniques: area stripping and contour stripping. Where coal seams are relatively flat and near the surface, and extend over large acreages, as in much of the west, area stripping is the dominant technique. Three of the proposed surface mines addressed in this impact statement will use area stripping methods. No description of contour mining will be presented as none of the mines in northwest Colorado employ this method, nor is its use envisioned.

Prior to initial mining in any area, all suitable soil material capable of sustaining plant growth is removed and stored for eventual redistribution during land reclamation. Topsoil covering initial pits, boxcut overburden areas, and roads will be stockpiled away from the coal outcrop in areas that will not soon be disturbed by mining or covered with overburden. The topsoil initially removed from mine areas and facility sites will probably be stockpiled for an extended period of time and will be graded and seeded to reduce erosion.

Topsoil removed in advance of mining, except for that initially stockpiled, will be placed directly onto the newly graded spoils; this will reduce the amount of soil material that must be stockpiled and rehandled and will spur the revegetation cycle. Soil material from stockpile areas will be used when direct placement cannot be done, and will ultimately be used to cover the areas disturbed by the final cuts and highwall sloping operations.

The nature and thickness of suitable soil material is determined by detailed soil surveys of prospective mining sites; grading and topsoil replacement plans are based on these data.

Following removal of the topsoil, the earth and rock overlying the coalbed (overburden) are excavated. In area strip mining, this overburden is removed in long narrow parallel bands or strips, after which the exposed coal is removed. With the exception of the first cut (boxcut), overburden from each cut is cast into the previous cut from which the coal has been removed. Overburden from the boxcut is placed on land from which the soil material has been removed, but which is otherwise undisturbed, and is located outside of the area to be mined. 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 RII-2 depicts a cross-section and plan of a portion of a strip coal mine. Both single and multiple seams near the surface can be mined in this manner.

Most strip mine operators drill and blast overburden material so it can be more easily and efficiently handled. Bulldozer-equipped crawler tractors prepare a bench for drills at approximately the desired width of cut. Then blast holes are drilled on a predetermined pattern to a depth near the top

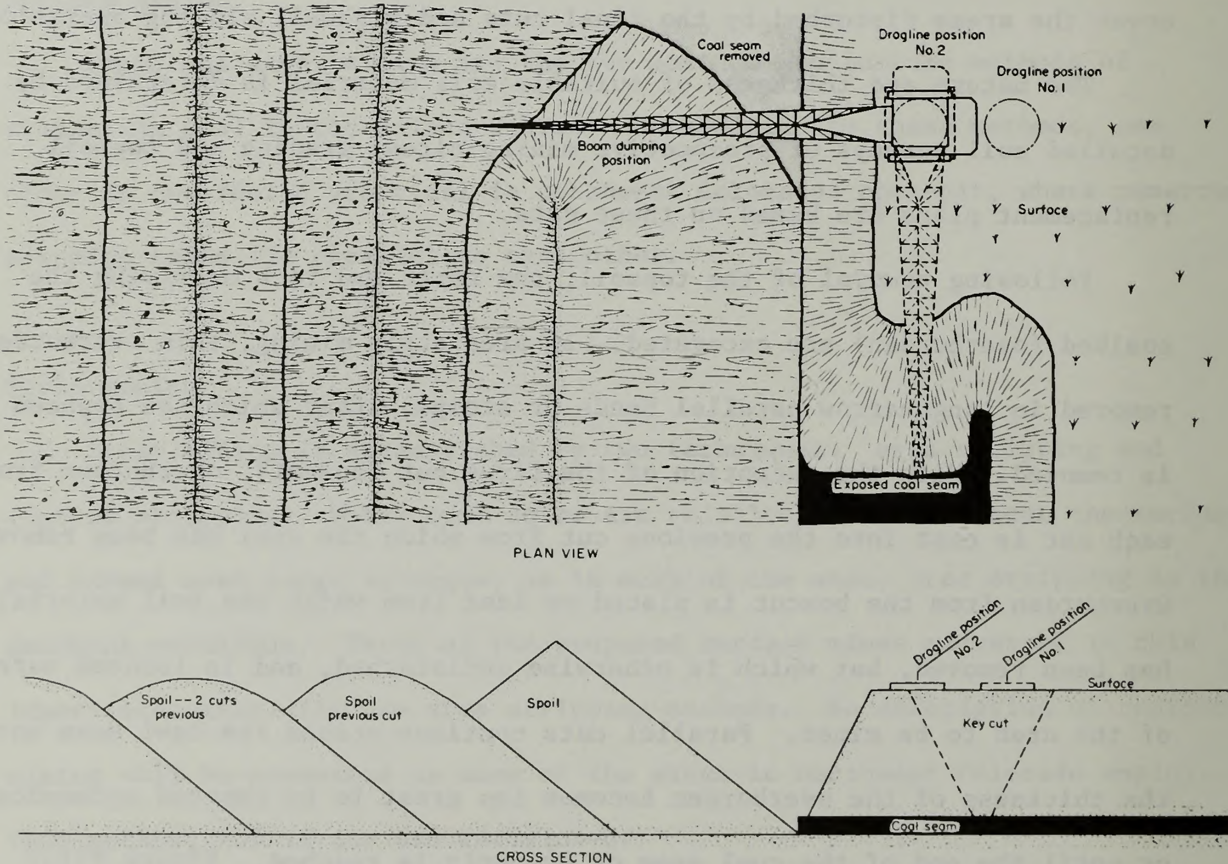


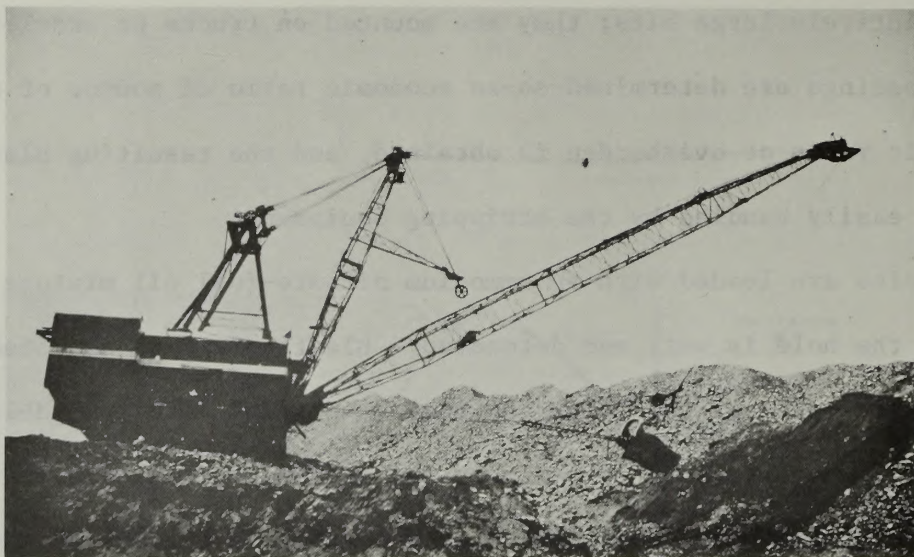
FIGURE RII-2

Cross-section and plan view of a strip coal mine.

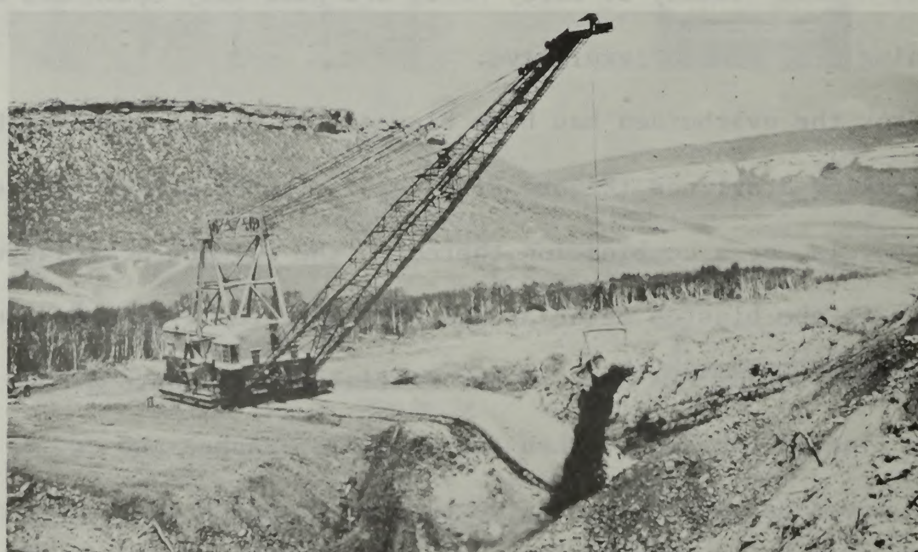
of the coalbed. Overburden drills are generally electrically powered and use relatively large bits; they are mounted on trucks or crawlers. Drill hole spacings are determined so an economic ratio of pounds of explosive to cubic yards of overburden is obtained, and the resulting blasted material can be easily handled by the stripping equipment.

Holes are loaded with an ammonium nitrate-fuel oil mixture, or water-gel if the hole is wet, and detonated. Blasting can be expected on a daily basis, generally in the afternoon between shifts. Electric delay blasting caps are generally used to maximize the breaking effect and minimize seismic shock. The amount of explosive used in each hole depends on the depth and size of the hole, the nature of the overburden material encountered, the location of the various strata that must be broken, and the spacing of adjacent holes. Twenty to fifty holes are generally detonated at one time containing 5-20 tons of explosive.

After the overburden has been blasted, it will be removed by either large walking draglines (Figure RII-3 a,b,), rubber-tired scrapers and power shovels, or a combination thereof. The walking dragline will move adjacent to the blasted material and will cast the overburden into the previous pit, or in the case of the initial boxcut, onto ground outside the outcrop line of the coal. When the dragline reaches the end of the pit it will be moved back to begin the next cut. Scrapers and trucks move overburden to previously undisturbed ground or return it to mined-out pits. Parting material lying between coal seams can be removed with scrapers, front-end loaders and trucks, or draglines.



a



b

FIGURE RII-3

Walking draglines in operation in northwest Colorado.

Once the coal is uncovered, it will be cleaned of any extraneous material and slack coal by a bulldozer-equipped crawler tractor or road grader, then drilled and blasted. Broken coal will be loaded by front-end loaders or electric crawler-mounted shovels into coalhaulers (Figure RII-4) and taken from the pit to receiving hoppers (Figure RII-5) at the primary crusher. Bucket capacities of coal-loading shovels and front-end loaders commonly range from 10-20 tons, and coal haulers range in capacity from 40-200 tons. Figures RII-6 and RII-7 give different views of shovel and front-end loader operations for coal removal.

Recovery rates for the area strip mining method generally range from 85-95 percent. Area stripping should continue to be the dominant form of surface mining in the area.

Auger mining

Auger mining consists of 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 triple, 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. Highwall stability problems and subsidence are created by auger mining. Recovery rates of that portion of a seam mined are commonly only 30-40 percent. Auger mining has been used in the past in the tri-county area of northwest

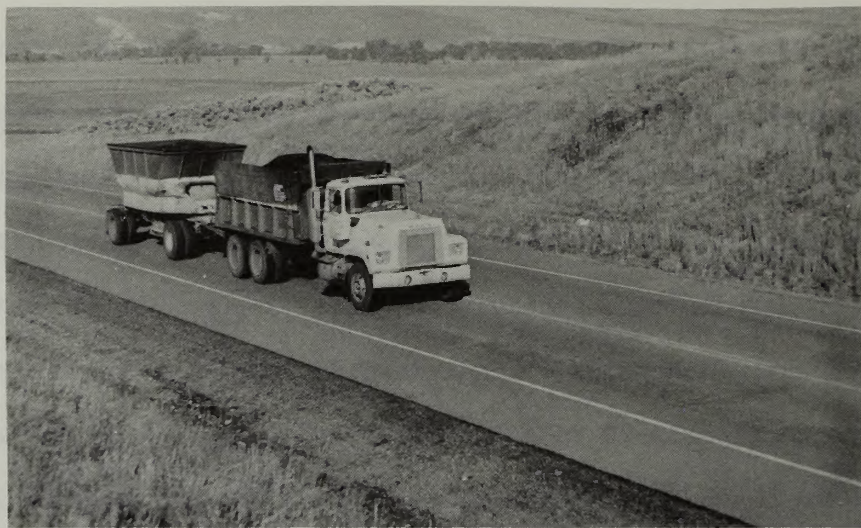


FIGURE RII-4

On-highway coal hauler.

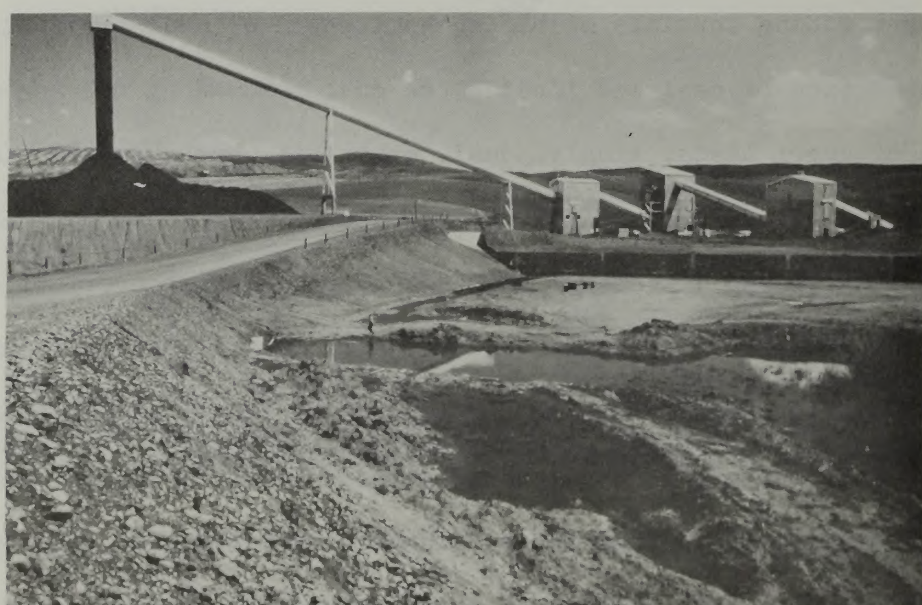


FIGURE RII-5

Receiving hopper, crusher, tipple and load-out facilities of Energy Fuels Corporation.

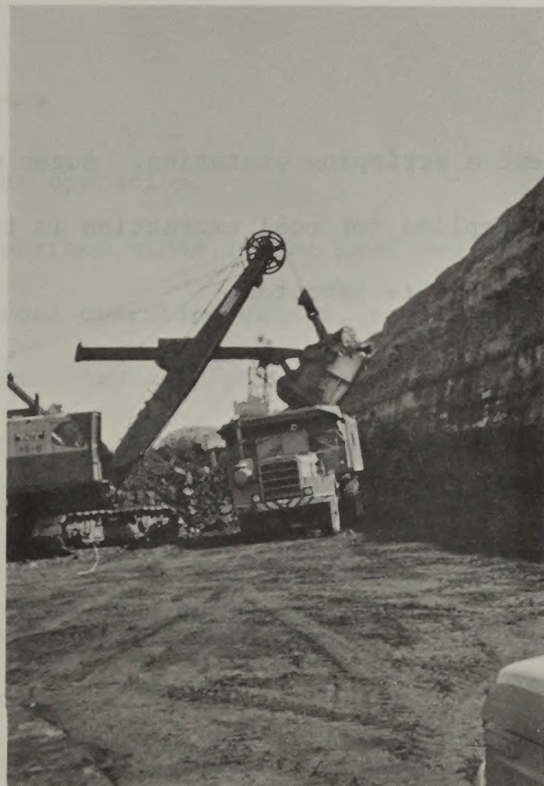


FIGURE RII-6

Power shovel removing and loading coal.

FIGURE RII-7

Front-end loader removing and loading coal.

Colorado to supplement a stripping operation. Auger mining methods could again conceivably be applied for coal extraction in the area; however only limited use of this method is expected.

Open-pit mining

In open-pit mining overburden is removed and placed outside the mining area. As mining progresses, the pit increases in size and depth, and overburden is either returned to the mined-out pit, or more commonly continued to be placed elsewhere.

This method is used extensively for mining ores of copper and iron, uranium, and sand and gravel. 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 can be removed with either scrapers or shovels loading into trucks. Coal is loaded into coal haulers and taken to the tipple. Open-pit mining of coal offers a much greater opportunity for returning overburden material to the worked-out pit than of copper, uranium, etc.

The truck and shovel operation for overburden removal is conducted on benches 35-50 feet high in the blasted overburden. Electric crawler-mounted shovels load overburden into off-highway trucks for transfer to spoil disposal area. Coal is loaded in a similar manner as in a strip mine. The major advantage of this system is the great flexibility for placing the overburden exactly where desired. Recovery rates for open-pit mining of coal generally average 90-95 percent. One of the proposed mine operations analyzed in this statement will use open-pit mining methods.

Reclamation at surface operations

Reclamation of surface mines in the past has ranged from nothing to very little; when a coal operation ceased, equipment of value was removed, and the site abandoned. Any attempt to restore an area was done after the mine was abandoned and did little to lessen the visual impacts of the mining operation or return the area to production. That practice is no longer acceptable; Federal coal leases require concurrent reclamation of mines, and several States have mined-land reclamation laws that require reclamation on private or state lands.

No industrial operation can restore a site to the exact original condition; however the impacts can be greatly reduced by a comprehensive reclamation plan. Therefore present reclamation of a site generally consists of making it safe, acceptable in appearance, and available for other uses, including planned improved uses.

Section 5 of the Federal coal lease, 43 CFR subpart 3041, and 30 CFR Part 211 gives the mining supervisor or his agent the authority to approve or disapprove a lessee's surface protection plans; the supervisor is responsible for the plans being carried out. This in effect gives the mining supervisor authority to see that air and water pollution and land erosion are prevented, that other natural resources are protected, and that surface mined lands are reclaimed according to plan, and maintained and protected until reclamation is complete.

The Colorado Open Mining Land Reclamation Act was passed in 1969 and amended in 1972 and 1973. The law defines reclamation as "the employment during and after an open mining operation of procedures reasonably designed to minimize as much as practicable the disruption from the open mining operation and to provide for the rehabilitation of any surface resources adversely affected." The law requires that reclamation be concurrent with the mining operation, and be completed in three years. Ridges and peaks are to be not less than 15 feet wide, the objective "even or gently undulating skyline". Land use and revegetation plan for reclamation is determined by the operator and approved by the Land Reclamation Board. Further guidelines are established for reclaimed planning including forest, range, recreation, agriculture, and other intensive uses. More detail on requirements for reclamation and for protection of natural resources in and surrounding the mine area can be found in the Mitigating Measures Required by Law or Regulation section of Chapter VI of this statement.

Since the passing of current legislation, as mining companies seek leases and/or permits for new mines or expansion of current operations, they must comply with current regulations, and reclamation will become more uniform from mine to mine. Reclamation procedures of current mining operations in northwestern Colorado generally consist of regrading the spoils to approximate natural terrain and revegetation, by drilling or aerial broadcasting a variety of plant species (usually consisting of two to ten grass species, and one to three legume species.)

As land use objectives expand, laws and regulations are more strictly enforced, reclamation becomes an integral part from the beginning of the coal operation, and new reclamation techniques are developed, reclamation will become more uniform, and therefore easier to describe.

Railroads

The need for a railroad, approximate location, and load requirements can evolve in the development planning for a specific, or group of specific, energy projects in an area. During this reconnaissance stage of planning, considerations are given to such things as available rail service, transportation regulations, and cursory economic viability of a new rail line. Provided that the railroad is desirable and potentially possible, the study progresses into formal preconstruction phases of development.

Preconstruction

The preconstruction phase can be divided basically into three parts: feasibility studies which generally requires from six months to one year to complete, environmental studies, and preconstruction investigations and design, which may require up to two years to complete. Time requirements vary depending on the magnitude of the proposed railroad project and the complexity of problems encountered during planning.

The feasibility stage is primarily an economic study of all possible routes and provides comparisons such as survey grade, structure requirements, conflicts with existing facilities and utilities, construction restrictions and costs, rights-of-way lengths, availability of construction materials, and preliminary geologic investigations.

Generally another product of this study is the identification of possible major environmental considerations. The environmental studies analyze the total spectrum of the environment, and combined with the feasibility study result in final route selection.

Following route selection, preconstruction investigations continue and include foundation investigations, detailed line and grade surveys, construction material investigations, etc; these lead to final design for the railroad. This phase also includes rights-of-way, and necessary borrow material acquisitions, and ordering of materials, which may require as much as 18 months for delivery (W. R. Grace Railroad Feasibility Report 1975).

After final engineering design and preparation of construction specifications and contract, the railroad sponsor generally solicits competitive bids from construction contractors, and awards the contract timed to coincide with materials delivery.

Construction

Construction begins with access roads and clearing of rights-of-way. All areas to be excavated or covered by fill are stripped of vegetation and foreign matter. As soon as it is cleared the alinement is surveyed and grade-staked preparatory to actual construction.

Excavation and fill operations, structure construction, such as bridges and under-overpasses, and relocation of existing facilities can be done simultaneously. However in cold climates the compacted embankment-fill operations must be discontinued during the winter months. In this region completion of 12-15 miles of railroad/year would probably qualify as good progress for an average contractor.

Typically, while bridges and other structures are being constructed, excavation of cuts, both rock and common, and construction of embankment-fills up to subgrade level would be going on all along the alinement. The fills, composed as much as possible of cut material, are placed in 12-inch moisture controlled lifts that are roller (sheepsfoot) compacted. Next ties are placed on the subgrade; rails are placed; and select gravel ballast is placed over the ties up to the top of the rails. The rails with ties attached are then lifted up while the ballast is compacted around the ties. Suitable riprap, either from rock cuts along the line or from borrow areas, is then placed along the embankment in areas subject to erosion or otherwise in need of armor protection. During operation railroad crews perform track inspection, maintenance, snow removal, and emergency repairs.

Generating Plants

Preconstruction

Land acquisition and plant design begin after economic analyses prove favorable. A typical coal-fired plant needs about two acres of land per megawatt of power generating capacity. This rule of thumb depends somewhat on the cooling method used by the plant (cooling ponds need large areas to be effective). The water requirements are lower than the rule of thumb for large multi-unit plants, where facilities for additional units are shared. Plant design involves several main functions: (1) fuel handling, (2) power generation, (3) cooling, (4) waste treatment, (5) transformers and switching, and (6) office and maintenance service.

Fuel handling.

Regardless of the method for getting fuel to the plant (rail, conveyor, etc.), bulk receiving and storage areas are needed on the plant site. A typical system provides for crushing and sampling the coal before it is transferred by conveyor to storage piles of known quality. Designs include dust control measures during the active processes of crushing and transfer. Spraying with water and a wetting agent controls dust during storage. Fuel oil for start-up operations is stored in small quantities. Coal is blended for uniform quality and moved to the boilers by conveyor. Most conveyors are now covered for efficiency and dust control.

Power generation

A structure is required to house the steam-generating boiler and steam-driven turbines that are the heart of the generating system; this normally is the largest building on the plant site. Boilers are designed for minimum NO_x emissions from the combustion process and for maximum efficiency of conversion of water to steam. Turbines are designed to most effectively utilize steam expansion and heat to impel electricity-producing generators.

Cooling

Generating plants recycle water in the boiler/turbine system because the water to be converted to steam must be demineralized, and otherwise treated chemically, to prevent damage to the boiler and turbines. Because the system depends on the expansion that results from converting water to steam, reconversion of spent steam to water is essential before the cycle begins again. This involves condensing the steam by transferring its heat to water circulating in condensers. Condenser cooling water also is treated to minimize damage to the system, so it too recirculates and must be cooled to retain efficiency of heat transfer.

The major cooling process at a plant is for cooling water that in turn condenses spent steam. Plant designers have options among several principal methods for this process and commonly use combinations of methods to suit the particular circumstances of a plant and its surroundings. The main methods are: 1) once-through cooling, 2) cooling ponds, and 3) cooling towers.

Cooling by once-through water involves such large volumes of water that the source must be major rivers, lakes, or the ocean. Water passes through the system once and returns to the source so the thermal addition to the source is kept to a minimum.

Cooling ponds also require large volumes of water but far less than once-through systems. Water that has absorbed heat from the condenser coolants goes to large ponds on or near the plant site, where evaporation from large surface areas transfers heat to the air. Spraying the water in the ponds can accelerate the cooling process. Because evaporation is an essential part of this process, water loss is high, and considerable volumes of make-up water must be added when pond-cooled water returns to cool condenser water.

Cooling towers work on the principle of passing air over a "rain" of hot water which is cooled by evaporation. Some systems use fans to create a draft through the towers; other systems rely on natural draft. The fan draft towers are smaller and less expensive to construct but more expensive and troublesome to operate. The natural draft towers are large and costly to construct but are less expensive to operate and are more easily maintained.

Water loss again is an unavoidable result of evaporative cooling, but the loss is less than from cooling ponds.

Dry towers, where air passes over hot water confined by piping, is the system for cooling that requires the least water, but cooling efficiency is low and the method is not widely used.

Regardless of the cooling method or combination of methods used at a plant, the designers must include condensers and other necessary facilities for cooling. Ponds require larger land area; towers require larger structures.

Waste treatment

Waste products from coal-fired steam generating plants principally result from fuel combustion and cooling. Other sources are preparation of water for the system, fuel handling, and plant operation and maintenance. The combustion process generates chemical emissions, particulate emissions (fly ash), and bottom ash, which collects below the boiler fires. Emissions are minimized by fuel quality, boiler design, and stack design. Remaining chemical emissions in some plants are treated by "scrubbers" before venting through the stack. Remaining particulate emissions are largely removed by electrostatic precipitators before venting. Gaseous waste is vented through the stack; solid waste either is removed in solid form from the boiler and precipitators, or is slurried and piped to settling ponds on the plant site. Liquid wastes are sumped, piped to on-site ponds, settled, mixed, and either self-neutralized or treated.

Structures required are the stack and banks of precipitators near the base. Other facilities required are for on-site waste transfer, settling, treatment, and storage. Most plants ultimately store solid wastes such as ash, off-site.

Transformers and switching

Electricity generated by turbines is prepared for transmission in banks of transformers and then guided into the distribution system at a switching yard at or near plant site. These areas are fenced and are characterized by the spidery steelwork, insulators, and rows of equipment typical of electrical substations through distribution systems.

Office and maintenance

Plant design normally includes a small office structure, parking areas, and storage buildings and yards for equipment and supplies.

Construction

Construction begins after demand analyses and plant design prove to be economically feasible, and after all legal requirements are either met or are assured of being met during operation of the plant. Federal, State and local requirements include those involving zoning, air and water quality standards, environmental impact assessments, and various matters specifically bearing on public or private utilities.

Construction practices are typical of major engineering works. Site preparation includes foundation engineering to ensure continued integrity of the system. Structural engineering of the buildings, stack, and other facilities similarly ensures integrity. Actual construction methods follow accepted practice and result in a relatively short period of labor-intensive activity. Many plants now are designed to encompass multiple generating units when increased demand calls for more generating capacity; each unit operates independently, but some facilities can be shared among the units.

Figure RII-8 is an example of a plant with one unit in operation and a second unit under construction; the various structures and facilities are typical.

Construction costs range widely but a modern plant now costs about $400/kilowatt of generating capacity.

Operation and Maintenance

Operation normally is continuous except for routine maintenance and emergencies. In the course of operation coal is received, crushed, sampled, and stored for blending into the most advantageous boiler fuel. Fuel is introduced to the boilers at a rate that is dependent on the Btu value of the coal, which ranges widely among different coals and to some extent within each coal bed. The amount of coal required/hour can be approximated as follows: assuming about 40 percent efficiency in converting Btu value of coal to energy, each kilowatt-hour (kwh) requires 8,530 Btus to produce. Given Btu value of a particular coal, the number of kwh produced/pound of coal is derived by dividing Btu value of the coal by 8,530, dividing the resulting number into the power generated, and converting to tons. The quantity of coal needed is large, as the following example shows:

Btu value of the coal = 10,000 Btu/lb.

Generating capacity = 500 megawatts

$$\frac{10{,}000}{8{,}530} = 1.17 \text{ Kwh/lb. of coal}$$

$$\frac{500{,}000}{1.17} = 427{,}350 \text{ lbs. or } 213.7 \text{ tons of coal/hour}$$

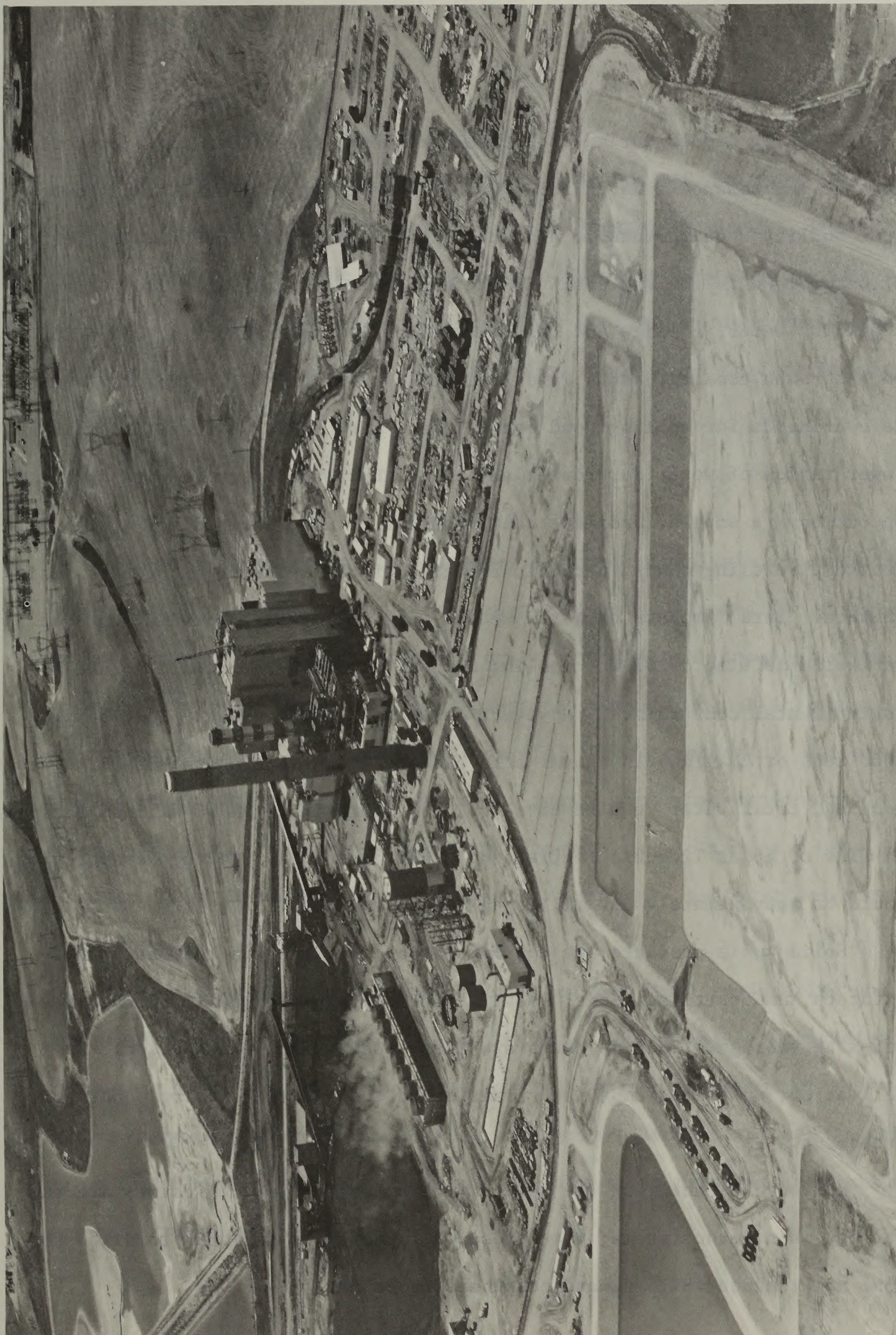


FIGURE RII-8

Coal-fired power generating plant, Hayden, Colorado.

Water is needed during operation for steam, for condensing, for cooling, and for maintenance. Water for steam and condenser cooling is treated to meet quality requirements in a process that is virtually continuous, because of water loss in the systems. If the condenser cooling water is in turn cooled by water, a large and continuous flow is required during operation of once-through cooling, and a lower but still substantial flow for replenishment is continuous for cooling pond operations. Air cooling systems maintain a lower inflow of water for replenishment. Other water requirements during operation are smaller and less continuous; they are required for dust control, settling ponds, periodic flushing of the systems, and general maintenance. Total amounts of water needed vary enormously depending on such variables as size of plant, cooling method, climate, fuel quality, and environmental constraints. However, assuming a 500 megawatt plant burning 5000 tons of coal/day in a semi-arid climate and utilizing fan-draft towers for cooling, total water requirements would be approximately 7.8 million gallons/day (a flow of about 12 cubic feet/second), and consumption through evaporation would be approximately 6.3 million gallons/day.

Solid waste products are continually accumulating in boilers, precipitators, and settling ponds. Most of these are periodically removed for off-site storage. Liquid wastes are less abundant and more periodic in derivation; most are sumped and transferred to on-site settling ponds for treatment.

Periodic cleaning of the boilers, turbines, and precipitators are the largest maintenance items; plant reserve capacity is designed to allow for most maintenance while demand continues to be met.

Transmission Lines

At the writing of this analysis there were no specific powerline construction applications that would require Federal approval. However several projections in the report indicate that powerline construction could occur in the region as a result of increased coal production; therefore this analysis will include a brief description of those steps that typically occur in powerline construction.

Preconstruction

Early in the preconstruction phase, a corridor analysis is conducted to determine all possible routes. Each route is then evaluated for engineering and environmental considerations. A draft environmental impact statement is prepared for those lines requiring Federal approval, and public comment is then incorporated into a final environmental impact statement. All studies leading up to this point are designed at identifying the most desirable route. After a route is selected, the alinement is plotted on a map, and a detailed field investigation is conducted to evaluate geologic and engineering conditions.

These investigations provide information for final engineering and preparation of design specifications for the line, as well as providing landowners with first-hand knowledge of the proposed alinement of the project. Rights-of-way are then finalized with appropriate landowners, and at this point final engineering is conducted, specifications prepared, materials ordered, and contracts awarded.

Construction

The first operation in the construction phase is the clearing of obstructions along the right-of-way. This includes removal of vegetation and rock outcrop to the extent to allow access along the line, and to provide cleared areas for storage of material. Access roads are then constructed along the route. Some excavation is required at the tower locations so that adequate footings or other support structures can be set in place. When structural material is delivered, it may be located at each location along the route, or stockpiled at marshalling sites along the right-of-way. Steel towers may be assembled on the ground and later placed in position by specialized cranes. Wood pole structures are placed in augered holes and tamped. After the towers are set in place, conductor cables are strung, ground wires clipped in, and other hardware installed on the powerline. This operation generally proceeds at the rate of about one mile/day.

Construction progress is monitored by the project sponsor throughout the work schedule to identify any deficiencies prior to actual trial energization of the line. The line is then energized and integrated into the existing system.

Operation and Maintenance

Technical studies are made periodically as new powerlines are added to existing networks. These studies are used to determine the most efficient means of transmitting and distributing electricity.

Existing powerlines require periodic inspection and maintenance checks. This requires a certain degree of accessibility along the line, and usually a road or trail is maintained along the route to allow traffic by ground vehicles. These roads are often used by many individuals other than powerline employees and therefore require periodic upgrading. The roads are often travelled during inclement weather because power outages occur during or after severe storms. Vandalism is an increasing problem and requires additional maintenance work, such as replacing insulators, broken conductors, and damaged transformers.

Water Development

Ground Water

Most of the mining operations in the area encounter some water. Strip mining will encounter water in pits, and underground mining will encounter water in tunnels. The amount of water produced in this way seldom exceeds a few tens of gallons/minute; it is used to sprinkle roads to keep the dust down during dry periods; at other times it is discharged into nearby streams.

In most cases, water in streams is natural ground water discharge from the formation from which coal is being mined, and therefore the water quality discharged into the stream from the mine is similar to the stream water. Water from the mine may come from somewhat deeper in the formation than the natural stream discharge, in which case water from the mine may be somewhat higher in dissolved solids.

In drier parts of the area, water from the mines probably would be discharged into a dry stream bed and absorbed into the ground within a relatively short distance, usually less than a mile.

Domestic water for use at the mine is usually derived from wells.

Although a well which will yield several tens of gallons/minute may be needed, total use at these facilities is small. None of the mines in the area use water for cleaning coal or any other industrial purposes at the mine.

Large supplies of water are commonly used for cooling in generating plants; there is at present no known ground water source for this supply.

Surface Water-Hydrologic Structures

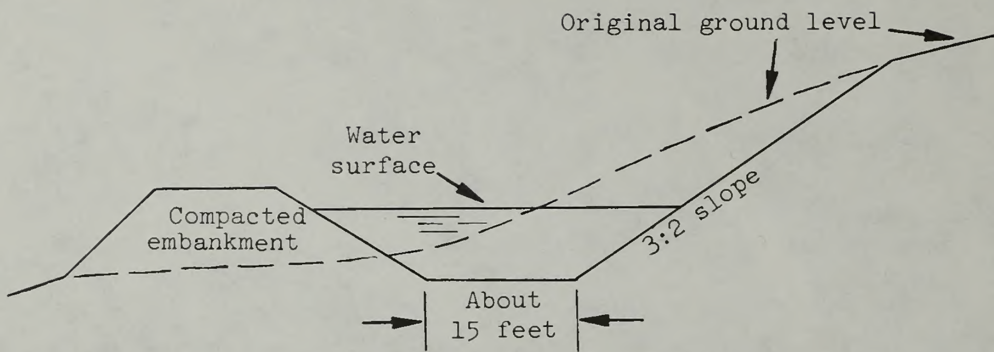
To protect some mine areas from collecting excess water during periods of heavy precipitation and runoff, perimeter ditches (Figures RII-9 and RII-10) will be established above the working areas of the mine. These ditches will carry runoff to one or more small (less than ten acres) settling ponds where suspended solids will settle out. Overflow from the ponds will be directed to a natural stream channel. Settling ponds may also be constructed by damming a natural water course where there is a likelihood of collecting sediment-ladened flow from mining operations. Culverts will be installed under roads and railroads to insure drainage and unrestricted flow of water. Check dams (Figure RII-10) will be constructed to create settling ponds in areas where rapid runoff would create excessive erosion. These dams create catchment basins to retard flow rate, provide an area in which solid materials can settle, and also provide a watering source for local animal populations.

Diversion structures may be constructed in some stream channels to divert water onto adjacent land for irrigation, or to divert water from a stream into a storage basin.

FIGURE RII-9

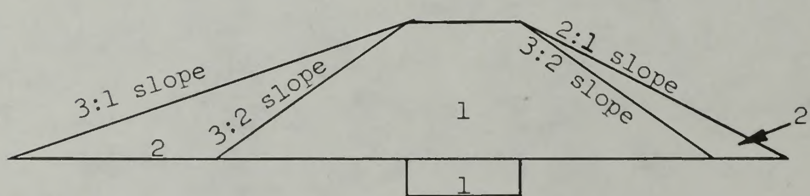
View of a typical diversion ditch.

SOURCE: Powder River EIS.



A. Typical Ditch Section. Slopes Cut at 3:2; Bottom of Ditch Width of Bulldozer Blade.

Ratio distance to rise	Percent grade	Angle of slope
3:2	67	33.7°
2:1	50	26.6°
3:1	33	18.5°
5:1	20	11.3°



1. Impervious clay or clay sand and shale
2. Semi-pervious material of selected stability, graduated in coarseness to outer slopes; compacted.

B. Typical Earth Fill Dam Section. Core Trench Depth One-Fourth of Dam Height; Top of Dam and Core Trench 15 Feet Wide.

FIGURE RII-10

Sections of ditch and dam showing slopes of embankments.

Large dams may be constructed on larger streams to impound water for irrigation or electric power production. The capacity of large dams and reservoirs may exceed the natural flow of a stream in any one season. However such reservoirs may be filled over a period of years with unappropriated water from early spring runoff. After a reservoir is filled to an operating level, the water may be used for power production and subsequently for irrigation of downstream lands.

A system of storage reservoirs which has a total capacity greater than the average annual flow of the drainage basin is not uncommon. Several reservoirs may be constructed in a stream system, filled over a period of years with excess spring runoff and perhaps flood flows, then operated as a unit to derive the most benefit from the stored water. In the operation of an individual reservoir, it may be filled during spring runoff, then may be partially emptied to satisfy downstream commitments such as power demands if electric power is generated, or some storage must be released to provide capacity for flood storage. During years of deficient flow, the reservoirs may operate at much less than full capacity. Conversely, during years of excess flow, water may have to be wasted to operate a reservoir or system of reservoirs safely.

Chapter III

Coal Related History and Present Activity

THIS CHAPTER IS A BRIEF SUMMARY OF THE PAST HISTORY OF COAL DEVELOPMENT WITHIN THE STUDY REGION. PRESENT ACTIVITY IS ALSO DISCUSSED IN TERMS OF MINING METHODS, COAL UTILIZATION, AND RECLAMATION PROCEDURES.

CHAPTER III

COAL-RELATED HISTORY AND PRESENT ACTIVITY

History

Summary of Operations

Recorded production of coal in Colorado since 1864 totals about 588 million tons. Of this total approximately 69 million tons or 12 percent has been mined from the three northwest Colorado counties under consideration in this Environmental Impact Statement: Routt, Moffat, and Rio Blanco.

The existence of extensive coal deposits in the three counties has been recognized since the earliest period of settlement. Wagon mines were operated to supply coal to local inhabitants at widely separated sites in and around the Yampa, Lower White River, and Danforth Hills Coal Fields by 1900 or earlier. Numerous underground mines were operating in the Oak Creek mining district prior to 1905 when Fenneman and Gale (1906) conducted geologic investigations of the coal fields. The James, Shuster, and Steamboat Springs Electric Company's as well as other mines were operating at that time in high-grade coal beds near Oak Creek.

Several coal mines were being operated at the same time on Dry Creek, about six miles south of Hayden, Routt County, and in Hayden Gulch, five to six miles farther south. Coal was being mined by 1900 near the main road (now U.S. Highway 40) a few miles east of Craig, Moffat County. Other mines operated 12 miles northeast of Craig, where extensive mining from wagon mines was carried on prior to 1920 and continued into the 1930s, and near Lay, 18 miles west of Craig, as early as 1892. Numerous underground mines operated in the early 1900s in the Danforth Hills area as well.

Transportation of the mined coal was difficult in the early 1900s and was the limiting factor in further development. However the arrival of the railroad in the early 1900s stimulated coal mining in the entire region. The Moffat Railroad reached the eastern border of the Yampa Coal Region in 1906; further development of mines in the Oak Creek vicinity resulted. Coal from local mines was used to fuel the railroads as well as for export. When the railroad was extended in 1923 from Steamboat Springs to Craig, small mining towns sprang up along the route and additional mines went into production.

As the demand for coal decreased in later years, many mines and small mining towns closed down. The history of coal mining and associated employment and income in the three-county study area has been a series of "peaks and valleys" in the past 50 years. See Appendix D for description of coal production from these three counties from 1887 through 1974.

Mining Methods

The first mines to operate in the tri-county region were underground mines. Most of the mines were opened by a drift with the tipple located below the portal to facilitate handling the coal by gravity flow. Early mines extracted coal by room-and-pillar method using picks and shovels. Mechanization of the mines was prevalent by the early 1900s. Coal was first undercut with reciprocating punch machines powered with steam or compressed air. Later electrically powered chain cutting machines were developed and their use became widespread by the 1930s. In 1913, 300 cutting machines were in operation in Colorado, producing 25 percent of that year's output. By 1917, 32.7 percent of the output was machine cut; in 1923, 47.3 percent; in 1925, 52.7 percent; and in 1934, 71 percent. After undercutting, coal was drilled and blasted with black powder or permissible explosives and hand loaded. Shaking conveyors were first used to load coal in the early 1920s. Mobile mechanical loading machines were used to some extent in the 1930s, but their use did not become widespread until the 1940s. Continuous mining machines were first used in 1968 in a mine south of Craig.

The first strip mine to operate in the region was the Edna Mine, northwest of Oak Creek in 1946. The Wadge and Lennox seams were stripped at this mine. Several other small strip pits were opened in the 1950s. By the early 1960s the greater portion of the tri-counties' coal production was being mined by strip mining methods in Routt County. This trend has continued to the present.

Reclamation

The first formal restoration of surface mined lands in northwestern Colorado began in 1965. On April 16, 1965, a voluntary memorandum of understanding was agreed to by the Colorado Department of Natural Resources and officials of the major coal mining companies operating in the State. The memorandum was signed by R. T. Eckles, coordinator for Colorado's Department of Natural Resources, who was administering the reclamation program, and by representatives of Energy Coal Company, Peabody Coal Company, and The Pittsburg and Midway Coal Mining Company. The Memorandum of Understanding, the first voluntary agreement with respect to reclamation entered into by any state, focused national attention on Colorado.

During 1965, the same year the agreement was signed, 538 acres of Colorado land were rehabilitated by the coal companies (Table RIII-1). This represented more than half of the total land area affected by surface mining since its inception in the State in 1946. In 1966 31 acres were seeded and a total of 5,325 trees and shrub seedlings were planted. In 1967 nine species of grasses and legumes totaling 9,520 pounds of seed were planted on 476 acres, and 32 species of trees and shrubs totaling 7,100 seedlings were transplanted; however the location and numbers of each species are unknown. In 1968 311 acres were seeded and an unknown number of tree and shrub seedlings transplanted; all seed was broadcast aerially and seedlings were transplanted by hand. Most of the spoils were graded before seeding; this consisted of flattening the ridgetops to a width of approximately fifteen feet leaving the effects of mining still very evident (Figure RIII-1).

TABLE RIII-1

Historical Rehabilitation Efforts

Rehabilitation efforts completed on northwestern Colorado's surface mined land as the result of a cooperative agreement between the Colorado Department of Natural Resources and the following companies: Energy Coal Company, Peabody Coal Company and The Pittsburg and Midway Coal Mining Company.

1965 — Seeding[1/]

Edna Mine	136 acres
Energy Mine	132 acres
Osage Mine	200 acres
Seneca Mine	70 acres
Total	538 acres

1966 — Seeding[2/]

Edna Mine	1 acre
Energy Mine	18 acres
Seneca Mine	12 acres
Total	31 acres

Shrub and Tree Transplanting[3/]

Edna Mine	150 seedlings
Energy Mine	1,225 seedlings
Osage Mine	2,075 seedlings
Seneca Mine	1,875 seedlings
Total	5,325 seedlings

1967 — Seeding[4/]

Edna Mine	60 acres
Energy Mine	50 acres
Osage Mine	276 acres
Seneca Mine	90 acres
Total	476 acres

Shrub and Tree Transplanting[5/]

7,100 seedlings
Location of transplanting unknown.

1968 — Seeding[6/]

Edna Mine	100 acres
Energy Mine	92 acres
Seneca Mine	119 acres
Total	311 acres

Shrub and Tree Transplanting[7/]

The location and numbers of seedlings transplanted is unknown.

1/ The seeding mixture consisted of the following:

Intermediate Wheatgrass	5 Lbs./Acre
Pubescent Wheatgrass	4 Lbs./Acre
Smooth Brome	4 Lbs./Acre
Timothy	3 Lbs./Acre
Durar Hard Fescue	1 Lb. /Acre
Rhizoma Alfalfa	3 Lbs./Acre
Yellow Blossom Sweet Clover	2 Lbs./Acre
Alsike Clover	3 Lbs./Acre
Total	25 Lbs./Acre

2/ The seeding mixture was the same as the one used in 1965 except the amount of Timothy was reduced, resulting in a total mixture of 23 pounds/acre.

3/ Seedlings consisted of the following:

450 Austrian Pine	200 Golden Willow	100 Autumn Olive
700 Ponderosa Pine	200 Hackberry	200 Squaw Bush
200 Lodge Pole Pine	100 Sycamore	300 Buffalo Berry
1,450 Chinese Elm	50 Eastern Cottonwood	400 Russian Olive
200 Rocky Mountain Juniper	50 Silver Maple	200 Bladdersenna
225 Green Ash	300 Black Locust	

4/ The seeding mixture consisted of the following:

Crested Wheatgrass	2 Lbs./Acre
Western Wheatgrass	2 Lbs./Acre
Tall Fescue	2 Lbs./Acre
Orchardgrass	1 Lb. /Acre
Bromegrass	4 Lbs./Acre
Cody Alfalfa	4 Lbs./Acre
Rhizoma Alfalfa	2 Lbs./Acre
Yellow Blossom Sweet Clover	2 Lbs./Acre
White Blossom Sweet Clover	1 Lb. /Acre
Total	20 Lbs./Acre

5/ Seedlings consisted of the following species:

Blue Spruce	Austrian Pine	Eastern Red Cedar
Lilac	Lodgepole Pine	Rocky Mountain Juniper
Caragana	Ponderosa Pine	Sage
Plum	White Fir	Tamarix
Chinese Elm	Mountain Mahogany	Alianthus
Ash	European Black Alder	Squaw Bush
Sand Cherry	Service Berry	Bladdersenna
Golden Willow	Narrowleaf Cottonwood	European Sage
Hackberry	Scotch Pine	Black Locust
Honey Locust	Douglas Fir	Buffaloberry
	Quail Bush	Russian Olive

6/ The seeding mixture was the same as 1967 except Timothy was substituted for Orchardgrass and Vernal alfalfa was substituted for Cody alfalfa.

7/ Seedlings used were the same as 1967, and the numbers of each species are unknown.

FIGURE RIII-1

The effects of strip mining are still very evident after early rehabilitation programs, Energy 1 mine.

Since very poor records were kept of the locations and dates of seedings and transplanting it is difficult to accurately assess the success of these efforts, especially the shrub and tree transplanting. Overall vegetation establishment on the spoils has been fair to good. Results vary from essentially no vegetation on very coarse-textured spoils on steep south- and west-facing slopes, to excellent stands on slopes with similar aspects containing more fines, and on north- and west-facing slopes with varying degrees of texture.

Alfalfa has been the outstanding species used in spoil revegetation in this area; it is an excellent soil stabilizer and grows on steep slopes and all exposures (Figure RIII-2). In stands dominated by alfalfa, only the taller grasses, such as smooth brome and intermediate wheatgrass, have been able to compete and contribute to forage production.

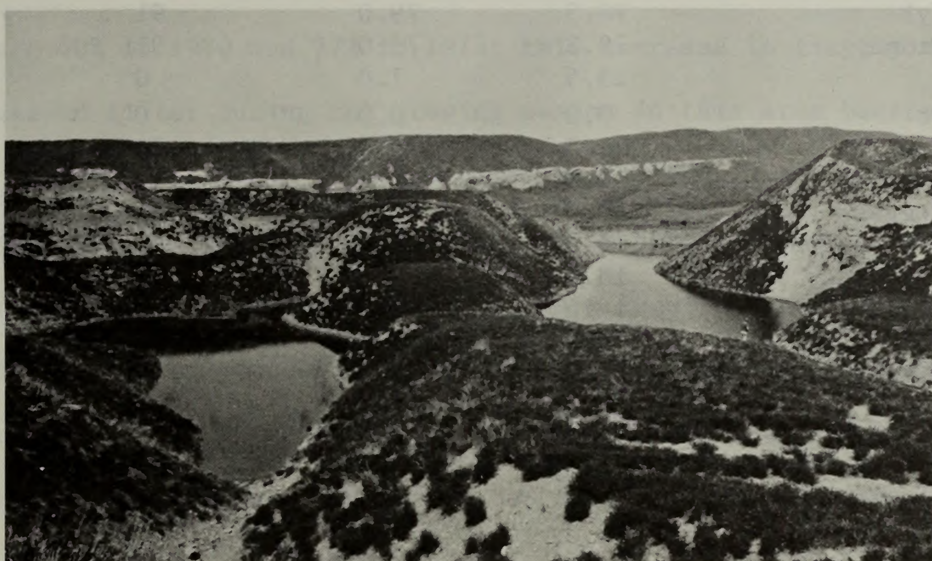


FIGURE RIII-2

Alfalfa has proven to be an excellent soil stabilizer on mine spoils on steep slopes and any exposure. Spoil material appears quite impermeable, as the two reservoirs pictured differ in elevation by approximately 10 feet, but are quite close; the water is of adequate quality to support fish (Peabody's Seneca 1 mine).

Berg (1975) sampled Peabody's Seneca 1 mine in 1970 and 1975 and found that following the reclamation efforts of the late 1960s (Table RIII-1), alfalfa dominated for at least 10 years (Table RIII-2). The apparent reason for these results is the Nitrogen (N) supplying ability of alfalfa, as the spoils are very N-deficient. The spoils sampled by Berg (1975) appear to be the most productive spoils in the region, partially because the area has been

TABLE RIII-2

Frequency and Relative Productivity by Species on Seneca 1 Spoils 1/

Species	1970 Sampling % Frequency 2/	1970 Sampling % of Total Production	1975 Sampling % Frequency 2/	1975 Sampling % of Total Production
Alfalfa (Cody)	78.5	79.0	91	57.4
Alfalfa (Rhizoma)	78.5	79.0	91	57.4
Sweet Clover	23.5	7.0	0	T 3/
Alsike Clover	0.0	0.0	0	0
Smooth Brome	31.5	6.0	70	24.4
Timothy	5.0	0.2	2	T
Crested Wheatgrass	19.0	1.0	28	3.1
Intermediate Wheatgrass	15.0	2.4	31	12.6
Pubescent Wheatgrass	15.0	2.4	31	12.6
Orchardgrass	16.5	3.0	28	3.1
Tall Fescue	10.5	0.3	6	.1
Hard Fescue (Durar)	0.5	T	4	.1
Cheatgrass	2.0	0.3	10	.8
Russian Thistle	2.0	T	0	0
Unidentified Forbs	2.0	T	8	T
Canada Thistle 4/	1.5	T	2	.4
Big Sage 4/	0.5	T	0	0
Bluegrass 4/	0.0	0.0	3	T
Goatsbeard 4/	0.0	0.0	2	T
Vetch (Vicia) 4/	0.0	0.0	1	T
Phlox 4/	0.0	0.0	1	T
Artemisia dracunculus 4/	0.0	0.0	1	.5
Dandelion 4/	0.0	0.0	1	T
Yarrow 4/	0.0	0.0	3	T

1/From Berg, W. A., 1975. Changes over five years in the composition and herbage production of seedlings on strip-mine spoils in northwestern Colorado. Progress report. Total production was 1700 and 1830 lbs/acre dry weight in 1970 and 1975 respectively.

2/Percent of the time this species occurred within the 1/2 m^2 sampling area.

3/T = Trace.

4/Not seeded.

very lightly grazed since reseeding. Herbage production averaged 1700 pounds dry weight/acre in 1970 and 1830 pounds in 1975. The difference is not believed to be significant, but the differences in composition probably are (Berg 1975). The reduction in dry matter produced by alfalfa was offset in overall productivity by increases in dry matter produced by smooth brome and wheatgrasses. Soil cover by living and dead vegetation averaged 60% in 1970 and 77% in 1975; this increase is largely due to an increase in litter during the growing season in this area because of the bloat hazard. Because of the steepness of the spoils and the bloat problem, the usefulness of the vegetation produced is very limited.

Plantings of woody species in the late 1960s were not done in a systematic manner and success was difficult to monitor. Initial establishment of deciduous species was fair to good; survival of conifers was poor to nil. Browsing by big game and sheep has severely retarded growth of the deciduous species. Russian olive and caragana are the species which now show the most vigor, probably because they are less palatable than the other species and possibly because of their N-fixing ability. The initial growth of Hansen's rose and Chinese elm was outstanding, but these species have been particularly heavily browsed.

Competition for moisture between the woody and herbaceous species is obvious. Where deciduous woody plantings were made in areas with limited or no competition from herbaceous species, growth has been satisfactory (taking into account the heavy browsing). Growth of the woody species has been restricted in even moderate stands of herbaceous species.

Very little invasion of native species has occurred on old mine spoils, indicating that raw overburden material may not be suitable for growth of native species.

The effects of strip mining remain very evident after rehabilitation efforts of the past; approximately 3,300 acres have been revegetated, but are not producing to the capacity possible had more intensive reclamation efforts been utilized.

Present Activity

Summary of Operations

In 1974, four strip operations and four underground operations produced 3,710,416 tons of coal from the three northwest Colorado counties of this study. These three counties thereby produced over half of the State of Colorado's total production of 6,90,686 tons. Production figures for 1974 by county and company are shown in Table RIII-3.

TABLE RIII-3

1974 Coal Production in Study Region

County	Company or Operator	Tonnage
Moffat	Red Wing Mine Colowyo Coal Company	28,741
	Wise Hill 5 Empire Energy Corporation	212,010
	Total	240,751
Rio Blanco	Rienau 2 American Fuels Corporation	11,766
Routt	Apex 2 Routt Mining Corporation	11,282
	Edna Strip Pittsburg & Midway Coal Mining Company	1,134,089
	Energy Strip 1 Energy Fuels Corporation	1,240,150
	Energy Strip 2 Energy Fuels Corporation	575,393
	Seneca Strip 2 Seneca Coals, Ltd. (Peabody)	496,985
	Total	3,457,899
	Total	3,710,416

SOURCE: Colorado Division of Mines

A brief description of each of the operations follows:

The Red Wing mine was operated by underground methods by Colowyo Coal Company from 1945 to December 1, 1973. On that date, W. R. Grace & Company acquired Colowyo Coal Company. Coal was mined from Federal lease D-034365 about 25 miles southwest of Craig, Moffat County, Colorado. In February of 1974 the mine was closed by Federal coal mine inspectors due to the dangers posed by a fire in an adjoining underground mine; carbon monoxide was detected within the Red Wing mine and the company was fearful of fire. W. R. Grace & Company has no plans for reopening this underground mine in the immediate future as it lies adjacent to their proposed strip mine area.

The Wise Hill 5 mine is located 8 miles south of Craig, Colorado. The mine is operated by Empire Energy Corporation on Federal, State, and private lands. However in 1974 there was no production from Federal coal leases. The company does not anticipate production from federal lease land until the issuance of their competitive lease applications C-13134 and C-21981, shown in Appendix A. Production has been increasing steadily since the company acquired the mine in 1971, and currently the mine is producing 2,000 tons/day. Empire Energy plans to increase production to an estimated 4,000 tons/day within the next several months; this increased production will be gained through the addition of a second continuous mining unit. In February 1975 Empire Energy began producing coal from the Williams Fork Strip 1, a new strip mine on State land. By April 1975 production had increased to 2,000 tons/day. Production is anticipated to remain at this rate until summer 1976, when the combination of a new dragline and moving to a new pit will increase production to an estimated 4,000 tons/day.

The Rienau 2 mine, located approximately eight miles north of Meeker, was operated by American Fuels Corporation. Coal was mined from Federal coal lease C-076713. In March 1975 the mine was closed by Federal coal mine inspectors because the face equipment was non-permissible. Coal was mined from the twenty-foot thick Rienau bed of the Mesaverde formation which dips 17° to the north. Plans to reopen the underground mine are not known at this time.

The Apex 2 mine is a small underground mine operated on Federal coal lease D-046544 by the Routt Mining Corporation. The mine is located five miles west of Oak Creek, Routt County, Colorado. The mine is in the 52-inch-thick lower series Pinnacle Bed in the Iles Formation; it supplies the local domestic market for heating fuel. There are at present no plans to increase production from this mine.

The Edna Strip mine is located on Federal, State and private land about four miles northwest of Oak Creek, Routt County, Colorado. The mine has been owned and operated since 1961 by Pittsburg and Midway Coal Mining Company (P&M), a wholly-owned subsidiary of Gulf Oil Corporation. The mine has been in existence since 1946, during which time the Lennox and Wadge seams of the Williams Fork formation have been mined. Coal is currently being mined from the Wadge seam on private land. The last production from Federal land was from coal leases D-053710 and D-041478 in 1968. The next anticipated production from Federal land will be in 1977 from coal lease D-033327. The mine is currently producing at a rate of 1,200,000 tons/year. Approximately 100 acres are disturbed by mining operations and haul roads each year.

The Energy Strip 1 and Energy Strip 2 mines, located about ten miles northwest of Oak Creek, Colorado, are operated by Energy Fuels Corporation. Energy Strip 1 is located in the 6-10 foot thick middle series Wadge bed on Federal coal leases D-052547 and C-081330 as well as private coal land. Coal is mined at Energy Strip 2 from the 5-foot thick upper series Fish Creek bed. This mine is presently located on private land and Federal coal lease C-0128433; yearly production from mines 1 and 2 is currently 2.5 million tons. In addition Energy Fuels Corporation is mining at the Energy 3 mine, located about seven miles northeast of 1 and 2 mines on private land. A large acreage of overburden has been stripped exposing the Wadge coal seam. Coal production began in June 1975 upon completion of the new tipple at the Energy 3 mine. The company anticipates an average yearly production of 500,000 tons of coal from Energy 3 mine.

The Seneca Strip 2 mine is operated by Peabody Coal Company for Seneca Coals Ltd., a joint venture of Peabody and Western Utility Coal Company. The mine is located about five miles southeast of the Hayden station power plant, Routt County, Colorado. Coal is mined from the Wadge seam, which averages 12 feet in thickness. Coal is currently mined from both private and state land. The last production from Federal land was from coal lease C-088199 in April 1974. The next Federal land that the company intends to strip at Seneca 2 is contingent upon the acquisition of competitive lease application C-19885, located in Section 1, Township 5 North, Range 87 West. Approximately 50-55 acres are disturbed by mining operations and haul roads each year.

In June 1975 there were two active underground coal mines and six active strip mines in the three counties. However, the Williams Fork Strip 1 and Wise Hill 5 Mines of Empire Energy Corporation were idle, so the production in June from the six producing mines was 447,663 tons of coal.

Numerous companies were actively engaged in exploration of coal properties on Federal, State and private lands in 1974. Peabody Coal Company drilled over 200 exploration holes to an average depth of 65 feet to delineate the outcrop at their proposed Seneca 2-W Mine. In addition Peabody drilled three water monitor wells for baseline data on water quantity and quality. Utah International drilled 16 exploration holes on the Federal leases encompassed in their Yampa Project property and continued their baseline environmental data gathering program. W. R. Grace & Company drilled 81 exploration holes on their Axial Basin property and dug several test trenches. In a joint program with the USGS, the BLM, and the Bureau of Reclamation, seven shallow wells and two deep wells were drilled on the Grace property to assess water quality and quantity. Consolidation Coal Company drilled 16 exploration holes on Federal leases north of Meeker. Kemmerer Coal Company drilled 19 exploration holes on their Federal coal prospecting permit lands along the Colorado-Wyoming border. Ruby Construction Company drilled five exploration holes in 1974 on their Federal lease south of Hayden to delineate and correlate the coal beds.

Several coal companies have submitted exploration plans to the Area Mining Supervisor for exploration drilling on Federal leases in 1975.

Among these companies are: Moon Lake Electric Association, Inc., Consolidation Coal Company, W. R. Grace & Company, Energy Fuels Corporation, and Utah International Incorporated. Companies anticipating exploration in 1975 on State and private lands include Thomas C. Woodward and possibly Coal Fuels Corporation.

Mining Methods

Both of the underground mines operating in April 1975 within the tri-county area employ the room-and-pillar mining method. The conventional system is used by Routt Mining Corporation at their Apex 2 mine. The coal is undercut, drilled, and blasted. An electric-powered loading machine loads the coal into shuttle cars. The shuttle cars then discharge the coal onto a belt conveyer for transportation to the tipple at the surface.

Empire Energy Corporation uses the continuous system at their Wise Hill 5 mine. A continuous mining machine cuts the coal and loads into shuttle cars for transportation to the belt conveyor.

The Pittsburg and Midway Coal Mining Company employs the area strip mining method at their Edna mine. Successive cuts are made across the strike of the bed working from the lower levels of the dip slope up the pitch. The overburden is stripped with a dragline equipped with a 40-cubic-yard bucket and a 225-foot boom. Coal is loaded with a nine-yard diesel-electric shovel into both 40-ton and 60-ton off-highway coal haulers. The trucks haul the coal from the pit to a 150-ton hopper where it is lowered 700 feet vertically down the east side of a ridge by a three-section 2,462-foot belt conveyer.

Energy Fuels Corporation uses a dragline fleet as well as bull-dozer equipped crawler tractors and scrapers to strip the overburden. Two electric draglines are used at the Energy 1 mine for overburden removal. Coal excavation and loading is accomplished by rubber-tired, front-end loaders. These loaders fill off-highway haulage trucks for transportation to the coal storage facility. At the Energy 2 mine, over-burden is stripped with two 7 1/2 yard diesel draglines supplemented by the scraper and dozer fleets. Coal loading and hauling is similar to the Energy mine. The Energy 3 mine employs scraper and truck and shovel operations to remove overburden. Coal is loaded with front-end loaders into 50-ton off-highway trucks for conveyance to the storage and load-out facility.

An area strip mining technique is used at Peabody Coal Company's Seneca Strip 2. Overburden is removed with a 15-cubic-yard dragline. The company is currently loading coal with a 7-cubic-yard shovel into 50-ton truck-trailer units for haulage to the Hayden power station six miles away.

The Williams Fork Strip 1 mine of Empire Energy Corporation is currently removing overburden with scrapers and rock trucks exposing the "K" seam. The overburden is first ripped with bulldozers, or in places where the overburden is harder, drilled, and shot with explosives. The overburden is then either loaded in trucks with front-end loaders or picked up with scrapers, for transportation to the spoil dump area. A modified pull-back mining method is being used, where spoil is returned to areas from which coal has been removed. The company has ordered a new

16-cubic-yard dragline for delivery in spring 1976. With the delivery of this dragline the company will employ an area strip mining technique of mining coal similar to the other strip mines.

Utilization

The major portion of the coal currently produced within the tri-county area of northwest Colorado is utilized by Colorado consumers. Pittsburg and Midway Coal Mining Company ships coal to the Great Western Sugar Company, to Public Service Company of Colorado, to the City of Colorado Springs, and to the Pueblo Army Depot. Energy Fuels ships the major portion of their coal to Public Service Company of Colorado, supplying 46 percent of that utility's demands. Energy Fuels also ships coal to St. Louis, Missouri, to Amherst Industries, Incorporated, a West Virginia-based marketing firm. Peabody Coal Company supplies coal to the Hayden station power generation plant. Empire Energy Corporation supplies coal to power plants in Colorado Springs, Colorado, and Omaha, Nebraska. Routt Mining Corporation markets their coal to local users. Utah International's strip mine will supply the Colorado-Ute mine mouth generating plant.

Reclamation

The most significant advancement of current restoration practices is the development of a reclamation plan before mining and reshaping of the spoils to approximate original contours (Figures RIII-3 and RIII-4).

FIGURE RIII-3

Current grading procedures at Pittsburg and Midway's Edna mine. Grading is begun after three rows of spoils are produced. Foreground has been seeded with a rangeland drill.

FIGURE RIII-4

Surface configuration after grading at Peabody's current Seneca 2 mine.

At Pittsburg and Midway's Edna mine, spoils are regraded to approximate original contours and seeded to the following species with a rangeland drill: manchar smooth brome, nordan crested wheatgrass, intermediate wheatgrass, pubescent wheatgrass, hard fescue, Russian wildrye, and yellow sweet clover. Alfalfa has been eliminated from the mixture because of bloat problems with domestic livestock. Current reclamation procedures at Edna mine have not been utilized for a long enough period of time to predict success. Pittsburg and Midway will utilize results of test plots of grasses and shrubs planted on their spoils by the U.S. Soil Conservation Service to continually upgrade their seeding mixture.

The following species are included in the test plots:

Seeded Species	Accession
Western wheatgrass	Arriba
James penstemon	NM-724
Western wheatgrass	Rosana
Palmer penstemon	NM-618
Western wheatgrass	P-727
Rocky Mountain penstemon	Bandera
Thickspike wheatgrass	Critana
Alfalfa	
Streambank wheatgrass	Sodar
Indian ricegrass	Paloma
Great Basin wildrye	C-43
Fourwing saltbush	P-15585
Russian wildrye	Vinall
Crownvetch coronilla	Chemung
Hard sheep fescue	Durar
Yellow sweet clover	

Transplanted Species	Accession
Russian olive	Wy 292A
Oregon grape	NM 1095
Rose	NM 1081
Winterberry (euonymus)	Pink lady
Russian olive	NM 476
Cliffrose	NM 624
Rose	NM 1070
Skunkbush sumac	Wyo 843
Rose	NM 1043
Mountain mahogany	NM 715
Silver buffaloberry	NM 1163
Woods rose	NM 1068
Antelope bitterbrush	NM 503

In addition to reshaping to approximate original contours, Energy Fuels is also removing topsoil before overburden removal to replace on shaped spoils (Figures RIII-5 and RIII-6), and plans to return part of their mined lands to cropland.

FIGURE RIII-5

Topsoil has been removed from this area prior to mining for replacement on reshaped spoils, Energy 2 mine.

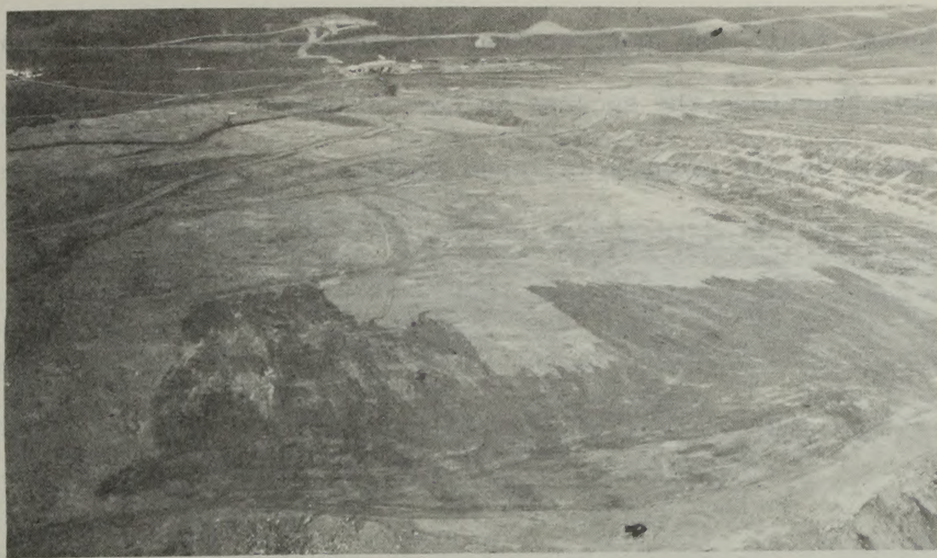


FIGURE RIII-6

Dark area is where topsoil has been replaced after reshaping, Energy 1 mine.

Energy Fuels is returning topsoil to a depth of approximately 18 inches on areas reclaimed for cropland, and eight inches on areas reclaimed for grazing land. The current seed mixture on grazing land areas is smooth brome, orchard grass intermediate wheatgrass, and alfalfa. Cropland areas will be primarily seeded to small grains.

Energy Fuels is also rehabilitating the spoils from the old mining operation by leveling and reshaping the spoils to approximate original contour, replacing topsoil to a depth of four-six inches where available, and reseeding.

Energy Fuels' current reclamation program has only been implemented recently; therefore the success is not yet known. However topsoil replacement should greatly increase reclamation potential if the replaced topsoil is protected from erosion. A small area, approximately two acres, was topsoiled and seeded two years ago; the most obvious difference that topsoil has provided is the invasion of the following native species: mullen, yarrow, larkspur, big sagebrush, penstemon, dandelion, and wild onion.

Peabody's reclamation program is much like their old program except for new grading procedures (Figure RIII-4). The following seed mixture is aerially seeded in the spring: vernal alfalfa, rhizona alfalfa, yellow sweet clover, crested wheatgrass, intermediate wheatgrass, western wheatgrass, smooth brome, tall fescue, and timothy. No areas returned to approximate original contours have been revegetated, but some areas that have been extensively graded and revegetated produce a relatively good vegetative cover that is dominated by alfalfa.

Peabody plans to create a lake in the cut at the bottom of the slope at the current Seneca 2 mine. Also fly ash from the Hayden power plant is dumped into one of the old pits at the Seneca 2 mine and buried (Figure RIII-7).

Empire Energy opened a surface mine April 1975; since this mine is relatively new, only a small part of their reclamation plan has been implemented. They are removing topsoil before mining and will replace it to a depth of twelve inches after regrading the spoils to the approximate original contours. An area about ten acres in size has been regraded

FIGURE RIII-7

Fly ash from the Hayden power plant is dumped into an old pit at Peabody's Seneca 2 mine and buried.

and topsoil replaced, but it has not been seeded.

Seeding mixtures will vary according to exposure (as recommended by the Soil Conservation Service) and will consist of the following:

North and East Facing Slopes and Flat Areas

Crested wheatgrass	2.00 Lbs./Acre
Streambank wheatgrass	1.00 Lbs./Acre
Pubescent wheatgrass	2.00 Lbs./Acre
Western wheatgrass	2.00 Lbs./Acre
Russian wildrye	2.00 Lbs./Acre
Green needlegrass	0.50 Lbs./Acre
Cicer milkvetch	0.25 Lbs./Acre
Yellow sweet clover	0.25 Lbs./Acre
Little rabbitbrush	0.10 Lbs./Acre
Big sagebrush	0.10 Lbs./Acre
Antelope bitterbrush	0.50 Lbs./Acre
	10.70 Lbs./Acre

West, South, Northwest, and Southwest Facing Slopes

Streambank wheatgrass	4.00 Lbs./Acre
Pubescent wheatgrass	4.00 Lbs./Acre
Western wheatgrass	4.00 Lbs./Acre
Sand dropseed	1.00 Lbs./Acre
Indian ricegrass	2.00 Lbs./Acre
Little rabbitbrush	0.25 Lbs./Acre
Big sagebrush	0.25 Lbs./Acre
	15.50 Lbs./Acre

Current reclamation practices of existing mines do not alleviate the effects of strip mining, but the companies are returning mined lands to a state with much higher potential and less obvious topographic differences than former rehabilitation efforts achieved.

Chapter IV

Description of the Environment

THE FOLLOWING CHAPTER DESCRIBES THE PHYSICAL, BIOLOGICA AND CULTURAL RESOURCE VALUES WHICH CONSTITUTE THE ENVIRONMENT WITHIN THE STUDY REGION. ALTERATIONS OF THESE RESOURCE VALUES WOULD RESULT IF AND WHEN FEDERAL APPROVAL IS GRANTED. ADDITIONAL EMPHASIS IS GIVEN TO DESCRIPTIONS OF THOSE ENVIRONMENTAL COMPONENTS MOST LIKELY TO BE IMPACTED BY COAL DEVELOPMENT AND ASSOCIATED ACTIVITIES WITHIN THE STUDY REGION.

CHAPTER IV

DESCRIPTION OF THE ENVIRONMENT

Non-living Components

Geologic and Geographic Setting

Topography

Routt, Moffat, and northern Rio Blanco Counties are almost surrounded on the east, south, and west by the Southern Rocky Mountains, the White River Plateau, and the eastern Uinta Mountains.

The eastern boundary of Routt County coincides partly with the Continental Divide, which runs generally south through the Sierra Madre, Park, and Gore Ranges of the high and rugged Southern Rocky Mountains. The three ranges noted here are commonly referred to collectively as the Park Range, and this report will continue that usage. Elevations are mostly from about 8,000-10,000 feet, with some peaks rising to almost 12,000 feet. Two important tributaries of the Yampa River, the Elk, and Little Snake Rivers, together with some of their tributaries, drain the northern half of the west slope of these mountains. Small tributaries of the Yampa drain the west slope of the southern half.

In northern Routt and northeastern Moffat County, the Elkhead Mountains, with elevations ranging from about 7,500 to more than 11,000 feet, extend westward from the Park Range. Relief is mostly more subdued here than in the Park Range. Principal streams draining the Elkhead Mountains are Elkhead and Fortification Creeks running south to Yampa River, and Slater Creek running north to Little Snake River in Wyoming.

The southernmost and southwest parts of Routt County and northeastern Rio Blanco County occupy the northern fringes of the Flat Tops area of the White River Plateau. In this mountainous region, elevations are mostly between 8,500-11,000 feet. From east to west, Sand Point (11,182 feet), Pyramid Peak (11,611 feet), Pagoda Peak (11,120 feet), Sleepy Cat Peak (10,848 feet), and Uranium Peak (9,351 feet) are the dominating features. To the northeast, north, and northwest of these peaks, long ridges and "flat tops" or mesas descend to the lower elevations of Williams Fork Mountains and Danforth Hills. Thornburgh Mountain (8,057 feet), long and sinuous, is one such ridge. Although this is a high and mountainous region, relief is mostly more subdued than in the Park Range. The White River and its upper tributaries, and the Yampa and several of its tributaries, and the Williams Fork River have their source in this northern Flat Tops area.

The Yampa River has a broad and flat to slightly rolling flood plain a few miles wide. The valley occupied by the Yampa River continues southeastward from the town of Yampa to about three miles south of Toponas; drainage west and south of Toponas is southward into the Colorado River. The rolling surface of this valley is interrupted at several places from the vicinity of Phippsburg to near Toponas by volcanic plugs which protrude abruptly a few hundred feet above the general surface. The Yampa River drops from an altitude of 7,320 feet just south of Oak Creek to 6,960 feet at the head of Pleasant Valley north of Blacktail Mountain, to 6,680 feet at Steamboat Springs, and 6,170 feet at Craig.

In one of the main coal mining areas of this region, between Oak Creek and the site of Mount Harris on the Yampa River, the surface includes gently rolling to relatively rugged hills. Some of the latter have a long, fairly gentle-to-moderate slope on one side and a steep slope with some cliffs on the other. Elevations between Oak Creek and Mount Harris vary from 6,500-8,600 feet and relief is mostly moderate, except in Twentymile Park where it is low.

The moderately rugged Williams Fork Mountains and Danforth Hills, with elevations of 6,800-8,800 feet and generally moderate relief, are lower mountain ranges trending northwesterly from the foothills area of White River Plateau region. Iles and Duffy Mountains, with total relief of about 1,300 feet and maximum elevation of 7,510 feet, may be considered western segments of Williams Fork Mountains. Williams Fork River, flowing in a narrow rocky canyon, separates Iles Mountain from Williams Fork Mountains; Milk Creek, in a similar canyon, separates Iles from Duffy Mountain. Between Iles and Duffy Mountains on the north, and Danforth Hills on the south, lies the Axial Basin, a flat-to-gently-rolling area about 6,600-6,700 feet in elevation. The relatively isolated Juniper Mountain, rising abruptly from 6,600 to 7,874 feet in elevation within two miles, blocks the Axial Basin to the northwest.

Meeker lies at the western edge of a broad bowl-like topographic basin that has a flat-to-broadly-rolling to partly-hilly surface. The flat area along the White River near Meeker is known as Agency Park. This basin is surrounded by Danforth Hills on the northwest, White River Plateau and its foothills on the northeast, east, and south, and by ridges of Grand

Hogback on the west. The northern rim of the basin near Meeker is steep and curved to give an amphitheatre effect. Little Beaver Creek joins Coal Creek which flows into the White River just above Meeker.

West of the Danforth Hills are the Gray Hills, Colorow Mountain, and Citadel Plateau, where relief is moderate-to-low, and elevations are generally about 6,800-8,300 feet. Gray Hills is the name given to a high northwest-trending ridge that is separated from Danforth Hills by Strawberry Creek valley. Colorow Mountain and Dick Ridge are two of several southwest-trending ridges which descend from the Gray Hills. Citadel Plateau, separated from Gray Hills by Deep Channel Creek and only partly separated from Danforth Hills, is an area of small high mesas and long narrow ridges; Escarpment Peak (8,014 feet) is the highest point. Small tributaries of the White River drain this general area.

North and northeast of Williams Fork Mountains, a broad and rolling open area slopes gently northward for a distance of 4 to 8 miles to westward-flowing Yampa River. Elevations here are about 6,200-6,800 feet. This segment begins at the east near Mount Harris. Between Hayden and Craig, gently rolling country opens northwest to merge with Sand Wash Basin.

Sand Wash Basin, covering most of Moffat County, is an area of predominantly broad rolling plains with local hilly areas, ridges and buttes. Much of it is drained by Little Snake River and its tributaries. Elevations generally are about 6,200-7,200 feet, but range from 5,800 feet in Little Snake River valley to 8,120 feet on Vermillion Bluffs. Vermillion Creek drains the western part of the basin, west of Vermillion Bluffs. Little Snake River, flowing eastward along the northeast side, mostly in Wyoming, turns south and flows through the central part and joins Yampa River about ten miles south of the basin between Cross Mountain and Uinta Mountains. Timberlake Creek and Scandinavian Gulch are the most important tributaries of Little Snake River in the northeastern part of the basin. Fortification, Lay, and Spring Creeks draining southward to the Yampa are separated from Little Snake drainage by a relatively high westward-trending divide that begins at Black Mountain, at the west edge of the Elkhead Mountains, and terminates on the west in Bald Mountain (7,228 feet) and Godiva Rim (about 7,200 feet).

Western Moffat County is dominated by two eastward and southeastward-trending prongs of the Uinta Mountains (Hanson 1969). The northern prong may be divided into Cold Spring and Diamond Mountain highlands, and the southern prong into Douglas Mountain and Blue Mountain highlands. The Yampa River, flowing westward in a deep canyon, is the boundary between the latter two highlands. Between the two prongs is a valley, about four miles wide and more than 25 miles long, known as Browns Park; Green River flows eastward through this valley and then turns southward to cut through the southern prong of the Uintas in the deep Canyon of Lodore. Vermillion Creek flows from Sand Wash Basin, southward across the northern prong of the Uinta Mountains, then northwest in Browns Park valley to join Green River. Diamond Peak (9,710 feet) is the highest point in the eastern Uinta Mountains, and the lowest is in Whirlpool Canyon of the Green River at the Utah boundary (5,080 feet). Relief varies from moderate to very high. The landforms include craggy peaks, ledges and ridges, broad open rolling highland areas, large flat-topped mesas, steep and partly vertical escarpments and cliffs, deep canyons, and narrow gorges and chasms. Relief is from 1,000-3,000 feet in canyons of Green and Yampa Rivers; Dinosaur National Monument includes these canyons.

Skull Creek Basin, partly surrounded by Skull Creek Rim, is a prominent topographic feature on the south flank of Blue Mountain highland. Relief is moderate and elevations are from about 5,800-7,700 feet.

Cross Mountain, a relatively small feature just beyond the eastern end of the Uinta Mountains, and separated from them by Little Snake River, is of moderate relief and ranges in elevation from about 6,000-7,804 feet. Yampa River cuts across the southern end of Cross Mountain in a canyon that is more than 1,000 feet deep.

The area between the Uinta Mountains and Cross Mountain on the north, and the White River on the south is characterized by broad, open plains with low relief, interrupted by long and wide-to-narrow ridges and some moderately hilly land. Elevations range from about 5,200-7,700 feet. Principal features are Elk Springs Ridge with Wapiti Peak (7,702 feet), Pinyon Ridge, Coal Ridge, Coal Oil Rim and Coal Oil Basin of the Rangely oil field area, and Raven Ridge which trends northwesterly into Utah. Several intermittent streams drain the area and are tributaries of White River.

Stratigraphy

Regional stratigraphy

There are approximately 50 named stratigraphic formations or groups in the study region. Distribution of most of these formations is shown on various regional maps, particularly those compiled by Burbank and others (1967), Miller (1975), and Tweto (1975 a, b). The two maps by Tweto have been used to compile the geologic map for the present report (Appendix A). A summary of various characteristics of these formations is presented in Appendix A of this report.

The basic stratigraphic unit used by geologists is the "formation", which is defined as a mappable geologic unit. Two or more formations may constitute a "group", and any given formation may have one or more formal or informal "members." An example of the use of this nomenclature is as follows:

Mesaverde Group
  Williams Fork Formation
    unnamed upper part
    Twentymile Sandstone Member
    unnamed main part
  Iles Formation
    Trout Creek Sandstone Member
    unnamed main part
    Tow Creek Sandstone Member

The Lexicon of Geologic Names of the United States (Keroher et al, USGS Bulletin 1200, 1966) describes such units as to geographic area, lithology, age, etc. Age of a stratigraphic unit is described as shown in Table RIV-1.

Coal beds of economic interest are present only in strata of Late Cretaceous and Tertiary age. These will be more fully described in the following part of this report.

The oldest rocks present form the core of the eastern Uinta Mountains

TABLE RIV-1

Major Stratigraphic and Time Divisions in Use by the U. S. Geological Survey

Era	System or Period	Series or Epoch	Estimated ages of time boundaries in million of years 1/ (A)	(B)
	Quaternary	Holocene		
		Pleistocene	1.5-2	1.8
		Pliocene	ca.7	5.0
		Miocene	26	22.5
Cenozoic	Tertiary	Oligocene	37-38	37.5
		Eocene	53-54	53.5
		Paleocene	65	65
	Cretaceous	Upper (Late)		
		Lower (Early)	136	
		Upper (Late		
Mesozoic	Jurassic	Middle (Middle)		
		Lower (Early)	190-195	
		Upper (Late)		
	Triassic	Middle (Middle)		
		Lower (Early)	225	
		Upper (Late)		
	Permian	Lower (Early)	280	
		Upper (Late)		
	Pennsylvanian	Middle (Middle)		
		Lower (Early)	320	
		Upper (Late)		
	Mississippian	Lower (Early)	345	
		Upper (Late)		
Paleozoic	Devonian	Middle (Middle)		
		Lower (Early)	395	
		Upper (Late)		
	Silurian	Middle (Middle)		
		Lower (Early)	430-440	
		Upper (Late)		
	Ordovician	Middle (Middle)		
		Lower (Early)	ca.500	
		Upper (Late)		
	Cambrian	Middle (Middle)		
		Lower (Early)	570	
Precambrian				

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle and upper may be used where there is no formal subdivision of a system or of a series.

1/Estimates for ages of time boundaries are under continuous study and subject to refinement and controversy. Two scales are given for comparison:

(A) Geological Society of London, 1964, "The Phanerozoic Time-scale; a Symposium", Geological Society London, Quarterly Journal, v. 120, suppl., p. 260-262.

(B) Berggren, W. A., 1972, "A Cenozoic Time-scale--Some Implications for Regional Geology and Paleobiogeography, Lethaia, v. 5, no. 2, p.195-215.

and the bulk of the Park Range. These rocks are of Precambrian age as are outcrops in Juniper and Cross Mountains. These rocks have been described by Hansen (1965, 1969) in the Uinta Mountains; on Juniper Mountain by Abrassart and Clough (1955); and at Cross Mountain by Dyni (1968), Kanizay (1938), and McKay (1974).

The strata younger than and overlying the Precambrian rocks are almost entirely of sedimentary origin. These sedimentary formations vary in thickness and lithology from place to place. Some units are relatively uniform over large areas whereas others undergo abrupt variations. Thus different names are used for stratigraphically equivalent, and in some cases, lithologically similar units in different localities. One of the most common variations is from non-marine coal-bearing strata to marine non-coal-bearing strata.

After the Precambrian, the next younger strata are of Paleozoic age; these rest on or adjacent to the Precambrian rocks in the southeastern and western parts of the region. Equivalent strata were removed by erosion before deposition of still younger rocks in some areas, as along the west side of the Park Range. All but the youngest Paleozoic rocks have also been removed by erosion in the area of the Yampa coalfield, and thus are not found when drilling for oil there, as in the Tow Creek oil field. The Paleozoic strata are composed mostly of marine limestones, dolomites, sedimentary quartzites, and interbedded shales. A brief history of northwestern Colorado (Haun 1962) describes the origin of these and succeeding strata.

The strata of early and middle Mesozoic age (Triassic and Jurassic systems) are mostly reddish sandstones, mudstones, siltstones, and shales, with some conglomerate and thin limestone and gypsum beds or lenses. These were mostly of continental origin.

Formations of late Mesozoic age (Cretaceous) are the oldest strata that have coal beds of economic interest in northwestern Colorado. Sediments comprising the oldest Cretaceous strata of the region, the Dakota, Mowry, Frontier, Niobara, and Mancos formations, were deposited under marine and near-marine conditions. After deposition of the Mancos Shale, sediments of the Iles and Williams Fork Formations were deposited mostly in terrestrial environments, including swamps where organic materials accumulated ultimately to be changed to the present coal beds. Fluctuations of sea level continued, so that occasional sediments of marine or near marine origin are interbedded with the non-marine coal-bearing beds. The twentymile and Trout Creek Sandstone Members, for example, are beach sands; and the upper part of the coal-bearing Williams Fork Formation grades and interfingers eastward with marine beds of the Lewis Shale. Following deposition of sediments of the Lewis Shale, Fox Hills Sandstone, and perhaps lower beds of the Lance Formation under marine or near-marine conditions, the seas withdrew from the region for the last time. The latest Cretaceous sediments were deposited under terrestrial conditions, including swamps in which organic debris accumulated to later form the coal beds of the Lance Formation. Ritzma (1955) provides a brief history of the end of the Cretaceous and early Cenozoic time in this region.

Cenozoic time began during uplift of mountain ranges, including the Park Range and the Uinta Mountains, and formation of large intermountain basins. These earth movements changed the nature of sedimentation in the region; thus the strata present in these formations differ somewhat from those in the older formations.

During parts of earliest Tertiary time, in the Paleocene epoch, swamps were present, and the accumulated organic material became the coal beds of the Fort Union Formation. These coal beds are thus approximately the same age as the lignites of Montana and North and South Dakota, some of the Powder River Basin coal beds, and the lignite beds of the Denver Basin (Soister 1974).

Sedimentation in these intermountain basins throughout the Tertiary was mostly in stream channels and floodplains and in lakes, with modifications by ash falls from volcanic activity. The greatest part of the post-Fort Union strata are of Eocene age. These beds in northwestern Colorado and southwest Wyoming (Sand Wash Basin) are described by Bradley (1964).

After these rocks were deposited, igneous intrusions and volcanic lava flows in the White River Uplift area and along the west side of the Park Range produced basaltic lavas that overlie the Browns Park Formation and older rocks. In the Elkhead Mountains area and further south, coal beds were locally metamorphosed to higher rank coal by the heat from some of these intrusive bodies.

During Quaternary time, and extending to the present, erosion and removal of sediments from the older rocks has been the dominant process. Glacial moraine deposits, river terrace gravels, alluvium, talus, landslides, slumps, rockfalls, loess, colluvium, eolian sand, and calcareous tufa deposits have formed during the Quaternary.

Coal stratigraphy

Coal has been found in several formations in northwestern Colorado. The oldest coal reported is in "Older Pennsylvanian rocks" (now Morgan Formation) in T.10.N., R.101W., west of Vermillion Creek; here Sears (1924) measured a stratigraphic section which had "thin irregular beds of coal" in a sequence of limestone, sandstone, and shale. The next oldest known is in the Dakota Sandstone at Steamboat Springs where Blackmer (1939) reported "a small seam of coal, two to three inches thick, 77 feet from the top of the Dakota . . . ". Neither of these coal occurrences are of economic interest.

Coal beds of economic interest occur in the Iles and Williams Fork Formations of the Mesaverde Group, and the Lance Formation, all of Late Cretaceous age, the Fort Union Formation of Paleocene age, and locally in the Wasatch Formation of early Eocene age. The sequence of these coal bearing rocks is shown in Figure RIV-1 from Bass, Eby, and Campbell (1955).

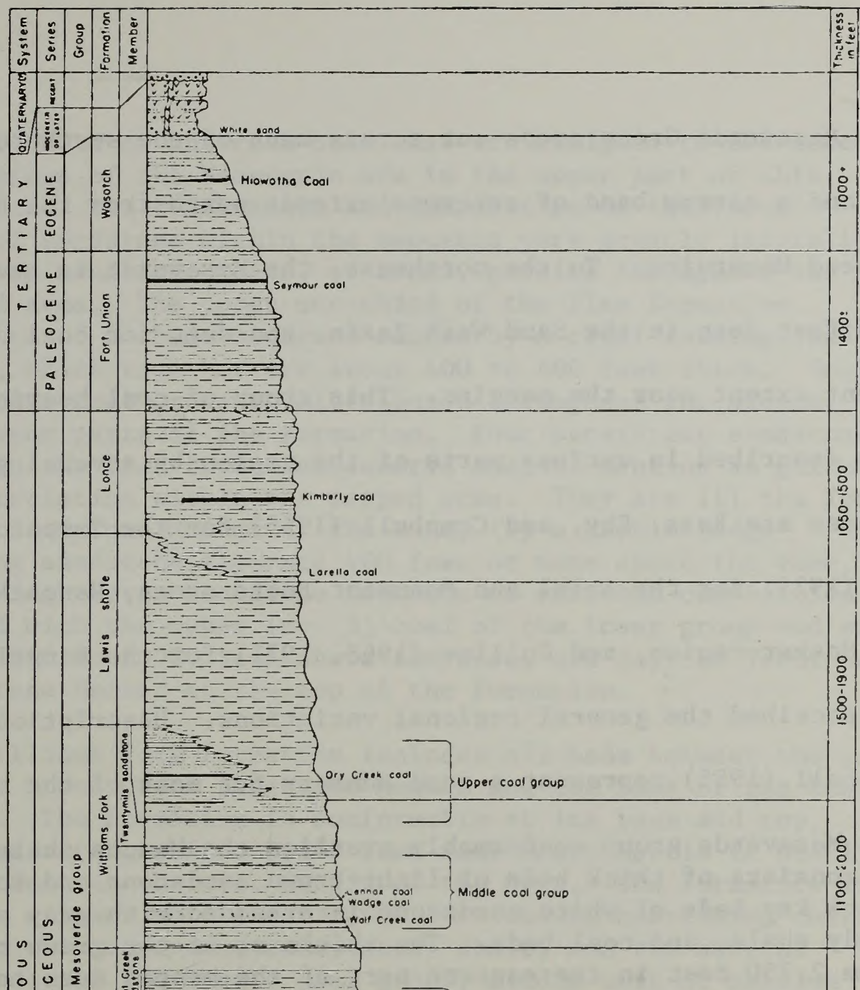


FIGURE RIV-1

Stratigraphic section of coal-bearing formations of northwest Colorado.

SOURCE: U.S. Geological Survey Bulletin 1027

The Mesaverde Group crops out across much of the southern half of the region, and a narrow band of outcrops extends north from the Hayden area to the Elkhead Mountains. To the northwest, the Mesaverde is several thousand feet deep in the Sand Wash Basin, too deep for coal development at present except near the margins. This group of coal-bearing rocks has been described in various parts of the region by several geologists. Among these are Bass, Eby, and Campbell (1955) for the Yampa coal field, Hancock (1925) for the Axial and Monument Butte areas, Hancock and Eby (1930) for the Meeker region, and Cullins (1968, 1971) for the Rangely area. Gale (1910) described the general regional variations. Descriptions by Bass, Eby, and Campbell (1955) represent a good summary for most of the region:

> The Mesaverde group conformably overlies the Mancos shale. It consists of thick beds of light-brown sandstone and some thick key beds of white sandstone interbedded with gray shale, sandy shale, and coal beds. The thickness of the group ranges from 2,750 feet in the eastern part of the mapped area to 3,450 feet in the western part. Its westward increase in thickness is due chiefly to a change of facies of the beds in the lower part of the Lewis shale, which directly overlies the Mesaverde. These beds consist of marine shale in the eastern half of the area, where they are placed in the Lewis shale, and they change westward into interbedded sandstone, sandy shale, and coal, and these are included in the Mesaverde group.
>
> In the area adjacent on the west to the mapped area, the Mesaverde group was divided into two formations by Hancock (1925): the Iles formation below and the Williams Fork formation above. The two formations and their members are readily recognizable in the mapped area.
>
> The Iles formation, in the lower part of the Mesaverde group, consists of a sequence of rocks about 1,500 feet thick. The lower two-thirds of the formation, 1,000 to 1,100 feet thick, consists of massive ledge-forming beds of light-brown, light-gray, and white sandstone interbedded with gray sandy shale, shale, and in its upper part, coal beds. This sequence forms rugged cliffs that rise high above the broad lowland formed on the Mancos shale. Such cliffs are particularly prominent in the Williams Fork Mountains north of the Williams Fork

River. Most of the coal beds that are assigned to the lower coal group of the Mesaverde are in the upper part of this sequence. The thicknesses and composition of individual beds of sandstone within the sequence vary greatly laterally, but some sandstone units, or zones, persist throughout the mapped area. The upper one-third of the Iles formation consists of a shale sequence capped by a cliff-forming sandstone, which together are about 400 to 600 feet thick. Coal of the lower coal group is distributed throughout the middle and upper parts of the formation. Four persistent sandstone beds in the Iles formation deserve special mention as guides to correlation within the mapped area. They are (1) the Tow Creek Sandstone Member at the base, (2) a double ledge-forming sandstone sequence 400 feet or more above the vase, (3) a light-gray sandstone sequence of variable composition associated with the upper (no. 3) coal of the lower group and situated about 900 to 1,000 feet above the base, and (4) the Trout Creek Sandstone Member at the top of the formation.

The Williams Fork formation includes all beds between the top of the Trout Creek Sandstone Member and the base of the Lewis shale. The formation is conformable at its base and top. Its thickness ranges from 1,100 feet near Mount Harris to nearly 2,000 feet at the west margin of the area. The formation includes a lower unit about 1,000 feet thick, consisting chiefly of shale, thin sandstone beds, sandy shale, and the several coal beds of the middle coal group, middle unit of massive white cliff-forming sandstone about 100 to 200 feet thick, called the Twentymile Sandstone Member; and upper unit of interbedded sandstone, sandy shale, shale, sandstone and the coal beds of the upper coal group.

Lower unit. - The lower unit of the Williams Fork formation is important because it contains several thick coal beds of the middle coal group. These beds include the Wolf Creek, Wadge, and Lennox beds in the Mount Harris and Oak Creek districts, and 3 to 4 beds that are greater than 5 feet thick and other thinner beds in the Williams Fork Mountains district. Logs of core holes and outcrops show that much of the lower half of the unit consists chiefly of soft sandstone, thin-bedded sandstone, sandy shale, coal beds, and thin beds of dark-gray to black shale. Although the upper half of the unit contains a few beds of sandstone, it consists chiefly of shale. In most places the coal-bearing part of the unit commonly forms fairly steep slopes above the Trout Creek Sandstone Member. In Williams Fork Mountains area these beds form red, rocky slopes (the color results from the natural burning of the outcropping coal). At several places in the mapped area, long dip slopes are formed by interbedded thin sandstone and sandy shale beds that lie 50 to 75 feet above the Wadge coal bed. At these places it may be possible to mine the Wadge and Lennox beds by stripping. In most places the upper half of the unit forms a broad lowland between the coal-bearing beds below and the ledge-forming Twentymile sandstone member above.

Twentymile Sandstone Member. - The twentymile sandstone member of the Williams Fork formation is similar in composition, color, and habit of outcrop to the Trout Creek Sandstone Member of the Iles Formation, from which it is separated by 900 to 1,100 feet of beds. It is a massive, white, ledge-forming sandstone about 100 to 200 feet thick and forms a prominent white ledge at the top of a steep slope rising above the broad lowland.

Upper unit. - The upper unit of the Williams Fork formation lies above the Twentymile Sandstone Member. It has the greatest range in thickness of any part of the formation. In the vicinity of Mount Harris, Twentymile Park, and Fish Creek, the thickness of the unit is about 200 feet. Here the unit consists of beds of sandstone, sandy shale, dark-gray shale, and one coal bed about 3 feet in thickness. It is overlain by gray shale beds of the Lewis shale. Westward, the western edge of the mapped area is about 850 feet in thickness. The lowermost beds of shale of the Lewis change westward to sandy shale, sandstone, and coal beds, and are there included in the Williams Fork formation. At Dry Creek, for example, several workable coal beds, including the thick Dry Creek coal bed, are present in this upper unit of the formation. In places, the upper unit includes several massive white sandstone beds that resemble the Twentymile member. One of these, which lies about 25 to 50 feet above the Twenty-mile member, is well exposed on Dry Creek. Another, near the top of the unit, forms conspicuous ledges near the west margin of the area and extends many miles beyond the area; it is particularly well exposed in T.6.N., R.92.W. (Hancock 1925).

The Williams Fork Formation increases greatly in thickness westward toward Meeker, where Hancock and Eby (1930) measured as much as 5,050 feet near the head of Strawberry Creek. Further west it thins to 2,650 feet in the Smizer Gulch area near the White River (Hail 1973).

The entire Mesaverde Group thins westward to about 2,400 feet in the Rangely area, where it is described by Cullins (1971) as follows:

East of Douglas Creek, the Mesaverde Group is divided, in ascending order, into the Sego Sandstone, the Iles Formation including the Trout Creek (?) Sandstone Member at the top, and the Williams Fork Formation.

The sandstone mapped as Trout Creek is tentatively correlated with the unit mapped as Trout Creek in the Elk Springs area by Dyni (1968) although in the Rangely area the Trout Creek is probably nonmarine. This member cannot be mapped on the west side of Douglas Creek with any degree of certainty. Therefore, because Douglas Creek is a well-known geographic feature to workers in western Colorado, it makes a very suitable boundary for the westernmost limit of the Trout Creek, and consequently, use of the Iles and Williams Fork Formations. West of Douglas Creek, informal units are mapped as part of the Mesaverde Group (undifferentiated).

East of Douglas Creek:

Williams Fork Formation

Interbedded grayish-orange to yellowish-gray fine-grained lenticular sandstone, gray shale, brown carbonaceous shale, and coal beds as much as 8 feet thick; numerous occurrences of strata baked by the in situ burning of coal beds. Equivalent to upper, main coal, and upper 250 feet of minor coal units. About 1,890 feet thick.

Iles Formation

Trout Creek(?) Sandstone Member. Light- to brownish-gray fine-grained massive porous sandstone; about 60 feet thick.

Main body. Interbedded light-brown and yellowish-gray fine to very fine grained sandstone, gray shale, brown carbonaceous shale, and thin coal beds; equivalent to lower two-thirds of the minor coal unit west of Douglas Creek; about 500 feet thick.

West of Douglas Creek:

Upper unit: Interbedded brown to yellowish-gray massive lenticular sandstones and yellowish-gray shale; about 1,100 feet thick.

Main coal unit: Interbedded grayish-orange very fine grained lenticular sandstone, gray shale, brown carbonaceous shale, and coal; thickest coal beds in lower part; maximum measured coal bed thickness is 15 feet (SE 1/4 Sec. 8, T.1N., R.102W.); about 540-680 feet thick.

Minor coal: Interbedded light-brown and yellowish-gray fine to very fine grained sandstone, gray to light-brownish gray shale, brown carbonaceous shale, and thin coal beds as much as 2.5 feet thick; base probably marks change from underlying marine strata to continental and brackish water strata; about 690-720 feet thick.

Sego Sandstone
Very light gray fine-grained massive sandstone, containing Inoceramus sp., at top; brownish-gray sandy shale in middle; and yellowish-gray to grayish-orange fine-grained sandstone at base; about 200-210 feet thick.

The Lewis Shale, generally about 1,000-1,900 feet thick, intervenes between the underlying coal-bearing Williams Fork and the overlying coal-bearing Lance Formation in the study region and intertongues with both.

The Lewis Shale and Lance Formation apparently are absent south and southwest of a line from Iles Mountain to Cross Mountain. Relations of the Lewis to the Lance in the Craig area are described by Bass, Eby, and Campbell (1955) as follows:

> In the westernmost part of the area the boundary is drawn below a massive sandstone that forms a rim rock. This rim rock is conspicuous half a mile north of Craig. North of Yampa River in the central part of the mapped area, a sequence about 500 feet thick, consisting of beds of lenticular sandstone, sandy shale, shale, coal, and coaly shale, forms a transition zone above the main body of marine shale of the Lewis shale. Much of this sequence lies stratigraphically below the rim rock sandstone of the western part of the area, according to Eby's tentative correlations. The boundary between the Lewis shale and Lance formation north of Yampa River was drawn at the base of a coarse-grained sandstone which is at the base of the sequence and 50 feet below a thick coal bed locally called the Lorella coal. The boundary was drawn arbitrarily because lenticular beds of sandstone and sandy shale are present below it.

Very little study has been made of the Lance Formation. Bass, Eby, and Campbell (1955) state that its thickness is about 1,050-1,500 feet (in the Yampa coal field area), and describe it as follows:

> It consists of interbedded gray shale, light-buff, and light-tan, soft, fine-grained sandstone, and a few coal beds. Of the coal beds, the Kimberley is the only one in the formation that is of much economic value. In the westernmost part of the area a thick ledge-forming, white to gray sandstone lies at the base of the formation and a thick, coarse-grained white sandstone is at the top. The basalt sandstone forms a rim rock half a mile north of Craig, and the upper sandstone forms a rim rock 3 miles north of Craig. North of Yampa River, in the north-central part of the mapped area, the Lance formation extends stratigraphically lower than in the westernmost part.

The coal-bearing Fort Union Formation of Paleocene age overlies the Lance Formation and occupies the same general areas. However, it is more extensive than the Lance, as it has been mapped as far southwest as the Smizer Gulch area between Meeker and Rangely (Hail 1973). The formation is described in the Yampa coal field area by Bass, Eby, and Campbell (1955) as follows:

> The Fort Union formation overlies the Lance formation and consists of interbedded brown sandstone, gray shale, and coal beds. The formation is similar to the Lance in general aspect, but differs from it considerably in details. The sandstone beds are coarser, the shale is prevailingly a lighter gray, and there are more ferruginous layers in the Fort Union than in the Lance. Fresh surfaces of the sandstone are speckled with white. At several horizons coal beds are present and some are locally quite thick. A conglomerate lies at the contact with the Lance formation; however, there is little clear local evidence of erosion. The age of the formation is indicated by fossil leaves.
>
> The thickness of the Fort Union formation cannot be directly measured anywhere in the area, but on the basis of data assembled during the mapping it is estimated to be about 1,400 feet.

Masters (1961) indicates a thickness for the Fort Union Formation of about 2,500 feet in the northern part of the Sand Wash Basin; the thickness is probably greater near the middle of this basin. McKay (1974) indicates a thickness of 800-2,500 feet near the southwest edge of the basin. Hail (1971) gives an approximate thickness of 1,675 feet in the Smizer Gulch area, and describes the formation as follows:

> Upper member - Brown to gray shale, carbonaceous shale, and minor coal shale; thin relatively persistent sandstone beds; lesser claystone and siltstone. Fossil pollen locality D4632, about 50 feet below top of member: age late Paleocene. Fossil pollen locality D4631, about 70 feet above base of member: age late Paleocene. Thickness near White River about 525 feet.
>
> Lower member - Olive-green to gray claystone; light brown to light-gray lenticular sandstone, mostly cross bedded to massive; sparse clay-pebble conglomerate; minor siltstone and mudstone; very sparse limestone and carbonaceous shale. May locally include equivalent of Ohio Creek(?) Formation at base, where not mapped separately elsewhere. Fossil pollen locality D4633; about 320 feet below top of member: age middle to late Paleocene. Fossil pollen locality D4629 about 350 feet above base of member: age early to middle Paleocene. Thickness near White River about 1,150 feet.

The Wasatch Formation, youngest known coal-bearing formation in the study region, has known coal beds mainly in the Hiawatha oil field area near the northwest corner of Colorado (Hornbaker, Speltz, 1973). Throughout most of the study region, the Wasatch consists mostly of medium to coarse-grained sandstone, drab to variegated mudstone, and some carbonaceous shale. Just north of the State boundary, in Wyoming, Roehler (1972 a, 1973 a) has noted thin coal beds in two members of the Green River Formation, but there are probably no beds of economic interest.

Structure

The overall structure of northwest Colorado is quite complex. The principal structural elements are the Park Range along the east side, the Uinta Mountains on the west, the White River Uplift on the south, and the Sand Wash Basin on the north. Subsidiary structures, folds and faults are shown on Foldout Map No. 4 in Appendix B.

A complex belt of folding with some faulting extends from near southern Routt County west-northwestward to the Uinta Mountains; the main coal mining area of the region, bounded by Oak Creek, Craig, and Meeker, lies in this fold belt.

The northern end of the Piceance Basin, termed the Coyote Basin during the 19th Century Hayden survey (Gale 1910), lies between this fold belt and the Rangely area. Rangely lies on the Douglas Creek Arch, which extends south from the Uinta Mountains to partially separate the Piceance Basin from the Uinta Basin in Utah.

Individual folds and faults are shown on Foldout Map No. 4 in Appendix B and on the large geologic map in Appendix A. As shown there, the most important coal bearing formations commonly occupy the flanks of anticlines. North and northwest of Craig, the coal bearing formations increase in depth to several thousand feet in the Sand Wash Basin.

Geomorphology

The dominating geomorphic features of northwest Colorado, the Park Range, Uinta Mountains, and White River Plateau ("The Flattops") have cores of hard, resistant Precambrian rocks, which are mostly flanked by fairly resistant Paleozoic and early Mesozoic strata.

Most of the region between these mountainous areas is underlain by somewhat less resistant strata of late Mesozoic and Tertiary age, so more subdued landforms are present there. However, there are some exceptions to this general rule: Cross and Juniper Mountains are small isolated anticlinal and faulted features that owe their presence to hard Precambrian and Paleozoic rocks.

Another exception is numerous volcanic plugs, dikes, domes, and lava flow remnants that occur northward from the White River Plateau area to the Elkhead Mountains and further north. These volcanic remnants are of more resistant rocks than the surrounding strata, and as a result of erosion, stand as chimney-like structures or cap high flat-topped hills. In areas where the strata underlying lava flows is quite soft, as is the case of the Browns Park Formation in the Elkhead Mountains, these high slopes are very susceptible to landslides.

The belt of folds between Oak Creek, Craig, and Meeker involves Late Cretaceous rocks, including the principal coalbearing formations. The combination of these folds and thick formations of soft and harder rocks has produced the setting for the principal coal mining. Some anticlines are breached so that the Mancos Shale is at the surface along the axis, and the harder Iles and Williams Fork Formations occupy flanking ridges. The Axial Basin is the largest of these breached anticlines; a wide gently rolling valley is formed on the Mancos Shale, and the flanks are occupied by the more resistant beds of the Iles Formation, which form part of the Danforth Hills to the south, and Iles and Duffy Mountains to the north. Flanks of the anticlines are typically eroded into long high cuestas. The gentle slope of the cuesta, where beds dip generally about 8°-15°, provides the typical setting for mining of the coal beds of the Mesaverde Group. The coal-bearing formations dip under the soft Lewis Shale in synclines, such as the Twentymile Park Syncline; in situations like this, strip-mining can take place only along the edges of the synclinal areas.

The Sand Wash Basin is mostly underlain by rocks that have low resistance to erosion. Consequently landforms in this basin are mostly of the wide rolling plains types, with gulley erosion and some badland areas along the lower slopes of escarpments and ridges.

A characteristic geomorphic feature of northwestern Colorado is streams superimposed on ridges, hills, and mountains of hard rocks, and entrenched meanders along most of these streams. The Yampa and Green Rivers are classical examples. From Craig, the Yampa meanders south to flow in giant entrenched meanders cut into the hard Iles and Williams Fork Formations on the north flank of Iles and Duffy Mountains, rather than continuing west on the softer Lewis Shale and Browns Park Formation. Further west the Yampa cuts through very hard limestone beds of the Morgan Formation on the north slope of Juniper Mountain, rather than through the softer Browns Park Formation. Still further west it flows in a steep canyon entrenched across the hard strata of Cross Mountain, and a few miles further enters the Uinta Mountains, flowing in very deep canyons cut through hard rocks of Dinosaur National Monument. The Green River similarly has cut the deep Canyon of Lodore through very hard Precambrian rocks of the Uinta Mountains.

These seemingly anomalous river courses have been formed by a process known as superposition. In late Tertiary time, when the thick Browns Park Formation covered the region more completely, including the breached anticlines, the general land surface was much higher than at present. As the soft Browns Park strata were removed by erosion, the ancestral Yampa River and other streams became entrenched in deep valleys. With continued erosion and lowering of the surface, these streams, being unable to escape from their deep valleys, were let down, or superposed, upon hard underlying strata and were thus forced to cut the deep canyons present today.

Studies of these superimposed streams have been made by several geologists, among them Bradley (1936), Hansen (1965, 1969) and Sears (1924, 1962). Gale (1910) gives a good description of some of the geomorphic elements of the region.

Paleontology

Paleontology has been studied in several parts of the region through the years. The Powell and Hayden surveys traversed the area and completed the first inventory of the region's fossils. More recently, parts of the area have been geologically mapped and some paleontological studies have been completed; however no regional paleontological study has been done. Among those who have studied paleontology in the region are: W. Cobben, vertebrate fossils; and Peterson, Miocene vertebrates. The fossiliferous formations (Figure RIV-1a) in the area can be classified into two general categories: marine and terrestrial. Fossils are found in most sedimentary rocks and are particularly common in shales and limestone. The majority of fossils represent marine animals, as conditions for preservation are usually better in aquatic than in terrestrial environments. In many cases, terrestrial animals and plants are preserved in water-laid sediments such as lakes, swamps, or rivers. Trace fossils (footprints, imprints, burrows) are recognized throughout the region.

Figure RIV-1a should be compared to the Geologic Map of Northwest Colorado (Appendix A) to determine potential fossil-bearing areas in the region.

ERAS	PERIODS AND SYSTEMS	EPOCHS AND SERIES	FORMATION	ENVIRONMENT	COMMON FOSSILS PRESENT	REFERENCES
CENOZOIC	TERTIARY	Miocene	Browns Park Formation	Fluvial Lacustrine; Eolian, Tuffs Airborne from Distant Volcanos	Ostracodes and Diatoms Vertebrate Fossils; Camel, Horse	Hansen, 1965 Peterson, 1928 McGrew, 1951
		Miocene	Bishop Cong-lonbrate	Fluvial	Non Fossiliferous	
		Eocene	Bridger Formation	Fluvial	Vertebrate Fossils	Gazin, 1959
		Eocene	Green River Formation	Fluvial Lacustrine	Vertebrate Fossils Fossil Fish; Fossil Leaves & insects. Fresh Water Gastropods & Pelecypods	Robinson, 1974 Bradley, 1964
		Paleocene and Eocene	Wasatch Formation	Fluvial and Lacustrine	Vertebrate Fossils, mammals Some Ostracodes and Gastropcds	McKenna, 1955
		Paleocene	Fort Union Formation	Fluvial in Part of Swamps and Marshes	Vertebrate fossils Fossil Leaves	Robinson, 1974 Hansen, 1965
		Paleocene	Ohio Creek Formation	Fluvial	Non Fossiliferous	
MESOZOIC	CRETACEOUS	Upper Cretaceous	Lance Formation	Fluvial import swamps	Non Fossiliferous A few leaf fossils Vertebrate fossils	Dorf, 1910 Robinson, 1974
		Upper Cretaceous	Lewis Shale	Marine off-shore	Marine Fossils - Ammonites	Dorf, 1938,194
		Upper Cretaceous	MESAVERDE GROUP: Williams Fork Formation	Fluvial in Part Swamps Litteral some Marine Shales	Fossil Leaves in Steamboat Springs and in the Coal Ammonities and Inoseramus Clams in Marine Shales	Bass, Eby, Campbell, 1955
		Upper Cretaceous	MESAVERDE GROUP: Iles Formation	Fluvial in Part Swamps Litteral some Marine Shales	Fossil Leaves in Steamboat Springs and in the Coal Ammonities and Inoseramus Clams in Marine Shales	Bass, Eby, Campbell, 1955
		Upper Cretaceous	Mancos Shale	Marine Offshore	Ammonites--Baculites Scaphites Inoseramus Clams	
		Upper Cretaceous	Frontier Sandstone	Marine Brackish Water	Pelecypods, Shark Teeth, and Plant Fossils	
		Lower Cretaceous	Mowry Shale Member of Mancos	Marine Offshore	Carbonized wood, Cyclord Fish Scales, Fish Bones	
		Lower Cretaceous	Dakota Sandstone	Fluvial, Marshes and Swamps	Silicified Wood, Ferns Dinosaur, Mollusk	Waage, 1959

FIGURE RIV-1a

Fossiliferous formations in the study region.

ERAS	PERIODS AND SYSTEMS	EPOCHS AND SERIES	FORMATION	ENVIRONMENT	COMMON FOSSILS PRESENT	REFERENCES
MESOZOIC	JURASSIC	Upper Jurassic	Morrison	Lake, Stream, Flood-plain & possibly delta deposits	Abundant dinosaur fossils	Untermann, 1949
			Curtis		Marine pelecypods, gastropods & cephalopods	Untermann, 1949
			Entrada		Non-fossiliferous	
			Carmel		Fossils uncommon	
		Middle Jurassic	Navajo	Eolian, basal layers waterlain	Dinosaur tracks	Untermann, 1949
	TRIASSIC	Upper Triassic	Chinle		Silicified wood. Phytosaur teeth & bone fragments. Amphibian bones.	Untermann, 1949
			Chinarump		Silicified wood common	Untermann, 1949
		Lower Triassic	Moenkopi		Reptilian tracks	Untermann, 1949
PALEOZOIC	PERMIAN		Park City		Gastropods & pelecypods	Untermann, 1949
	PENNSYLVANIAN		Weber		Unfossiliferous	
			Morgan		Brachiopods, corals, bryozoa & forominifera	Untermann, 1949
	MISSISSIPPIAN		Madison		Occasional fossiliferous layers. Corals, brachiopods & trilobites	Unterman, 1949
			Lodore		Frequently fossiliferous. Trilobites, brachiopods & gastropods.	Untermann, 1949

FIGURE RIV-1a (cont.)

Fossiliferous formations in the study region.

Mineral Resources

Coal

Landis (1959) describes the coal resources of northwest Colorado as follows:

> GREEN RIVER REGION
>
> The Colorado part of the Green River region, in Moffat, Routt and Rio Blanco Counties, is the southern extension of the Washakie basin of Wyoming and Colorado. All the coal reserves estimated for the Colorado part of the region lie within the Yampa coal field though coal may underlie the whole area. Structurally, the region is a broad southeastward-trending syncline with steep dips at the outcrop of the coal-bearing rocks and a gradual flattening of dip toward the center of the syncline. At the southeast edge of the area, folding, faulting, and small igneous intrusions have locally metamorphosed the coal to higher ranks than are present in the western part.
>
> YAMPA FIELD
>
> The Yampa field occupies the southern and eastern part of the Green River region. The coal occurs in the Iles and Williams Fork formations of the Mesaverde group and in the Lance and Fort Union formations. The coal of the Mesaverde group crops out in steep hogbacks on the edges of the regional syncline and ranges in rank from subbituminous to anthracitic. Most of the coal is of high-volatile C bituminous rank, with the coal in the extreme east edge of the field being of higher rank, locally anthracitic. The small tonnage of anthracitic coal in the eastern part of the field is included with the reserves of bituminous coal because it has been metamorphosed only locally near sills of basalt, and an accurate delineation of these small areas was not feasible. The subbituminous coal occurs in the upper part of the Williams Fork formation and in the Lance and Fort Union formations. In general, the outcrops of the Lance and Fort Union formations do not form as rugged a topography as does the Mesaverde group, and the coal beds are more likely to be concealed at the surface.
>
> The part of the field east of longitude 107° 30' W. is described in a report by Bass, Eby, and Campbell (1956) in which the coal reserves for the area were estimated by F. D. Spencer. Estimates of the reserves in the western part of the field are based on information contained in reports by Gale (1907, 1909, 1910), Hancock (1925), and the U.S. Bureau of Mines (1937). The coal

reserves of the field were estimated by individual bed, except the inferred coal west of longitude 107° 30' W. and south of latitude 40° 30' N., and a small area in northern Routt County, in both of which reserves were estimated on a coal-zone basis by Spencer and Erwin (1953). A total of about 23,607 million tons of coal, 76 percent of which is bituminous in rank and 24 percent of which is subbituminous, is estimated to have been originally present in an area of 828 square miles. An additional area of 852 square miles may contain minable reserves of coal with less than 3,000 feet of overburden.

DANFORTH HILLS FIELD

The Danforth Hills field comprises the area of outcrop of the coalbearing Mesaverde group on the northeast flank of the Piceance Creek basin. The regional dip is southwestward, but the regional structure is locally interrupted by several anticlines and synclines. The geology and coal resources of the field have been reported by Gale (1907 and 1910), Hancock (1925), and Hancock and Eby (1929).

As in the Grand Hogback field, the Mesaverde group consists of the Iles formation at the base and the Williams Fork formation at the top. The Trout Creek sandstone is the uppermost member of the Iles formation and is a conspicuous marker bed in the field. Three coal groups occur in the Williams Fork formation: the Fairfield group, which occupies the basal 1,300 feet of the formation; the Goff group, which occurs from 2,300 to 3,000 feet above the Trout Creek sandstone member; and the Lion Canyon group, which occupies the interval of rock from 3,000 to 4,000 feet above the Trout Creek sandstone member (Hancock and Eby, 1929, p.200-206). The Iles formation has 2 coal groups: the Black Diamond group, which occupies the interval of rock from 150 to 350 feet below the top of the Trout Creek sandstone member; and the Lower coal group, which occurs from 150 to 250 feet above the base of the Iles formation. In general, the individual coal beds within the coal groups are discontinuous and are difficult to correlate laterally. Hancock (1925, p. 40-41) and Hancock and Eby (1929, p.191) were seldom able to correlate individual beds over an area greater than one township. In this report the reserves were estimated by bed except in the northern part of the field where inferred coal reserves were estimated on a group basis, and in the part of the field west of longitude 108° W., where reserves were estimated on a coal-zone basis by Spencer and Erwin (1953).

The coal is mainly high-volatile C bituminous in rank, though some of the upper coal beds in the northern part of the field may be subbituminous.

A total of about 7,854 million tons of bituminous coal is estimated to have been originally present in 252 square miles of the field. An additional area of 18 square miles may contain minable reserves of coal with less than 3,000 feet of overburden.

LOWER WHITE RIVER FIELD

The Lower White River field includes the area underlain by coal-bearing rocks of the Mesaverde group, which lies between the Danforth Hills field and the Colorado-Utah State line. Gale (1909, 1910), who originally defined the field, included T.5N., R.96W., and this report follows that precedent.

The Williams Fork formation of the Mesaverde group has all the coal reserves that were estimated for the field. Coal may occur in the Iles formation, as it does in the adjoining Danforth Hills field, but information on which to base a reserve estimate is unobtainable. Reserves were estimated by the author on a bed basis for all measured and indicated reserves in the field, but all inferred reserves were estimated on a coal-zone basis by Spencer and Erwin (1953). Available information indicates that the coal is of high-volatile C bituminous rank and is noncoking. However, detailed information is lacking on the rank of the coal and on the thickness, persistency, and lateral correlation of the coal beds.

A total of about 7,012 million tons of bituminous coal is estimated to have been originally present in 553 square miles of the field. An additional area of 177 square miles may have minable reserves of coal with less than 3,000 feet of overburden.

Speltz (1974) estimated the resources of strippable coal in this region, based on the following criteria: ".... a minimum coal thickness of two feet, and a maximum overburden thickness of 150 feet, except where stripping conditions are ideal and coal thickness is greater than 20 feet." His data are reproduced in Table RIV-2, and the areas of strippable coal are reproduced from this Table as Figures RIV-2-5 in this report.

TABLE RIV-2
Strippable Coal Resources of Northwest Colorado

Estimated stippable coal resources in the Yampa coalfield, Green River region, Northwestern Colorado

Location		Identified			Undiscovered			Total	
Township	Range	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Quantity (thousand short tons)
T 6 N	R 93 W	-	-	-	3,043	6.7	36,700	3,043	36,700
	R 92 W	-	-	-	4,518	12	88,350	4,518	88,350
	R 91 W	2,092	11	41,000	3,356	4	24,150	5,448	65,150
	R 91 W	-	-	-	427	25	18,600	427	18,600
	R 90 W	1,027	11	20,350	6,390	4	46,000	7,417	66,350
	R 89 W	-	-	-	618	4	4,450	618	4,450
	R 88 W	-	-	-	1,044	10	19,650	1,044	19,650
	R 87 W	238	8	3,400	-	-	-	238	3,400
	R 86 W	-	-	-	399	5	3,600	399	3,600
T 5 N	R 93 W	-	-	-	1,103	5	11,700	1,103	11,700
	R 93 W	-	-	-	219	6.7	2,600	219	2,600
	R 92 W	-	-	-	323	6.7	3,900	323	3,900
	R 92 W	-	-	-	4,203	10	75,650	4,203	75,650
	R 91 W	1,987	11	39,350	352	4	2,500	2,339	41,850
	R 90 W	627	11	12,200	1,759	7	22,150	2,386	34,350
	R 89 W	-	-	-	837	6	9,000	837	9,000
	R 89 W	-	-	-	1,208	10	21,750	1,208	21,750
	R 88 W	865	10	15,600	1,132	5	10,200	1,997	25,800
	R 87 W	453	10	8,150	-	-	-	453	8,150
	R 87 W	903	8	13,000	-	-	-	903	13,000
	R 87 W	390	3	2,100	-	-	-	390	2,100
	R 86 W	1,331	3	7,200	1,892	3	10,200	3,223	17,400
	R 86 W	-	-	-	846	5	7,600	846	7,600
	R 85 W	1,378	6	14,900	333	5	9,900	1,711	24,800
T 4 N	R 87 W	1,084	8	15,600	181	5	1,600	1,265	17,200
	R 86 W	2,872	8	41,350	3,642	5	32,800	6,514	74,150
	R 86 W	1,703	10	30,650	-	-	-	1,703	30,650
	R 85 W	1,227	10	22,100	-	-	-	1,227	22,100
T 3 N	R 87 W	-	-	-	67	5	600	67	600
	R 86 W	-	-	-	76	5	700	76	700
Grand total...		18,177	-	286,950	37,968	-	464,350	57,145	751,300

Estimated strippable coal resources of the Danforth Hills coalfield

Location		Identified			Undiscovered			Total	
Township	Range	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Quantity (thousand short tons)
T 4 N	R 94 W	-	-	-	5,626	8	81,000	5,626	81,000
	R 93 W	-	-	-	618	8	8,900	618	8,900
	R 92 W	-	-	-	86	8	1,200	86	1,200
T 3 N	R 94 W	-	-	-	2,025	8	29,150	2,025	29,150
	R 93 W	-	-	-	2,682	8	38,600	2,682	38,600
	R 92 W	-	-	-	190	8	2,750	190	2,750
T 2 N	R 94 W	-	-	-	152	8	2,200	152	2,200
Grand total...		-	-	-	11,379	-	163,800	11,379	163,800

Estimated strippable coal resources of the lower White River coalfield

Location		Identified			Undiscovered			Total	
Township	Range	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Quantity (thousand short tons)
T 3 N	R 104 W	-	-	-	352	3	1,900	352	1,900
	R 103 W	-	-	-	399	3	2,150	399	2,150
	R 102 W	1,826	3	9,850	1,465	3	7,900	3,291	17,750
T 2 N	R 101 W	1,217	8	16,100	-	-	-	1,217	16,100
	R 100 W	-	-	-	3,338	8	48,000	3,338	48,000
T 1 N	R 101 W	-	-	-	571	3	3,100	571	3,100
Grand total...		3,043	-	25,950	6,125	-	63,050	9,168	89,000

Estimated strippable coal resources in the Tertiary subregion, Green River coal region

Location		Identified			Undiscovered			Total	
Township	Range	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Thickness (feet)	Quantity (thousand short tons)	Area (acres)	Quantity (thousand short tons)
T 12 N	R 102 W	-	-	-	1,293	3	6,750	1,293	6,750
	R 101 W	-	-	-	6,447	3	33,700	6,447	33,700
	R 100 W	1,141	3	5,950	4,593	3	24,000	5,734	29,950
	R 99 W	-	-	-	495	3	2,600	495	2,600
T 11 N	R 102 W	-	-	-	1,503	3	7,850	1,503	7,850
	R 101 W	1,075	3	5,600	5,277	3	27,600	6,352	33,200
	R 100 W	-	-	-	1,407	3	7,350	1,407	7,350
T 8 N	R 90 W	1,762	4	13,200	-	-	-	1,762	13,200
	R 89 W	2,065	9.5	34,700	-	-	-	2,065	34,700
	R 89 W	450	13	10,200	-	-	-	450	10,200
	R 89 W	1,948	6	20,350	-	-	-	1,948	20,350
Grand total...		8,441	-	90,000	21,015	-	109,850	29,456	199,850

SOURCE: Speltz, 1974

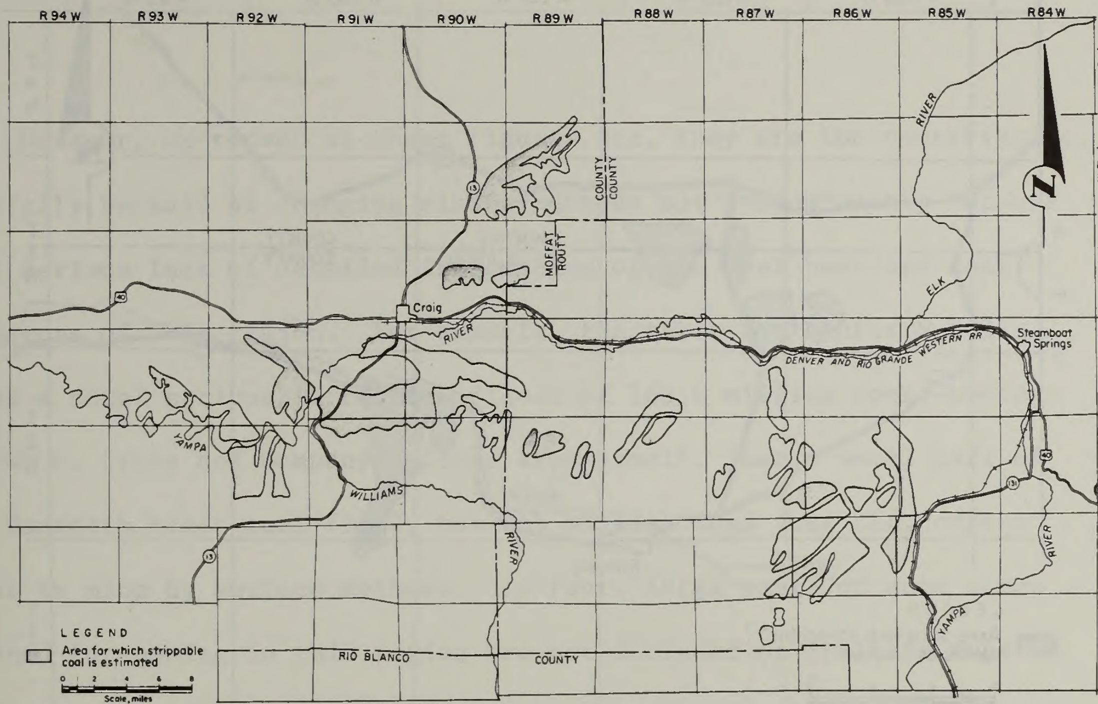


FIGURE RIV-2

Strippable coal in the Yampa coalfield.

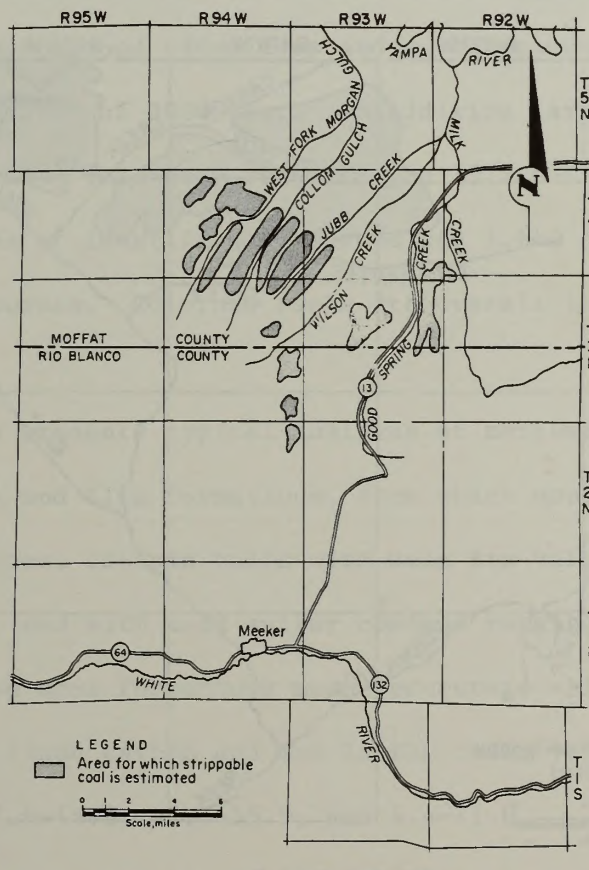


FIGURE RIV-3

Strippable coal in the Danforth Hills coalfield.

SOURCE: U.S. Bureau of Mines, 1974

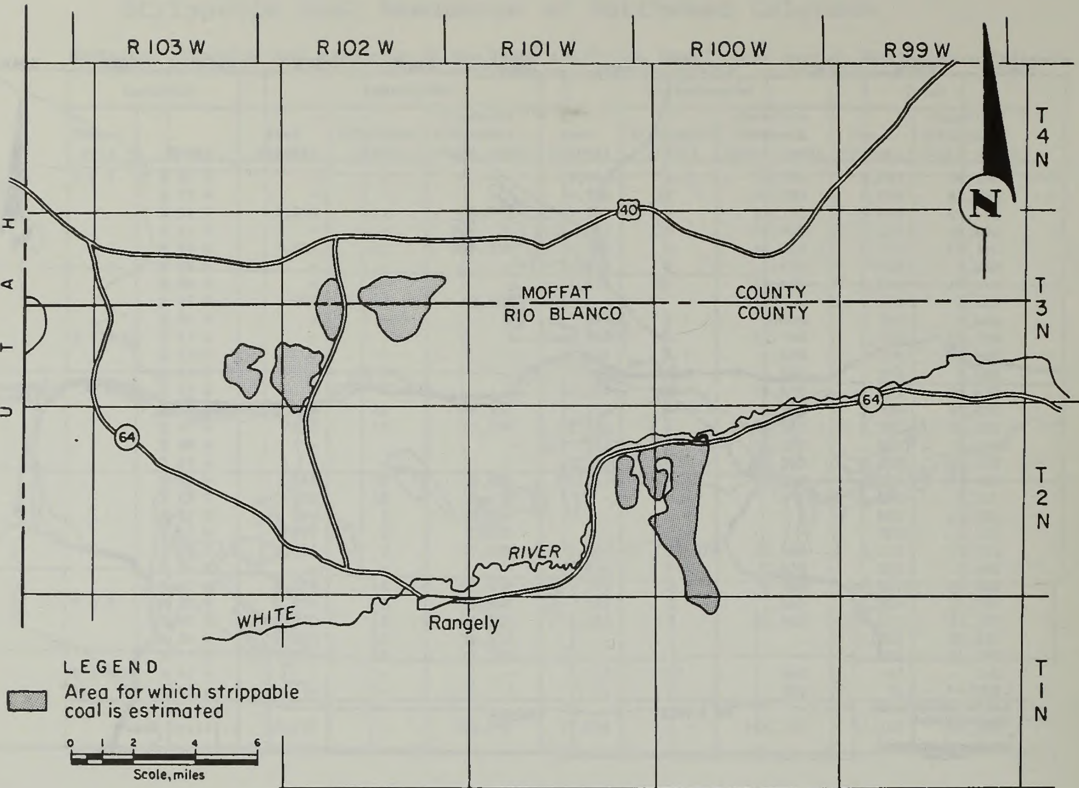


FIGURE RIV-4

Strippable coal in the lower White River coalfield.

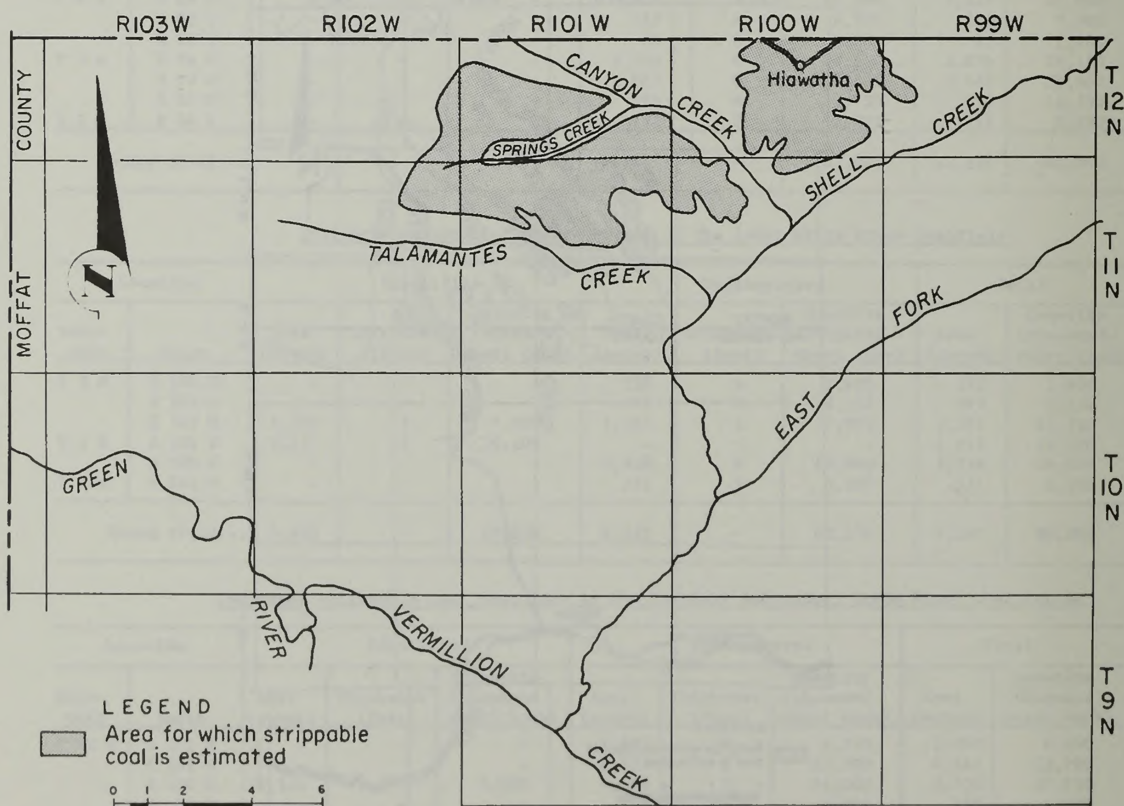


FIGURE RIV-5

Strippable coal near Hiawatha, Colorado.

SOURCE: U.S. Bureau of Mines, 1974

However, as recent as these figures are, they are too conservative, partially because of changing mining methods but predominantly because of a serious lack of detailed information on the coal beds and coal resources of this region. For example, the table for Danforth Hills shows a total strippable reserve figure of 163.8 million tons, whereas the W. R. Grace and Company's lease area itself, just a small part of the Danforth Hills coal field, has 165 million tons that the company plans to mine by surface methods. In fact, large parts of some areas planned for mining in this region are not included on Speltz's maps of strippable reserves; most of W. R. Grace's site and all of Area B of Peabody Coal Company are so excluded. Landis (1959) has estimated there are 38.3 billion tons of measured, indicated, and inferred original reserves of surface and underground bituminous and subbituminous coal in the study region to depths of 3000 feet. In addition large reserves of lignite are present. This compares with the 1972 national estimate of 1,580 billion tons of identified resources and 1,640 billion tons of hypothetical resources. Colorado ranks 7th overall in bituminous coal reserves.

Table RIV-2a presents typical analyses of northwest Colorado coals. The Williams Fork and Iles formations, from which most of the expected production will come, contain coals with mean Btu values ranging from 12,050-13,170/lb. and with mean sulfur content ranging from 0.3-1.9 percent. In these same formations mean percentage values of moisture, volatile matter, fixed carbon and ash in the coals vary respectively from 8.4-17.6, 37.6-44.0, 47.9-55.9, and 4.4-11.0.

TABLE RIV-2a

Typical Analysis of Northwest Colorado Coals

Formation	Coal bed or group	Coal field or area	Number of analyses	Moisture (percent) High	Moisture Low	Moisture Mean	Volatile matter (percent) High	Volatile matter Low	Volatile matter Mean	Fixed carbon (percent) High	Fixed carbon Low	Fixed carbon Mean	Ash (percent) High	Ash Low	Ash Mean	Sulfur (percent) High	Sulfur Low	Sulfur Mean	Btu/lb High	Btu/lb Low	Btu/lb Mean	Analyses basis
Wasatch	(No analyses available: these are from Wasatch coal beds in nearby Wyoming	Hiawatha	3(+?)	23.0	20.7	-							13.8	11.2	-	2.7	1.8	-	8,710	8,250	-	As received
Fort Union	Campbell and Seymour beds	Craig area	2(+?)	20.5	17.1	-							7.8	3.9	-	0.4	0.2	-	10,080	9,500	-	As received
		" "	2	14.2	12.47	13.34	33.9	29.92	31.91	50.02	46.7	48.36	7.59	5.3	6.45	1.21	0.3	0.62	10,360	10,290	10,325	Dry
Lance	Lorella and Kimberly beds	Craig-Hayden	2(+?)	21.8	19.6	-							6.5	4.1	-	0.7	0.5	-	9,720	9,660	-	As received
Williams Fork	Upper group	Yampa	2+	16.9	14.2	-							5.4	4.1	-	0.9	0.4	-	11,040	10,360	-	As received
	Upper group	Yampa	4	15.9	14.2	15.0							5.9	4.5	5.1	1.0	0.4	0.6	12,970	12,730	12,870	Dry
	Dry Creek	Yampa	5	14.7	14.2	14.4	38.2	36.8	37.6	56.2	55.8	55.9	7.4	5.6	6.4	0.5	0.4	0.4	12,840	12,510	12,700	Dry
	Middle group	Yampa	2+	11.8	7.7	-							11.5	3.4	-	0.6*	0.3	-	12,260	10,740	-	As received
	Middle group	Yampa	3	12.5	11.0	11.8							12.0	6.2	8.2	0.6	0.5	0.5	-	-	-	Dry
	Wadge bed	Yampa	786	18.3	6.2	9.8	43.3	37.0	40.3	55.4	47.7	52.0	13.2	3.4	7.6	1.8	0.3	0.5	13,450	11,620	12,610	Dry
	Lennox bed	Yampa	335	15.5	7.6	8.7	45.9	39.9	44.0	54.6	48.8	51.5	8.1	2.6	4.4	2.8	0.6	1.9	13,370	12,510	13,170	Dry
	Wolf Creek bed	Yampa	7	13.0	7.9	9.9	43.0	36.0	41.0	49.2	46.8	47.9	15.5	9.2	11.0	0.7	0.5	0.5	12,550	11,230	12,120	Dry
	Collom group	Danforth Hills	72	14.7	8.5	10.8	49.7	39.3	42.3	56.3	47.2	53.7	6.2	2.7	3.8	0.5	0.2	0.3	13,340	12,770	13,130	Dry
	Collom group	Danforth Hills	2+	15.4	11.4	-							6.3	2.2	-	1.0	0.3	-	11,770	10,140	-	As received
	------------	Lower White River	2+	14.1	11.2	-							8.5	4.4	-	0.5	0.4	-	11,230	10,800	-	As received
Iles	Pinnacle bed	Yampa	178	12.6	5.9	8.4	42.9	36.1	40.3	58.2	47.2	52.2	16.5	2.8	7.3	0.9	0.3	0.6	13,640	11,510	12,930	Dry
	Lower Group	Yampa	7	12.2	8.6	10.5							11.2	4.7	6.3	1.8	0.5	1.0	13,340	12,960	13,150	Dry
	Lower group 3	Yampa	1	9.0	9.0	9.0							5.9	5.9	5.9	0.5	0.5	0.5	13,150	13,150	13,150	Dry
	A	Danforth Hills	5	23.3	11.7	17.6							9.4	4.7	7.0	1.0	0.3	0.5	12,670	11,550	12,050	Dry
	Black Diamond group	Danforth Hills	1	12.5	12.5	12.5							7.8	7.8	7.8	0.8	0.8	0.8	12,410	12,410	12,410	Dry
	Black Diamond group	Danforth Hills	2+	13.4	9.2	-							10.0	3.7	-	0.6	0.4	-	11,970	11,220	-	As received

* "Local exceptions in the Lennox beds, where altered, show sulfur as high as 2.8%."

SOURCES: U.S. Bureau of Mines (Speltz, 1974)
Colorado Geological Survey (Hornbaker and Holt, 1973)
U. S. Geological Survey

Table RIV-2b presents similar data for coal from the Wadge bed in the Williams Fork formation. These data are from samples of coal burned at the Hayden 1 power plant. The table also shows quantities of trace elements in the coal and in both the fly ash and bottom ash from the power plant.

Oil and gas

A brief history of exploration and development of oil and gas in northwest Colorado has been written by Brainerd and Carpen (1962). The Rangely oil field is by far the largest producing field. Brainerd and Carpen (1962) describe the beginning of oil and gas production as follows:

> In the American Geologist of 1891, Arthur Lakes, Colorado School of Mines, Golden, describes the then well-known gas seeps in the White River Valley about thirty miles west of Meeker where Piceance Creek enters White River. We now know that these seeps are on the south flank of the White River structure. There are other gas seeps in the Piceance Creek valley to the south of its junction with White River.
>
> The widespread occurrence of oil and gas seeps in Northwestern Colorado gave considerable optimism for later prospecting in the area. The earliest drilling on record was in the White River Valley at the mouth of Piceance Creek at the gas seeps already mentioned. Two wells, each about 500 feet deep, were drilled at an approximate location, Section 2, T.1N., R.97W., during 1890. Each of these wells obtained some gas in the Tertiary Wasatch. The first well burned the rig and the second well was plugged.
>
> The shallow oil in the Rangely field, Ts.1 and 2 N., RS 101 and 102 W., Rio Blanco County, was discovered in 1902 at depths ranging from 500 to 1700 feet. The oil was 43 degree Be. gravity and was found in the porous parts of calcite veins in the Mancos Shale. It is possible that drilling was started at Rangely because of the oil seeps on the White River where it crosses the Rangely structure.

Production of oil and gas from the various fields in northwest Colorado is shown in Table RIV-3.

TABLE RIV-2b

Composition and Trace-element Content of Coal Used in and Ash from Hayden, Colorado Powerplant

COAL ANALYSES; ULTIMATE AND PROXIMATE ANALYSES OF COAL USED AT OPERATING POWERPLANT

(All values, except percent ash, reported on moisture- and ash-free basis; all percent values reported from laboratory to tenths of 1 percent: 0.0B no analysis; VOL. volatile matter; FIX C. fixed carbon; BTU, British thermal units; all analyses by Coal Analysis Section, U.S. Bureau of Mines, Pittsburgh, Pa.)

Source and geologic designation of coal samples

Plant served or to be served	Mine	County and State	Section, township and range	Age	Formation	Member	Bed(s)	Type of mine	No. of samples	Date collected
Hayden	Seneca	Routt. Colo.	27, 6 N., 87 W.	Late Cretaceous	Mesaverde	Williams Fork	Wadge	Strip	3	Sept. 3, 1971

SAMPLE	ASH %	C %	H %	O %	N %	S %	VOL %	FIX C %	BTU
0152236C	9.40	77.20	5.60	14.60	1.90	0.70	46.40	53.60	13470.
0152237C	0.0 B	0.0 B	0.0 B	0.0 B	0.0 B	0.0 B	0.0 B	0.0 B	0.0 B
0152238C	8.50	77.90	5.60	14.10	1.90	0.50	47.70	52.90	13720.

COAL ANALYSES; MAJOR COMPONENTS OF COAL ASH, OPERATING POWERPLANT

(Ash values, percent of coal; all other values, percent of ash; analyses reported from laboratory are generally three significant figures when values >1 percent, and two significant figures when values <1 percent.)

SAMPLE	ASH %	SIO_2 %	AL_2O_3 %	NA_2O %	K_2O %	CAO %	MGO %	P_2O_5 %	FE_2O_3 %	SO_3 %
D152236C	5.90	46.	32.	0.19	0.70	4.50	1.12	1.50	3.20	5.30
D152237C	10.20	48.	31.	0.41	1.20	3.10	0.82	1.10	2.00	2.90
D152238C	9.72	46.	31.	0.22	1.00	3.50	1.00	1.50	1.90	3.30

COAL ANALYSES; NINE TRACE ELEMENTS IN WHOLE COAL, OPERATING POWERPLANT

(All analyses in percent or parts per million of whole coal; value followed by L, indicates less than value given; EU, equivalent uranium (eU))

SAMPLE	ASH %	AS PPM	F PPM	HG PPM	SB PPM	SE PPM	TE PPM	TL PPM	EU PPM	U PPM
D152236C	5.90	1.L	170.	0.03	0.12	1.00	0.02L	0.20L	10.L	0.58
D152237C	10.20	1.L	200.	0.03	0.49	1.20	0.02L	0.20L	10.L	1.12
D152238C	9.72	1.L	190.	0.06	0.41	1.30	0.02L	0.20L	10.C	1.12

COAL ANALYSES; FOUR TRACE ELEMENTS IN COAL ASH, AND TOTAL NITROGEN AND TOTAL SULFUR IN COAL USED AT OPERATING PLANT

(Value followed by L indicates less than value given; 0.0 B, no analysis.)

SAMPLE	ASH %	CD PPM	CU PPM	LI PPM	ZN PPM	TOT N %	TOT S %
D152336C	5.90	1.00	69.	133.	37.	1.60	0.34
D152237C	10.20	1.00L	58.	113.	57.	1.60	0.41
D152238C	9.72	1.00L	48.	106.	31.	0.0 B	0.42

COAL ANALYSES; 22 TRACE ELEMENTS IN COAL ASH (SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSIS), OPERATING POWERPLANT

(O.N, not detected; value followed by L indicates less than value given.)

SAMPLE	ASH %	TI %	MN PPM	B PPM	BA PPM	BE PPM	CE PPM	CO PPM	CR PPM	GA PPM
D152236C	5.90	0.30	70.	2000.	2000.	7.	300.L	15.	30.	50.
D152237C	10.20	0.30	30.	1500.	1500.	3.	300.	10.	15.	50.
D152238C	9.72	0.30	30.	1500.	1500.	5.	300.L	10.	15.	30.

SAMPLE	GE PPM	LA PPM	MO PPM	NB PPM	ND PPM	NI PPM	PB PPM	SC PPM	SR PPM	V PPM
D152236C	0.N	100.	7.L	20.L	70.L	20.	70.	15.	1500.	70.
D152237C	0.N	150.	7.L	20.L	150.	10.	70.	15.	700.	70.
D152238C	0.N	70.	7.L	20.L	150.L	10.	70.	15.	700.	70.

SAMPLE	D PPM	YP PPM	ZR PPM
D152236C	100.	7.	300.
D152237C	50.	3.	300.
D152238C	50.	3.	300.

ANALYSES OF FLY ASH AND FURNACE BOTTOM ASH FROM OPERATING POWERPLANT; MAJOR COMPONENTS

(Sample number ending in F, fly ash; sample number ending in B, bottom ash, analyses reported from laboratory are generally three significant figures when values >1 percent, and two significant figures when values <1 percent.)

SAMPLE	SIO_2 %	AL_2O_3 %	NA_2O %	K_2O %	CAO %	MGO %	P_2O_5 %	FE_2O_3 5	SO_3%
0152239B	58.	25.	0.43	1.60	3.00	1.03	0.50	2.90	0.10
0152240B	60.	23.	0.43	1.40	4.00	1.30	1.00	3.70	0.10
D152241F	54.	28.	0.38	1.50	3.70	1.29	1.00	3.40	0.40

ANALYSES OF FLY ASH AND FURNACE BOTTOM ASH FROM OPERATING POWERPLANT: 13 TRACE ELEMENTS AND TOTAL NITROGEN AND TOTAL SULFUR

(Sample number ending in F, fly ash; sample number ending in B, bottom ash; value followed by L indicates less than value given; EU, equivalent uranium (eU); 0.0 B, no analysis)

SAMPLE	AS PPM	F PPM	HG PPM	SB PPM	SE PPM	TE PPM	TL PPM	EU PPM	U PPM
0152239B	1.	50.L	0.01L	0.20	0.50	0.02L	0.20L	20.	6.40
0152240B	3.	120.	0.01L	0.66	1.40	0.02L	0.40	10.	7.70
D152241F	6.	250.	0.08	1.80	12.00	0.10	1.10	30.	10.20

SAMPLE	CD PPM	CU PPM	LI PPM	ZN PPM	TOT N %	TOT S %
0152239B	1.00L	39.	86.	48.	0.0 B	0.04
D152240B	1.00L	42.	75.	42.	0.0 B	0.04
D152241F	1.00	75.	109.	103.	0.01L	0.11

ANALYSES OF FLY ASH AND FURNACE BOTTOM ASH FROM OPERATING POWERPLANTS: 22 TRACE ELEMENTS (SEMIQUANTITATIVE SPECTROGRAPHIC ANALYSIS)

(Sample number ending in F, fly ash; sample number ending in B, bottom ash; value followed by L indicates less than value given; O.N, not detected)

SAMPLE	TI %	MN PPM	B PPM	BA PPM	BE PPM	CE PPM	CO PPM	CR PPM	GA PPM	GE PPM
D152239B	0.30	100.	300.	1500.	5.	300.L	7.	30.	20.	0.N
D152240B	0.30	100.	300.	2000.	5.	300.L	7.	30.	30.	0.N
D152241F	0.50	100.	700.	2000.	7.	300.L	15.	30.	50.	0.N

SAMPLE	LA PPM	MO PPM	NB PPM	ND PPM	NI PPM	PB PPM	SC PPM	SR PPM	V PPM	Y PPM
0152239B	70.	0.N	20.L	150.L	10.	30.	15.	700.	70.	50.
D152240B	70.	7.L	20.L	150.L	10.	30.	15.	700.	70.	50.
D152241F	70.	7.	20.	150.L	20.	70.	15.	700.	100.	70.

SAMPLE	YP PPM	ZR PPM
0152239B	3.	300.
0152240B	3.	300.
D152241F	5.	200.

RECALCULATED COAL ANALYSES; MAJOR COMPONENTS ANALYZED IN COAL ASH CALCULATED TO WHOLE COAL BASIS, OPERATING POWERPLANT

(Percent ash in coal listed in second column; 0.0 B, original analysis below limit of detection.)

SAMPLE	ASH %	SIO_2 %	AL_2O_3 %	NA_2O %	K_2O %	CAO 5	MGO %	P_2O_5 %	FE_2O_3 %	SO_3 %
0152236C	5.90	3.	2.	0.01	0.04	0.27	0.07	0.09	0.19	0.31
D152237C	10.20	5.	3.	0.04	0.12	0.32	0.08	0.11	0.20	0.29
D152238C	9.72	4.	3.	0.02	0.10	0.34	0.10	0.15	0.18	0.32

RECALCULATED COAL ANALYSES; FOUR TRACE ELEMENTS ANALYZED IN COAL ASH CALCULATED TO WHOLE COAL BASIS, OPERATING POWERPLANT

(Percent ash in coal listed in second column; 0.0 B, original analysis below limit of detection

SAMPLE	ASH %	CD PPM	CU PPM	LI PPM	ZN PPM
D152236C	5.90	0.06	4.	8.	2.
D152237C	10.20	0.0 B	6.	12.	6.
D152238C	9.72	0.0 B	5.	10.	3.

SOURCE: U.S. Geological Survey, Southwest Energy Study, 1971, open-file report.

TABLE RIV-3

Oil and Gas Fields of Northwestern Colorado

Field Name	Discovery Well Location Sec.-T.N.-R.W.	Discovery Well Year	Number of Wells (1974) Producing	Number of Wells (1974) Shut-In	1974 Production Oil (Barrels)	1974 Production Gas (MMcf*)	% of 1974 Oil	% of 1974 Gas	Total to 1975 Oil (Barrels)	Total to 1975 Gas (MMcf*)	% of Regional Total Oil	% of Regional Total Gas	Relative Regional Position Increasing (+) or Decreasing (-) Oil	Relative Regional Position Increasing (+) or Decreasing (-) Gas
Bear River (new oil well)	11-6-87	1975	1		0	0	0	0	0	0	0	0	+	
Bell Rock (New well)	4-6-92	1973			0	0	0	0	0	0	0	0		
Big Gulch	16-7-93	1960	2	2	0	180.3	0	0.64	4,182	2,654	<0.01	0.23	-	-
Big Hole	22-10-94	1963	7		5,880	484.8	0.03	1.73	8,055	579	<0.01	0.05	+	+
Blue Gravel	25-9-91	1963	1		0	104.3	0	0.37	0	579	0	0.05		+
Buck Peak	25-6-90	1956	9	2	370,724	59.0	1.64	0.21	2,389,352	2,276	0.37	0.20	+	+
Colorow (See White River)	7-2-97	1967			0	0	0	0	0	0	0	0		
Craig Dome	9-6-91	1932	1		0	64.9	0	0.23	466	1,639	<0.01	0.14	-	+
Craig, North	33-8-90	1956	6		927	574.[illegible]	<0.01	2.05	14,218	6,647	<0.01	0.58		+
Curtis	25-6-86	1958		2	3,074	0.6	0.01	<0.01	200,734	93	0.03	<0.01	-	
Danforth Hills	32-5-95	1954	1	3	42,683	1.6	0.19	<0.01	2,976,612	266	0.46	0.02	-	-
Danforth Hills, North	19-5-95	1958	3		8,198	2.6	0.04	<0.01	332,797	105	0.05	<0.01	-	
Dill Gulch	17-5-89	1974		1	1,467	0	<0.01	0	1,467	0	<0.01	0		
Elk Springs	31-5-98	1946	0	0	0	0	0	0	528,723	13	0.08	<0.01	-	-
Fish Creek	20-5-87	1971	1		2,953	0.9	0.01	<0.01	9,313	3	<0.01	<0.01	+	
Focus Ranch	28-12-87	1971		1	812	0	<0.01	0	3,587	0	<0.01	0		
Four Mile Creek	3-11-91	1958	0	0	0	0	0	0	0	311	0	0.03		-
Grassy Creek	26-6-87	1959	4	3	28,364	0	0.13	0	458,982	51	0.07	<0.01	+	-
Hiawatha	22-12-100	1926	24	1	37,604	2,753.9	0.17	9.84	3,557,766	95,271	0.55	8.27	-	-
Hiawatha, West	19-12-100	1930	25	1	7,519	6,016.5	0.03	21.49	177,974	99,291	0.03	8.27		-
Hidden Valley	6-6-86	1957					0	0	18,685	6	<0.01	<0.01	-	-
Horse Gulch	24-5-91	1965	0	0	0	0	0	0	211,590	0	0.03	0	-	
Iles	22-4-92	1924	8	1	114,997	0	0.51	0	17,893,437	1,971	2.76	0.17	-	-
Indian Run	30-4-89	1956		1	0	0	0	0	0	0	0	0		
Lay Creek	13-8-93	1955	1		0	700.9	0	2.50	25	1,718	<0.01	0.15	-	+
Little Snake	14-12-95	1958	0	0	0	0	0	0	0	386	0	0.03		-
Maudlin Gulch	35-4-95	1947	10	1	127,264	21.9	0.56	0.08	6,190,978	1,097	0.96	0.10	-	-
Moffat	33-5-91	1924	4	1	9,927	0.4	0.04	<0.01	9,135,300	243	1.41	0.02	-	-
Nine Mile	6-2-92	1966	3		24,444	0	0.12	0	799,309	0	0.12	0		
Oak Creek	2-3-86	1949	0	0	0	0	0	0	52,980	0	<0.01	0	-	
Pagoda	34-4-89	1948		1	0	0	0	0	0	22	0	<0.1		-
Pinnacle	25-3-87	1956		1	195	0	<0.01	0	111,760	92	0.02	<0.1	-	-
Pole Gulch	16-12-92	1965	3		350	581.8	<0.01	2.08	5,377	4,617	<0.01	0.40		+
Powder Wash	5-11-97	1931	66	6	157,590	9,127.2	0.70	32.60	5,531,484	123,272	0.85	10.70	-	+
Powell Park	27-1-95	1957		1	0	0	0	0	1,205	252	<0.01	0.02	-	-
Rangely	33-1-102	1902	395	35	20,397,630	1,654.2	90.33	5.91	513,208,655	672,953	79.27	58.41	+	-
Renfro	20-8-86	1962	0	0	0	0	0	0	2,074	0	<0.01	0	-	
Round Table	14-12-96	1967	0	0	0	0	0	0	954	0	<0.01	0	-	
Sage Creek	36-5-88	1959		2	0	0	0	0	73,830	22	0.01	<0.01	-	-
Sage Creek, North	14-5-88	1960	1		14,822	0	0.07	0	412,653	0	0.06	0	+	
Shell Creek	1-11-100	1955	0	0	0	0	0	0	4,100	951	<0.01	0.08	-	-
Slater Dome	13-12-89	1954	0	1	0	0?	0	0	0	0	0	0		
Sugar Loaf	9-11-101	1953	12	2	7,754	3,638.5	0.03	13.0	209,504	45,551	0.03	3.95		+
Temple Canyon	17-4-95	1953		1	4,679	0	0.02	0	132,267	18	0.02	<0.01		-
Thornburg	16-3-91	1925	2	3	0	252.7	0	0.90	753,686	15,338	0.12	1.33	-	-
Tow Creek	7-6-86	1924	3		7,935	0	0.04	0	2,908,936	339	0.45	0.03	-	-
Waddle Creek	8-4-90	1964	3		8,121	0	0.04	0	314,062	0	0.05	0	-	
West Side Canal	13-12-92	1966	1	1	0	54.6	0	0.20	0	2,878	0	0.25		-
White River	31-2-96	1890	12	2	273	753.8	<0.01	2.69	1,410	2,242	<0.01	0.19		+
Williams Fork	18-5-91	1962	1	2	0	23.8	0	0.09	782,928	289	0.12	0.03	-	+
Williams Park	(3,4 N-87,88W)	<1920	(NO FIGURES AVAILABLE)											
Wilson Creek	35-3-94	1938	27		1,191,805	796.9	5.28	2.85	75,159,555	55,300	11.61	4.80	-	-
Winter Valley	8-4-98	1958	2	4	2,463	144.5	0.01	0.52	274,405	12,775	0.04	1.11	-	-
TOTALS			639	82	22,580,459	27,994.6	100	99.98+	647,386,861	1,152,110	99.57+	99.61+		

* MMcf - Millions of cubic feet per day; field gas figures rounded to nearest MMcf.
All percentages rounded to nearest 0.01%.

SOURCE: Colorado Oil and Gas Commission annual reports and other data.

Map Foldout No. 1 in Appendix B shows the oil and gas fields. Most of the fields in the southern half of the study region, except those west of a line from Meeker to Cross Mountain, are developed at the crest of anticlines, whereas coal development in the same area is mostly on the flanks of these structures.

A report by Turner (1962) describes the controls of oil and gas accumulation in northwest Colorado. Portions of that report are excerpted hereafter as particularly applicable to this EIS, in view of the possible future conflicts between coal versus oil and gas development:

> Entrapment of hydrocarbons in reservoir formations of northwestern Colorado can be classified within four major types of traps: (1) Structural (2) Fault (3) Stratigraphic (4) Fracture. Combinations of these, plus the influence of hydrodynamic forces, are becoming important considerations in the search for oil and gas in Northwestern Colorado.
>
> The well established anticlinal theory of accumulation has been eminently well proven throughout many decades of exploration in this area.
>
> The pure form of anticlinal trap is found in Asbury Creek, Baxter Pass, Big Gulch, Debeque, Garmesa, Iles, Moffat and many others.
>
> Many of the successful wildcat locations, originally intended as tests of anticlinal closures, have since been proven to have a "bonus" stratigraphic, fault or fracture trap. Specific examples of the supplemented anticlinal trap can be found in the Buck Peak, Divide Creek, Cameo, Rangely, Tow Creek, and Piceance Creek fields.
>
> Exploration of the "pure" fault trap is still in its infancy in northwestern Colorado. Numerous discoveries (9%) have been predicted upon or developed from fault closures in anticlines such as Elk Springs, Lay Creek, South Baggs and Douglas Creek, but the faulted nose and the "up-dip" fault closure have largely escaped exploration thinking until very recently. Some of the more specifically classified fault trap fields include Curtis, parts of Divide Creek and specific wells in the Cretaceous Niobrara formation on the southwest flank of Rangely. Even among these, there appears to be considerable room for arguments on the principal cause for accumulation of oil and gas.

The most recent trend in exploration indicates that enthusiasm is developing rapidly for the stratigraphic trap, particularly in the Tertiary Wasatch and Fort Union, and Cretaceous Lance, Lewis, and Mesaverde formations. During the last five years it has been evident that the permeability barrier and the "sudden" facies change have attracted enough interest to overtake anticlinal exploration as the predominant interest. This may have been triggered by the amazing successes and subsequent interpretation of stratigraphically trapped Mesaverde (Almond) oil and gas in the Desert Spring and Patrick Draw areas of Wyoming. Northwestern Colorado has many similar localities which are as yet untested, but are beginning to command the attention of exploration men.

A count of the stratigraphic oil and gas fields shows that about 37% of all the significant accumulations are the result of stratigraphic changes. Many of the earlier "anticlinal discoveries" are now considered to be, after more complete development, primarily stratigraphic accumulations. Reclassification of long standing and accepted anticlinal fields are therefore swinging statistics in favor of stratigraphic control.

In the same volume, Millison (1962) made the following statement regarding this situation:

More oil and gas fields in northwestern Colorado produce as a result of stratigraphic variations than produce from accumulations due to anticlinal closure. Older oil fields such as Rangely, Wilson Creek, Iles and Thornburg were discovered by drilling on closed anticlines that were easily mapped in the surface rocks. As the supply of these obvious anticlines diminished, smaller and less apparent surface structural anomalies were drilled. In many instances, oil or gas was discovered. With subsequent drilling it was learned that accumulation was due to stratigraphic variations. After a sufficient number of exploratory tests were drilled, subsurface studies revealed the myriad of potential traps that could be present, due to the rapid changes in the method, environment, and character of deposition throughout the sedimentary column. On closed anticlines, it is often difficult to determine whether the accumulation is the singular result of the arching of the rocks or the result of stratigraphic changes.

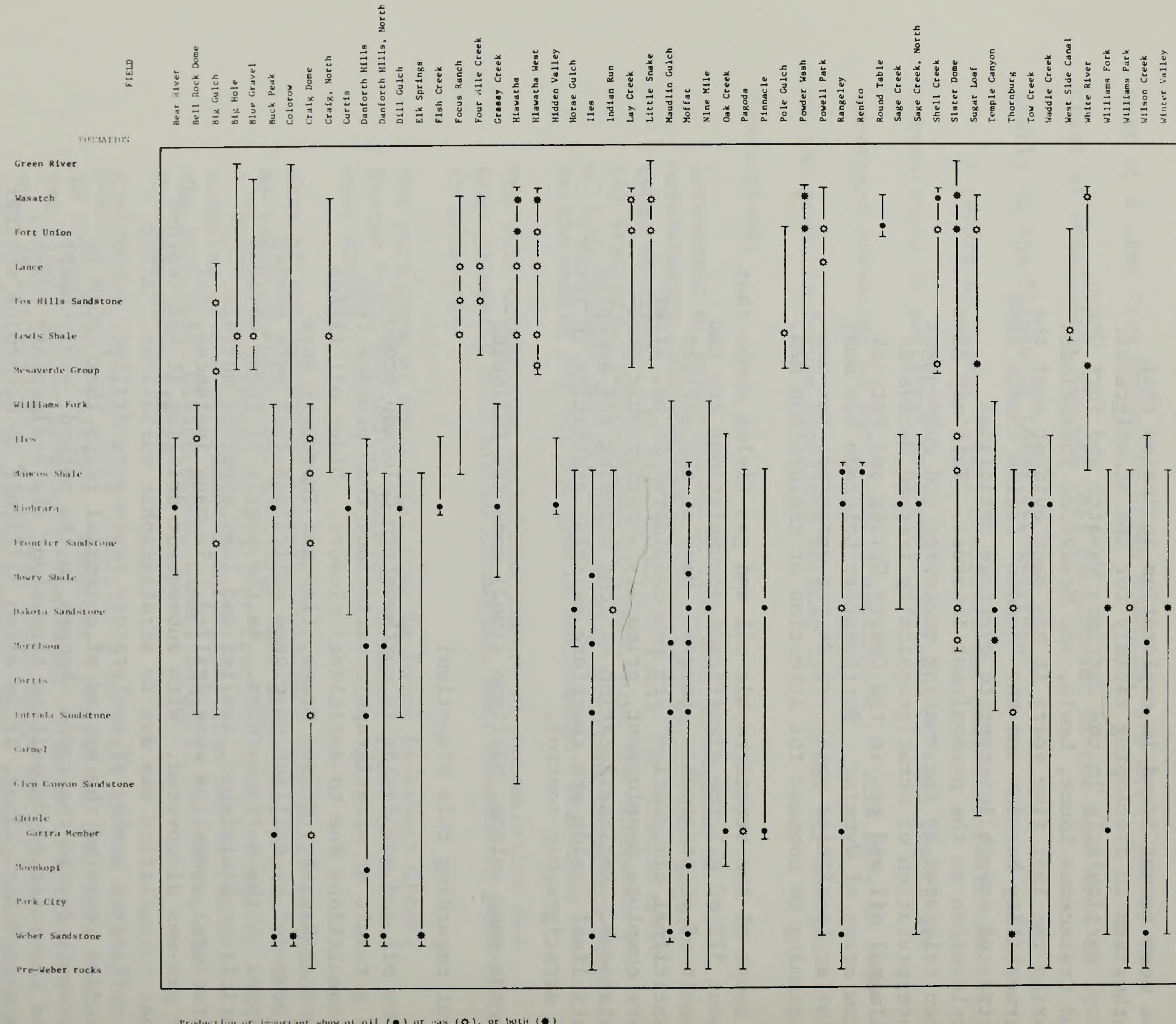


FIGURE RIV-6

Penetration chart of northwest Colorado oil and gas fields.

Millison's map indicated he was referring mainly to the fields of the Sand Wash and Piceance Basins, and the Douglas Creek Arch south of Rangely. Figure RIV-6 shows formations yielding oil and gas in the various fields.

Other minerals

Some minerals or natural materials other than coal, oil and gas occur in northwest Colorado, but are of less economic interest. These include oil shale, bituminous sandstone, uranium, gold, and monazite in placers, lode deposits of metals and zeolites. Map Foldout 5 in Appendix B shows the occurence of these minerals in the study region.

Oil shale

Oil shale occurs in beds of the Green River Formation in the Sand Wash Basin, and in the Gray Hills west of Meeker. The Gray Hills are in a northward extension of the Piceance Basin. The oil shale beds in the EIS area are much leaner, so far as is known, than the rich beds in Colorado, Utah, and Wyoming which are under development or are being considered for development. For example McKay (1974) reports analyses of weathered oil shale in the southwestern Sand Wash Basin averaging 0.3-16.6 gallons of shale oil/ton. This contrasts with the 25-30 gallons/ton where oil shale is being developed now.

Bituminous sandstone

Bituminous sandstone, commonly called tar sands, are known in the southwest Sand Wash Basin and near Rangely. Sears (1925) and Roehler (1973) describe the known occurrences.

Uranium

Uranium has been produced from the Browns Park Formation near Lay and Maybell, west of Craig. Minor deposits with no production occur in Precambian rocks of the Park Range near Steamboat Springs, and in the Dakota Sandstone east of Meeker.

Placer minerals

Gold placers were worked in the late 19th and early 20th Century at Hahns Peak and in the Sand Wash Basin north of Craig. The Hahns Peak gold placers were mainly in Quaternary colluvium. The Sand Wash Basin placers were mostly fossil placers, occurring in the Wasatch Formation of early Eocene age. Some Quaternary alluvium and terrace gravels near the Wasatch placers also produced some gold.

Monazite, a thorium mineral, has also been found in the Sand Wash Basin placers.

Lode deposits of metals

The best-known and most valuable lode deposits of metals are at Hahn's Peak. These have been described by Gale (1906) and by Young and Segerstrom (1973). The general geology was described by Segerstrom and Young (1972). These deposits contain anamalous amounts of silver, lead, and zinc.

Gale (1906) briefly describes a small amount of production of silver, gold, and lead from a few small mines here. Total production is not known. However, it cannot have been much, because Young and Segerstrom (1973) quote S. M. del Rio (1960) as reporting that "the value of precious and base metals mined from Routt County from 1873 to 1960 did not exceed $500,000." Nevertheless, they indicate this is a promising area for future mining.

> In 1,306 samples of drill core, silver content averages 9.7 ppm (parts per million) (140 times crustal abundance), lead 1,100 ppm (55 times crustal abundance), molybdenum 10.4 ppm (10 times crustal abundance), zinc 600 ppm (7.5 times crustal abundance), and copper 100 ppm (two times crustal abundance). Gold content of these samples was generally below detection limits. The most promising mineralized zone contains 16 x 10^6 cubic feet of rock, estimated to contain 26 tons of silver at a grade of 0.58 ounce per short ton, 6,500 tons of lead at a grade of 0.5 percent, and 2,600 tons of zinc at a grade of 0.2 percent. On a larger scale, in terms of a lower grade resource, a volume of 8.7 x 10^9 cubic feet is estimated to contain 7,100 tons of silver at a grade of 0.29 ounce per short ton, 710,000 tons of lead at a grade of 0.1 percent, and 430,000 tons of zinc at a grade of 0.06 percent.

Miller (1975) shows several additional lode deposits of these metals, as well as molybdenum, along the west flank of the Park Range north of Steamboat Springs. Little is known of these deposits, but presumably they are small.

In the Skull Creek area of western Moffat County, anomalous amounts of several metals in altered rocks of the Moenkopi Formation, and in other formations above and below, are reported by Cadigan (1972), who believes these may indicate the presence of economically significant deposits at depth. These occurrences are in the same general area of the copper-uranium-vanadium deposits described above, in the section of uranium. Cadigan (1972) states there are anomalous amounts of arsenic, boron, chromium, cobalt, copper, gold, lanthanum, lead, mercury, nickel, silver, uranium, vanadium, and zinc.

Zeolites

Zeolites are described in the Glossary of Geology and Related Sciences (Howell, 1960) as follows:

> Zeolites. A generic term for a group of hydrous alumino-silicates of Na, Ca, Ba, Sr, and K, characterized by their easy and reversible loss of water of hydration and their intumescence when heated strongly. Many are also characterized by a significant capacity for ion-exchange.

As indicated by Boles and Surdan (1973), the uses of natural zeolites will undoubtedly expand on a large scale in the near future. Roehler (1973) describes the use of the zeolite mineral clinoptilolite, and the occurrence of large tonnages in the Sand Wash Basin:

> In industry, zeolite minerals are used, for example, as agents for moisture absorption and for deodorization, as an additive to aid in retention of fertilizer on agricultural lands, and, in the form of clays, for papermaking. Clinoptilolite, as an agent for the removal of ammonia nitrate from wastewaters, is expected to have its major use in the control of water pollution (Mercer, 1969, p.209).
>
> An example of a minable clinoptilolite deposit in the Washakie and Sand Wash Basins is the "robins-egg-blue" tuff marker bed in the Washakie Formation...The bed ranges in thickness slightly less than ten feet to at least 100 feet. It has a distinct blue-green color, probably imparted by iron compounds...R. A. Sheppard(oral commun., May 1972) has estimated that the bed in the Washakie Basin contains at least five billion tons of clinoptilolite. Mineral investigations by Kenneth Segerstrom and E. J. Young in 1966 (oral commun., March 1973) suggest that nearly as much clinoptilolite may be present in the bed in the Sand Wash Basin.

The Washakie Formation mentioned by Roehler is the Wyoming equivalent of the Bridger Formation of Colorado; the clinoptilolite bed lies near the base of the Bridger Formation.

Near the Rangely oil field, Cullins (1969) describes the occurrence of other zeolites:

> The sodium zeolite analcime ($NaAlSi_2O_6H_2O$) occurs upward from the Parachute Creek Member of the Green River Formation into the lower part of the overlying Uinta Formation of late Eocene age. The thickest bed of analcime is 1.4 feet. Analcime is not present in sufficient quantities to be considered economically valuable in the foreseeable future. Dawsonite ($Na_3Al(CO_3)_32Al(OH)_3$) may be present in trace amounts, but X-ray diffraction analyses of 29 samples taken from various parts of the Green River Formation did not reveal its presence.

Water Resources

Ground water

Principles of occurrence

Ground water is that part of subsurface water that completely saturates the rocks and is under hydrostatic pressure. The permeability is the most important hydraulic characteristic of the rocks; it is determined by the size and degree of interconnection of openings in the rocks. The kinds of openings in the rocks that are of most concern in this area are those between grains and along fractures. In general the openings between grains are large in coarse-grained material such as sand and gravel, and small in fine-grained material such as clay or shale. Sandstone may or may not be permeable depending on the size of the sandgrains and the degree to which the spaces between the grains are filled with cementing material. In brittle rocks fracturing can greatly increase the permeability.

Many rocks are layered or bedded. Some of the layers are fine-grained or more tightly cemented than others, therefore the permeability of a formation along the bedding is usually much greater than across the bedding. When a saturated permeable zone is overlain by a less permeable zone, the water is referred to as confined or artesian. When the permeable zone is not overlain by a less permeable zone the water is unconfined or under watertable conditions.

Ground water originates as downward percolation from melting snow or spring rainfall. Individual permeable beds are most often recharged by downward movement from overlying less permeable beds rather than by direct percolation into the outcrop areas of these beds. Thus recharge is not confined to specific local areas, but literally occurs throughout the region. During the growing season the rainfall is almost entirely used by the vegetation in the area; little or no water reaches the saturation zone. Even in the fall of the year when growth ceases, the rainfall is retained in the soil to make up for deficiencies that developed during the summer. The only exception to the foregoing pattern of recharge is in areas that are dryfarmed. In such areas summer fallowing prevents the growth of vegetation and allows for possible recharge from precipitation throughout the year.

Ground water is discharged naturally through springs, directly into streams, and to water-loving vegetation where the zone of saturation is within reach of the roots of these plants. Two of the more common types of springs in the area are contact springs and artesian springs. Contact springs are formed where contact between permeable material and underlying less permeable material outcrops; the water in the permeable bed that is unable to travel downward through the underlying bed is discharged at the surface. Contact springs may be large or small depending on the amount of water recharged to the permeable bed; many of the smaller springs of this type dry-up seasonally. Artesian springs result from the upward movement of confined water sources through fractures; these springs may be large or small depending upon the source. In most of the area the bulk of the discharge is through water-loving vegetation or directly into the streams.

Quantity and quality

Ground water occurs throughout the area; its availability is limited by the permeability of the rocks. Large openings, as in coarse-grained material, will yield large amounts of water, and small openings will yield little water; with few exceptions the rocks of this region are not very permeable. The usefulness of the water is limited by the amount and kind of material dissolved in it.

A map showing a general breakdown of the ground water environments in the area is shown in Map Foldout 6 Appendix B. Three categories are shown on the map: (1) areas that are underlain by crystalline rocks; (2) areas that are underlain by thick marine shales; and, (3) areas that are underlain by other sedimentary rocks; (this category includes all of the coal-producing formations).

In general, yields of three-ten gallons/minute (gpm) of good quality water can be obtained locally from fractures in the crystalline rocks. This water can be expected to have less than 500 mgl total dissolved solids, and to otherwise meet Public Health Service requirements for dissolved constituents. The best place to drill is in upland valleys; they are more likely to be underlain by fractured rocks than adjacent higher ground.

Thick marine shales generally produce only small (1-5 gpm) yields of poor quality water, and due to their great thickness (1,000-5,000 feet), the prospects for obtaining supplies of good quality water at a reasonable depth are unfavorable. If sandstone members of these shale formations are encountered within 200 feet of the surface, the water will be better quality and may be usable for watering livestock.

Other sedimentary rocks which cover the remainder of the area generally include saturated permeable sandstones within at least 1,000 feet of the surface, and in most places a well can be completed at less than 500 feet. The depth depends upon local relief, and the water level in a well at a given site is likely to stand near the level of the closest stream. Wells drilled on high ground may need to be very deep. Expected yields depend largely on the thickness of saturated rock that is penetrated and upon how much drawdown is imposed on a well. Thus a well that penetrates only 50 feet of saturated rock may yield only three-ten gpm, whereas a well that penetrates a thousand feet or more of saturated rock can be pumped at a rate of several hundred gpm.

Water quality from sedimentary rocks is good in some places but only fair in most of the area. With few exceptions the water would be usable for livestock, and if better water was not available it could be used for domestic purposes. Such water commonly has a laxative effect which diminishes with continued use. The water from these rocks is generally unfit for irrigation use except on well-drained soils and with salt-tolerant crops.

Because of scale limitations one more category of water-yielding material is not shown on Map Foldout 6; this is the alluvium along the streams. Most of this alluvium is fine-grained and yields only small amounts of fair-poor quality water. However, in some parts of the region clean deposits of gravel or coarse sand yield large amounts (up to 1,500 gpm) of water to wells. Such places are isolated and cannot readily be located by surface methods; they cannot be expected to sustain their high yields over long periods of time.

There are no known ground water sources that are capable of the sustained high yields that would be required for municipal supplies, power plant cooling, coal gasification, or slurry pipelines.

The expected yield and dissolved solid content of water from wells is shown in more detail in Table RIV-4. The formation designations are keyed to the geologic map symbols and legend in Appendix A. The yield and dissolved solids are shown as follows: (1) minimum, which is near the bottom end of the expected range of values, (2) maximum, which is near the top end of the expected range, and (3) median, which represents the most common expected value for a well drilled in that formation. All of the values given are approximate estimates based on available well data and the character of the rocks. The estimates are on a where saturated basis; the Quaternary deposits that lie above stream level are not likely to be saturated nor are many of the Tertiary volcanic deposits.

Special mention is made here of three formations that are not in the table. The Glen Canyon Sandstone and the Entrada Sandstone of Jurasic and Triasic age provide water of good quality to wells that supply the town of Dinosaur (formerly Artesia). In the vicinity of Rangely water from these same rocks is saline. The Madison Limestone and its stratigraphic equivalent, the Leadville Limestone of Mississippian age, produce large quantities of saline water near McCoy in the southeastern part of the area, and at Meeker Dome, three miles east of Meeker. This limestone underlies much of the remainder of the area, but no information is available as to its yield or water quality; it is assumed that the water is also saline in the remainder of the area.

TABLE RIV-4

Water-Bearing Characteristics of Geologic Formations

Formation	Yield (gpm) Minimum	Yield (gpm) Median	Yield (gpm) Maximum	Dissolved Solids (mgl) Minimum	Dissolved Solids (mgl) Median	Dissolved Solids (mgl) Maximum
Qa, Qg, Qd	5	50	1,500	20	100	2,000
Other Q	1	2	10	20	300	2,000
Tbb, Tui, Tv	2	5	50	20	50	200
Tmi, Taf	2	5	50	20	50	200
Other T	2	10	20	30	1,500	20,000
Kl	2	20	100	200	800	3,000
Kls	1	2	20	600	4,000	10,000
Kwf, Ki, Kmv	1	10	300	200	1,000	8,000
Km	1	2	20	600	4,000	10,000
Kd	2	10	100	100	1,000	10,000
All J	1	10	200	300	1,000	10,000
All ₹	1	5	100	500	1,500	10,000
All P & IP	1	5	100	500	2,000	20,000
M	5	100	2,000	1,000	5,000	20,000
DE	1	10	50	200	500	2,000
Y & X	1	5	50	20	50	200

NOTE: Formation designations are keyed to the geologic map in Appendix A.

The present ground water developments in the area are almost entirely limited to small capacity wells and springs for domestic livestock use. The annual ground water recharge to the area drained by the Yampa River above Maybell is about 300,000 acre-feet; probably only 300 acre-feet of ground water per year is currently developed for use in the area.

Surface water

Quantity

Streamflow characteristics. The study region is drained by tributaries of the Green River, which in turn flows to the Colorado River in southeastern Utah. The study region is drained almost entirely by two major tributaries, the Yampa and White Rivers; of these two, the Yampa River dominates the study area. A minor tributary of the Green River, Vermillion Creek, drains the extreme northwest corner of the area. Map Foldout 7 in Appendix B shows the major streams and drainage pattern of the area. Table RIV-5 lists the major streams by tributary rank in downstream order.

The mean headwater elevation of streams in the eastern half of the Yampa River Subbasin is about 9,800 feet. Headwaters of streams in the Little Snake River are about 9,100 feet. Tributaries to the White River and its main stem begin at about 9,900 feet. Vermillion Creek, and its tributaries which drain a more desert-type area, head at about 8,000 feet in south-central Wyoming.

Stream types. Because of its lower altitude and low precipitation, Vermillion Creek Subbasin runs intermittently, and when combined with the Yampa River, provides only two percent of the total combined contribution of the two streams to the Green River.

TABLE RIV-5

Streams of Northwest Colorado by Tributary Rank and Downstream Order

- Colorado River Basin
  - Green River Basin
    - Vermillion Creek
    - Yampa River
      - Service Creek
      - Oak Creek
      - Walton Creek
      - Fish Creek (tributary to Yampa River)
      - Spring Creek
      - Soda Creek
      - Elk River
      - Trout Creek
        - Fish Creek (tributary to Trout Creek)
      - Grassy Creek
      - Elkhead Creek
        - North Fork Elkhead Creek
      - East Fork of Williams Fork
        - South Fork of Williams Fork
      - Williams Fork
      - Milk Creek
      - Middle Fork Little Snake River
        - North Fork Little Snake River
        - South Fork Little Snake River
      - Little Snake River
        - Battle Creek
        - Slater Fork
        - Savery Creek
        - Willow Creek
        - Fourmile Creek
    - North Fork White River
      - Lost Creek
      - South Fork White River
      - Big Beaver Creek
    - White River
      - Coal Creek
      - Piceance Creek

The Yampa River rises in the Park Range along the Continental Divide and flows westward to its junction with the Green River. Snowmelt is the principal source of water supply in the subbasin, and the pattern of seasonal runoff of the river and its tributaries is like that of other streams in the upper Colorado River Basin that have similar environment.

The water supply for the White River Subbasin also comes principally from melting of winter snowpacks on the high mountains, sustained by ground water recharge and some summer precipitation. There is considerable variation in watershed yield, reflecting climatological and meteorological differences in various parts of the subbasin. Water yields range from more than 20 inches of runoff for some parts of the higher areas in the subbasin to less than one inch in the desert areas. On an average, about 64 percent of the annual discharge occurs in the months of May and June.

Data available. Streamflows of the area have been monitored since 1901 by gages operated by the USGS in cooperation with the Colorado Water Conservation Board, Colorado Division of Water Resources, Colorado Division of Highways, State of Colorado; Colorado River Water Conservation District; Colorado Department of Health, Pollution Control Division; Bureau of Reclamation and the National Park Service, U.S. Department of the Interior. The location of the gages is shown in Appendix B, Map Foldout 11.

Surface waters can be transported from areas of supply to areas of demand. Therefore, data for many of the gages that have been operated in the Yampa and White River systems will be presented in order to present an overall picture of surface water resources in the coal development area.

Streamflow statistics. Table RIV-6 lists streamflow characteristics for many of the gaged sites shown in Map Foldout 11. Several gaging station records were not used because the records covered too short a period to indicate trends, i.e., less than five years. Average annual flows, low flows, and peak flow characteristics are listed in the table. Remarks are included for those streams whose natural flows have been influenced by works of man. Many streams have man-made structures such as reservoirs and diversions which affect natural streamflows by varying degrees. Table RIV-6 also shows flows with average recurrence intervals of 2, 5, 10, 25, and 50 years. Those stations that do not show the 10, 25, or 50 year recurrence intervals have records of less than 10, 15, or 20 years respectively. Predicting recurrence intervals with too short a record is considered misleading. Those stations with no recurrence interval data had data which were considered too unreliable for this purpose. A comparison of peak flows with corresponding recurrence intervals does indicate that the peaks seldom exceed the 50 year recurrence interval, which would indicate that major floods are unlikely.

Monthly hydrographs of selected streams, Figure RIV-7, indicate the seasonal runoff characteristics of the streams in the study area. Peak flows generally occurring in May and June verify the bulk of the annual runoff comes from melting snow.

Figure RIV-8 shows yearly hydrographs for representative streams in the study area. These hydrographs show the fluctuations of annual flows, which are due primarily to differences in annual precipitation. Average annual yields of the different streams are indicated by their

Streamflow Characteristics at Gaging Stations in Study Region

Station number	Station name	Drainage Area (sq mi)	Records Used (years)	Annual Mean Discharge (cfs)		Range of Annual Minimum Daily Discharge (cfs)	Peak Flows								Factors Affecting Natural Flow
							Average recurrence interval (years)					Maximum observed			
				Average	Range		2	5	10	25	50	Date	Discharge	Unit Discharge (cfs/sq mi)	
09236000	Yampa River near Toponas, Colo.	23	1952-65, 1966-73	40.3	31.2-55.7	1.6-15	190	257	305	369	420	July 2, 1957	436	18.9	Flow regulated by Stillwater and Yampa Reservoirs (combined capacity, 6,820 acre-feet)
09237500	Yampa River near Oak Creek, Colo.	227	1939-44, 1956-72	86.1	48.6-160	8.9-40	460	748	976	1,310	--	Apr. 16, 1962	1,400	6.17	Diversions for irrigation of about 12,000 acres above station. Two diversions for irrigation to Egeria Creek i Colorado River basin. Storage in Stillwater and Yampa Reservoirs (total capacity, 6,820 acre-ft).
09237800	Service Creek near Oak Creek, Colo.	38.2	1965-73	45.2	26.7-60.4	2.0-3.0	--	--	--	--	--	May 21, 1970	765	20.0	
09238000	Oak Creek near Oak Creek, Colo.	14	1952-57	8.38	5.14-15.3	1.4-2.4	59	104	--	--	--	May 9, 1957	140	10.0	Diversions for irrigation of about 1,000 acres above station. One diversion imports water from Trout Creek to Oak Creek above station.
09238500	Walton Creek near Steamboat Springs, Colo.	42.4	1920-22, 1965-73	87.4	52.0-143	4.5-9.7	1,260	1,780	2,170	--	--	June 15,1921	2,800 1/	66.0	Diversions above station by Highline Canal from Beaver and Storm King Creeks for irrigation below station.
09239400	Spring Creek near Steamboat Springs, Colo.	6.96	1965-72	9.42	5.76-12.1-	0.08-0.55	93	119	--	--	--	June 5, 1968	138	19.8	Diversions 1.3 miles above station by Steamboat Garden ditch for irrigation in Soda Creek drainage.
09239500	Yampa River at Steamboat Springs, Colo.	604	1904-6 1909-73	467	175-740	4-98	3,680	4,610	5,130	5,690	6,060	June 14, 1921	6,820	11.3	See remarks for stations 09237500 and 09238000. Diversions for irrigation of about 19,700 acres above station.
09240000	Soda Creek at Steamboat Springs, Colo.	47	1910-11, 1912 19	47.8	27.8-72.4	0--	--	--	--	--	--	June 12, 1918	694 1/	14.8	Diversions for irrigation of about 8,000 acres above station.
09240500	Elk River at Hinman Park, Colo.	61	1911-18	199	142-272	---	1,460	1,860	--	--	--	June 12, 1918	2,040	33.4	
09241000	Elk River at Clark, Colo.	206	1910-22, 1930-73	337	179-557	22-54	2,630	3,250	3,610	4,020	4,310	June 6, 9, 1912	4,470 1/	21.7	Diversions above station for irrigation of about 120 acre above and about 460 acres below station.
09242500	Elk River near Trull Colo.	415	1904-6, 1909-27	594	422-886	---	4,140	4,810	5,200	--	--	June 15, 1921	5,530	13.3	Diversions above station for irrigation of about 6,500 acres above and about 1,000 acres below station.
09243000	Trout Creek near Phippsburg, Colo.	16	1953-58	27.4	18.6-39.7	---	278	431	--	--	--	June 30, 1957	565	35.3	Regulation since April 1955 by sheriff. Reservoir (capacity about 900 acre-ft 1 mile above station. Rich Ditch diverts water above station from Trout Creek basin to Oak Creek basin.
09244100	Fish Creek near Milner, Colo.	34.5	1955-73	12.7	5.62-20.5	0.4-2.2	--	--	--	--	--	May 18, 1970	342	9.91	Diversions above station for irrigation.
09244300	Grassy Creek near Mount Harris, Colo.	25.8	1958-66	1.44	0.20-3.53	0-0	--	--	--	--	--	Apr. 20, 1965	247	9.57	

1/ Maximum daily discharge

TABLE RIV-6 (Cont.)

Streamflow Characteristics at Gaging Stations in Study Region

Station number	Station name	Drainage Area (sq mi)	Records Used (years)	Annual Mean Discharge (cfs) Average	Annual Mean Discharge (cfs) Range	Range of Annual Minimum Daily Discharge (cfs)	Peak Flows: Average recurrence interval (years) 2	5	10	25	50	Maximum observed Date	Maximum observed Discharge	Unit Discharge (cfs/sq mi)	Factors Affecting Natural Flow
09244500	Elkhead Creek near Clark, Colo.	45.4	1942-44, 1958-73	35.8	15.2-52.9	0.30-3.0	654	880	1,000	1,140	--	May 18, 1970	1,060	23.3	
09245000	Elkhead Creek near Elkhead, Colo.	64.2	1910;1920, 1953-	51.7	23.1-75.6	0-2.8	908	1,160	1,300	1,460	1,560	May 22, 1920	1,660 1/	25.9	
09245500	North Fork Elkhead Creek near Elkhead, Colo.	21	1910;1920 1958-73	17.2	8.24-27.9	0-0.67	402	652	837	1,090	--	May 21, 1970	1,100	52.4	Diversions above station for irrigation of about 100 acres of hay meadows.
09248600	East Fork of Williams Fork above Willow Creek, Colo.	108	1956-72	107	64.4-183	10-28	1,020	1,290	1,450	1,630	--	May 19, 1970	1,570	14.5	Diversions for irrigation of about 800 acres above station.
09249000	East Fork of Williams Fork near Pagoda, Colo.	150	1953-71	113	61.0-205	12-26	920	1,240	1,450	1,720	--	June 26, 1957	1,620	10.8	Diversions for irrigation of about 900 acres above station.
09249200	South Fork of Williams Fork near Pagoda, Colo.	46.7	1965-73	42.8	24.6-55.4	0.20-2.1	634	760	--	--	--	May 20, 1970	878	18.8	Diversions for irrigation of about 100 acres above and 50 acres below station.
09249500	Williams Fork at Hamilton Colo.	341	1904-6, 1909-27	219	141-396	---	1,930	2,530	--	--	--	June 10, 1917	3,400	10.0	Diversions for irrigation of about 4,500 acres above station. Small ditch imports water from nearby stream above station.
09250000	Milk Creek near Thornburgh, Colo.	65	1952-73	23.5	7.36-44.3	0.20-1.5	286	464	606	814	992	May 19, 1970	864	13.3	Diversions for irrigation of about 2,000 acres above station.
09253500	Battle Creek near Slater, Colo.	85.3	1942-51	83.	64.5-109	2.6-5.8	899	1,030	--	--	--	May 21, 1948	1,160	13.6	Diversions above station for irrigation of about 230 acres above and 70 acres below station.
09254500	Slater Fork at Baxter Ranch, near Slater, Colo.	80	1911-20, 1922	81.4	55.0-120	---	610	793	922	--	--	June 9, 1917	1,070	13.4	
09255000	Slater Fork near Slater, Colo.	161	1910-12, 1931-73	72.7	20.4-112	0-8.6	--	--	--	--	--	May 19, 1912	1,700	10.6	Diversions for irrigation of about 500 acres above station.
09255500	Savery Creek at upper station, near Savery, Wyo.	200	1940-44, 1952-72	45.0	18.4-76.1	0.60-12	460	837	1,140	1,590	1,970	Apr. 15, 1962	1,680	8.4	Diversions for irrigation of about 470 acres above station. Natural flow slightly affected by diversion above station to Platte River basin through Ranger ditch.
09256000	Savery Creek near Savery, Colo.	330	1941-46, 1947-72	104	39.7-207	0-14	--	--	--	--	--	May 4, 1952	2,670	8.1	Diversions for irrigation of about 640 acres above and 140 acres below station. Trans-basin diversion above station.
0925700	Little Snake River near Dixon, Wyo.	988	1910-23, 1938-73	514	212-930	0.20-10	4,610	6,110	7,050	8,190	9,000	May 26, 1920	9,600	9.7	Diversions for irrigation of about 9,500 acres above and 3,000 acres below station. Transbasin diversion above station.
09258000	Willow Creek near Dixon, Wyo.	24	1953-73	9.38	4.79-15.5	0-1.3	131	200	245	300	339	May 6, 1970	267	11.1	Regulation by Elk Lake (capacity, 400 acre-ft).
09251000	Yampa River near Maybell, Colo.	3,410	1904-5, 1910-12, 1916-73	1,549	517-2,948	2-345	9,950	12,500	13,900	15,600	16,600	May 19, 1917	17,900	5.2	Natural flow of stream affected by trans-basin diversions, numerous storage reservoirs, and diversions above station for irrigation of about 65,000 acres above and 800 acres below station.

1/ Maximum daily discharge

TABLE IV-6 (Cont.)

Streamflow Characteristics at Gaging Stations in Study Region

Station number	Station name	Drainage Area (sq mi)	Records Used (years)	Annual Mean Discharge (cfs)		Range of Annual Minimum Daily Discharge (cfs)	Peak Flows								Factors Affecting Natural Flow
							Average recurrence interval (years)					Maximum observed			
				Average	Range		2	5	10	25	50	Date	Discharge	Unit Discharge (cfs/sq mi)	
09251500	Middle Fork Little Snake River near Battle Creek, Colo.	120	1912-22	136	92.0-218	---	1,690	2,720	3,530	--	--	May 25, 1920	4,400	36.7	Diversions for irrigation of about 500 acres above station.
09251800	North Fork Little Snake River near Encampment, Wyo.	9.64	1956-65	25.7	20.0-34.7	1.1-2.2	--	--	--	--	--	June 7, 1957	515	53.4	Transbasin diversion above station to Hog Park Creek in Platte River basin for municipal, industrial, and irrigation uses.
09251900	North Fork Little Snake River near Slater, Colo.	29.3	1956-63	44.2	30.5-60.1	2.4-4.4	439	539	--	--	--	June 7, 1957	628	21.4	See remarks for station No. 09251800.
09252500	South Fork Little Snake River near Battle Creek, Colo.	46	1912-20	30.8	15.5-41.7	---	320	543	--	—	--	May 9, 1920	760	16.5	Diversions above station for irrigation of about 360 acres above and 80 acres below station.
09253000	Little Snake River near Slater, Colo.	285	1942-47, 1950-73	220	105-343	8.6-26	2,170	2,780	3,110	3,480	3,710	June 7, 1957	3,230	11.3	Natural flow of stream affected by transbasin diversions and diversions for irrigation of about 2,000 acres above station.
09259500	Fourmile Creek near Baggs, Wyo.	4	1911-23	6.56	3.77-14.2	---	82	132	163	--	--	June 9, 1917	168	42.0	Diversions above station for irrigation.
09259700	Little Snake River near Baggs, Wyo.	3,020	1961-68	523	261-771	0-13	4,620	6,610	--	--	--	Mar. 28, 1962	10,000	3.3	Diversions for irrigation of about 15,000 acres above station.
09260000	Little Snake River near Lily, Wyo.	3,730	1904, 1921-73	571	110-1,213	0-27	5,200	7,550	8,960	10,600	11,600	May 27, 1926	14,200	3.8	Diversions for irrigation of about 21,000 acres above station.
09302400	White River below Trappe Lake, Colo.	21.4	1956-65	27.8	19.0-42.2	2.9-9.6	--	--	--	--	--	July 4, 1957	481	22.5	Natural regulation by Trapper's Lake.
09302450	Lost Creek near Buford, Colo.	21.6	1964-73	22.3	12.6-28.1	0.8-1.9	--	--	--	--	--	May 18, 1970	818	37.9	
09302800	North Fork White River near Buford, Colo.	223	1903-6, 1956-73	290	201-402	85-150	1,340	1,630	1,790	1,960	--	June 8, 1905	1,950	8.7	Diversions above station for irrigation of a few hay meadows.
09303000	North Fork White River at Buford, Colo.	254	1910-15, 1919-20, 1951-73	311	221-550	90-180	1,400	1,910	2,250	2,680	3,000	May 30, 1912	3,150	12.4	Diversions above station for irrigation of about 900 acres above and 300 acres below station.
09303500	South Fork White River near Buford, Colo.	157	1903-6, 1910-15, 1942-47, 1967-73	263	202-351	60-90	1,740	2,200	2,500	2,890	--	June 17, 1906	3,230	20.6	Diversions for irrigation of about 600 acres of hay meadows above station.
09304000	South Fork White River at Buford, Colo.	170	1919-20, 1951-73	256	180-357	60-95	1,860	2,210	2,420	2,680	2,880	June 20, 1957	3,000	17.6	Diversions above station for irrigation of about 1,100 acres above and a few acres below stations.
09304100	Big Beaver Creek near Buford, Colo.	34.6	1955-64	14.9	5.92-29.6	0-0.6	205	297	--	--	--	June 3, 1957	395	11.4	One diversion above station for irrigation below station along the White River.
09304200	White River above Coal Creek, near Meeker, Colo.	660	1961-73	556	383-743	66-240	--	--	--	--	--	May 21, 1970	3,850	5.8	Diversions above station for irrigation of about 8,000 acres above and 4,000 acres below station.
09304300	Coal Creek near Meeker, Colo.	25	1957-68	5.23	2.78-9.51	0.40-1.2	51	80	99	--	--	May 11, 1958	102	4.1	Diversions for irrigation of a few acres of hay meadows above station.

TABLE RIV-6 (Cont.)

Streamflow Characteristics at Gaging Stations in Study Region

Station number	Station name	Drainage Area (sq mi)	Records Used (years)	Annual Mean Discharge (cfs)		Range of Annual Minimum Daily Discharge (cfs)	Peak Flows							
							Average recurrence interval (years)					Maximum observed			Factors Affecting Natural Flow
				Average	Range		2	5	10	25	50	Date	Discharge	Unit Discharge (cfs/sq mi)	
09304500	White River near Meeker, Colo.	762	1901-6, 1909-73	622	339-935	112-290	3,220	4,100	4,600	5,170	5,550	June 16, 1921	6,370	8.4	Diversions above station for irrigation of about 12,000 acres above and 3,000 acres below station.
09304800	White River below Meeker, Colo.	1,040	1961-73	625	454-791	141-300	--	--	--	--	--	June 15, 1965	4,010	3.9	Diversions above station for irrigation of about 22,000 acres above and a few acres below station.
09305500	Piceance Creek at Rio Blanco, Colo.	9	1952-57	1.40	0.77-2.55	0.10-0.30	12	19	--	—	—	May 9, 1957	23	2.6	Small diversions above station for irrigation of hay meadows above and below station.
09306200	Piceance Creek below Ryan Gulch, near Rio Blanco, Colo.	485	1964-73	16.6	8.30-29.1	0.21-6.0	139	221	--	--	—	Mar. 9, 1966	400	0.8	Diversions for irrigation above station.
09306500	White River near Watson, Utah	4,020	1904-6, 1918 1923-73	702	383-1,736	53-356	4,270	5,730	6,660	7,820	8,670	July 15, 1929	8,160	2.0	Diversions for irrigation of about 30,000 acres above station.

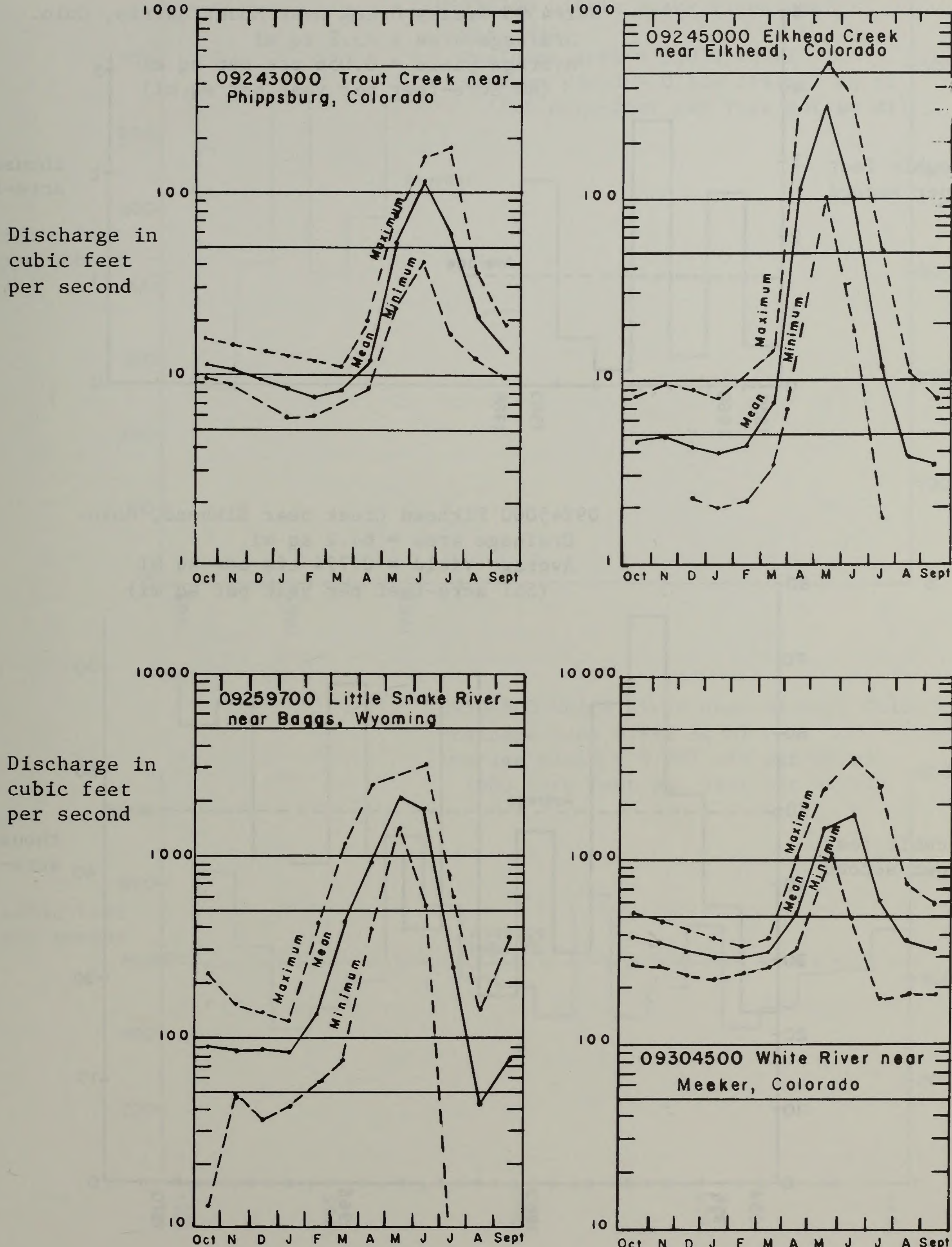


FIGURE RIV-7

Monthly hydrographs of selected streams in the study region.

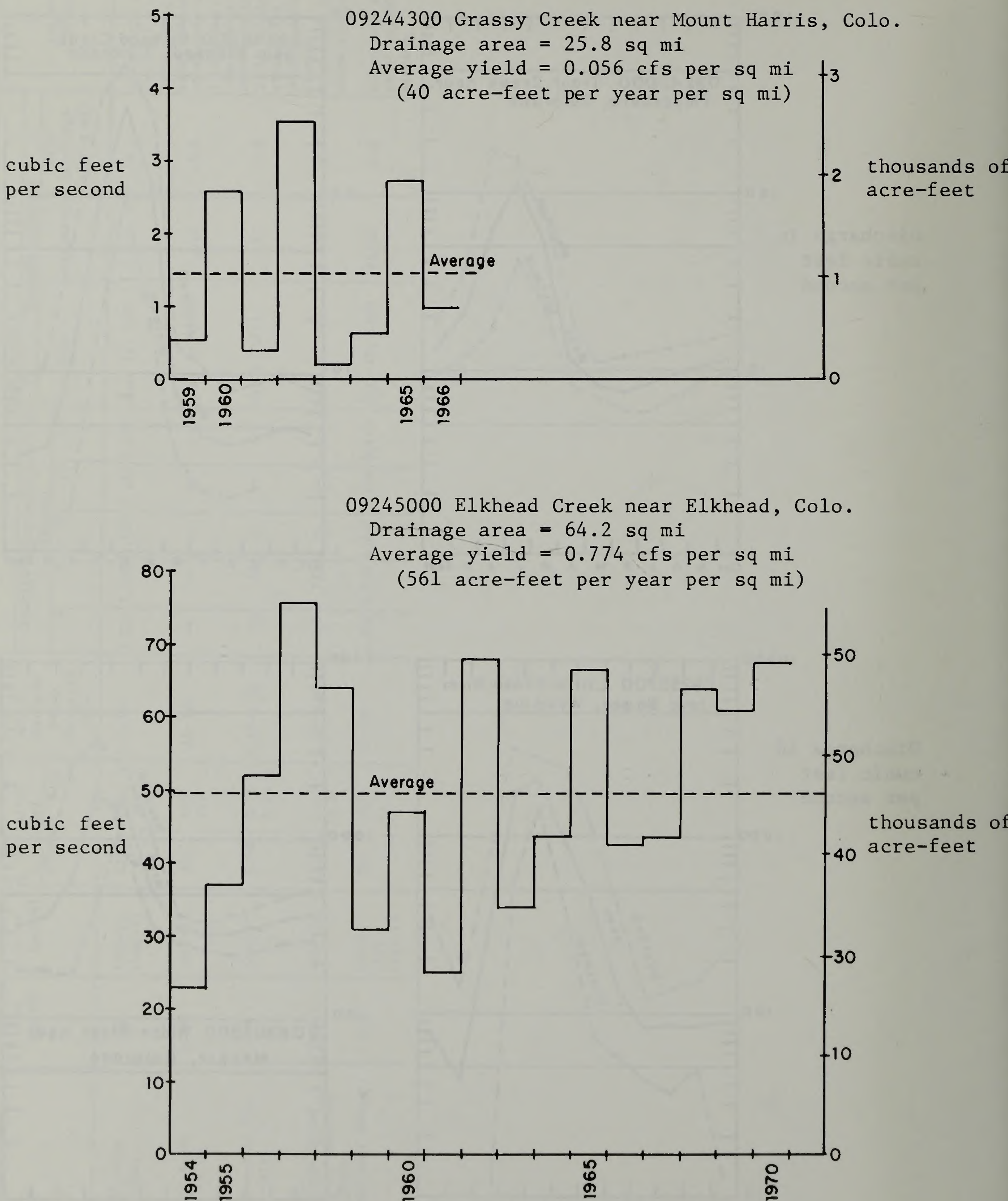
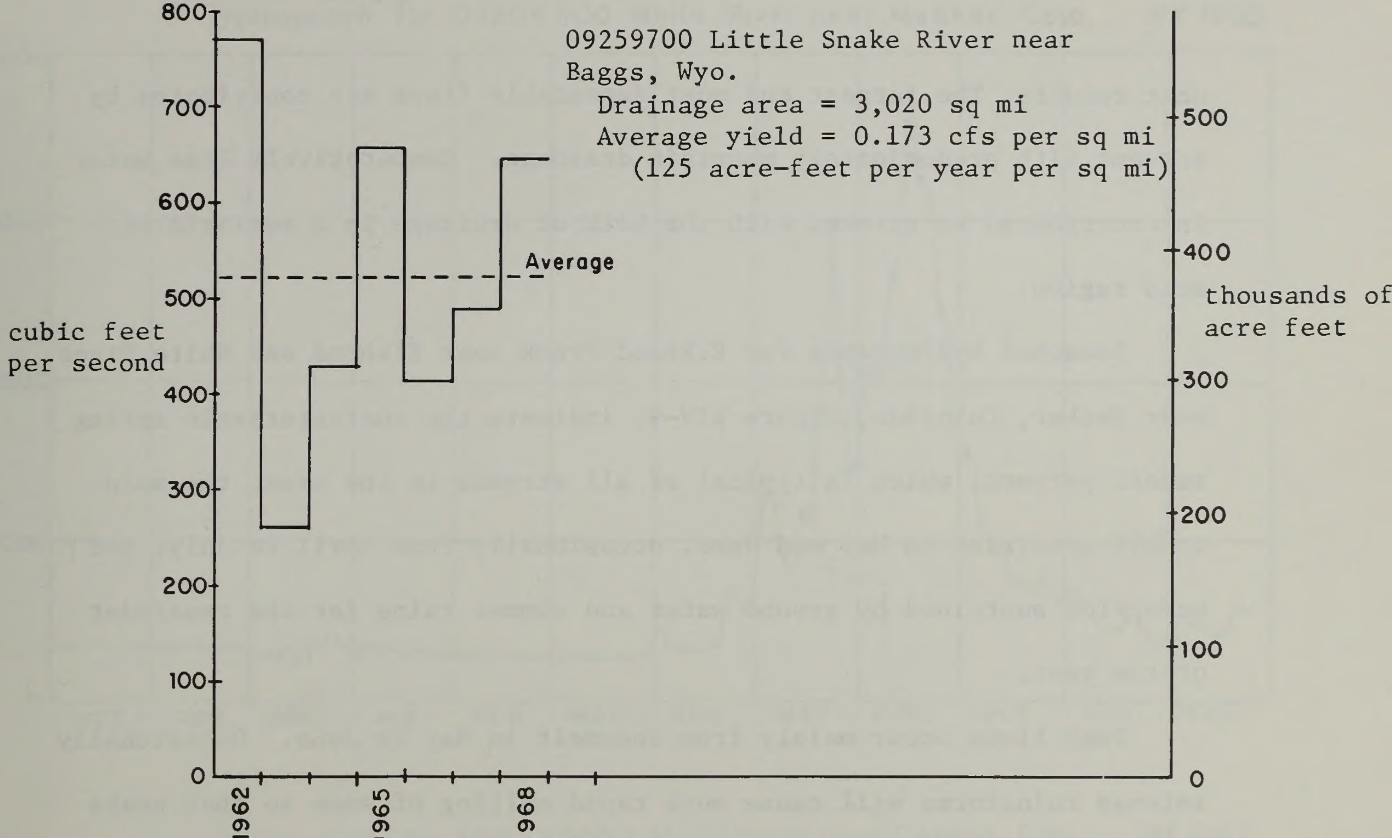


FIGURE RIV-8

Yearly hydrographs of selected streams in the study region.



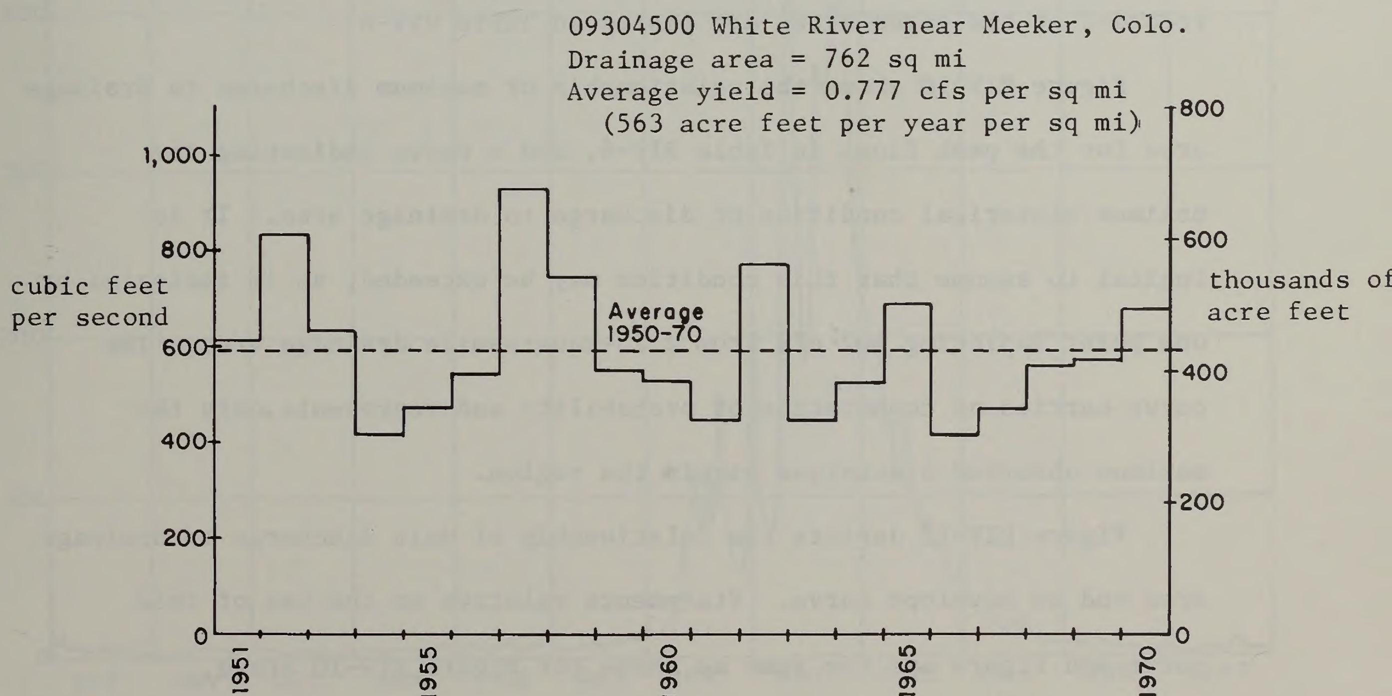


FIGURE RIV-8 (cont.)

Yearly hydrographs of selected streams in the study region.

unit runoffs. The largest and most dependable flows are contributed by streams with predominately mountain drainage. Comparatively less water is contributed by streams with the bulk of drainage in a semiarid to arid region.

Seasonal hydrographs for Elkhead Creek near Elkhead and White River near Meeker, Colorado, Figure RIV-9, indicate the characteristic spring runoff pattern, which is typical of all streams in the area, the main runoff occurring in May and June, occasionally from April to July, and base flow sustained by ground water and summer rains for the remainder of the year.

Peak flows occur mainly from snowmelt in May or June. Occasionally intense rainstorms will cause more rapid melting of snow so that peaks may occur in April or July. The maximum instantaneous flows that have been recorded at the gaged sites are listed in Table RIV-6.

Figure RIV-10 shows the relationship of maximum discharge to drainage area for the peak flows in Table RIV-6, and a curve indicating the maximum historical condition of discharge to drainage area. It is logical to assume that this condition may be exceeded, as is indicated by one point depicting 102 cfs from a 25-square-mile drainage area. The curve carries no connotation of probability and represents only the maximum observed discharges within the region.

Figure RIV-11 depicts the relationship of unit discharge to drainage area and an envelope curve. Statements relative to the use of this curve and figure are the same as those for Figure RIV-10 above.

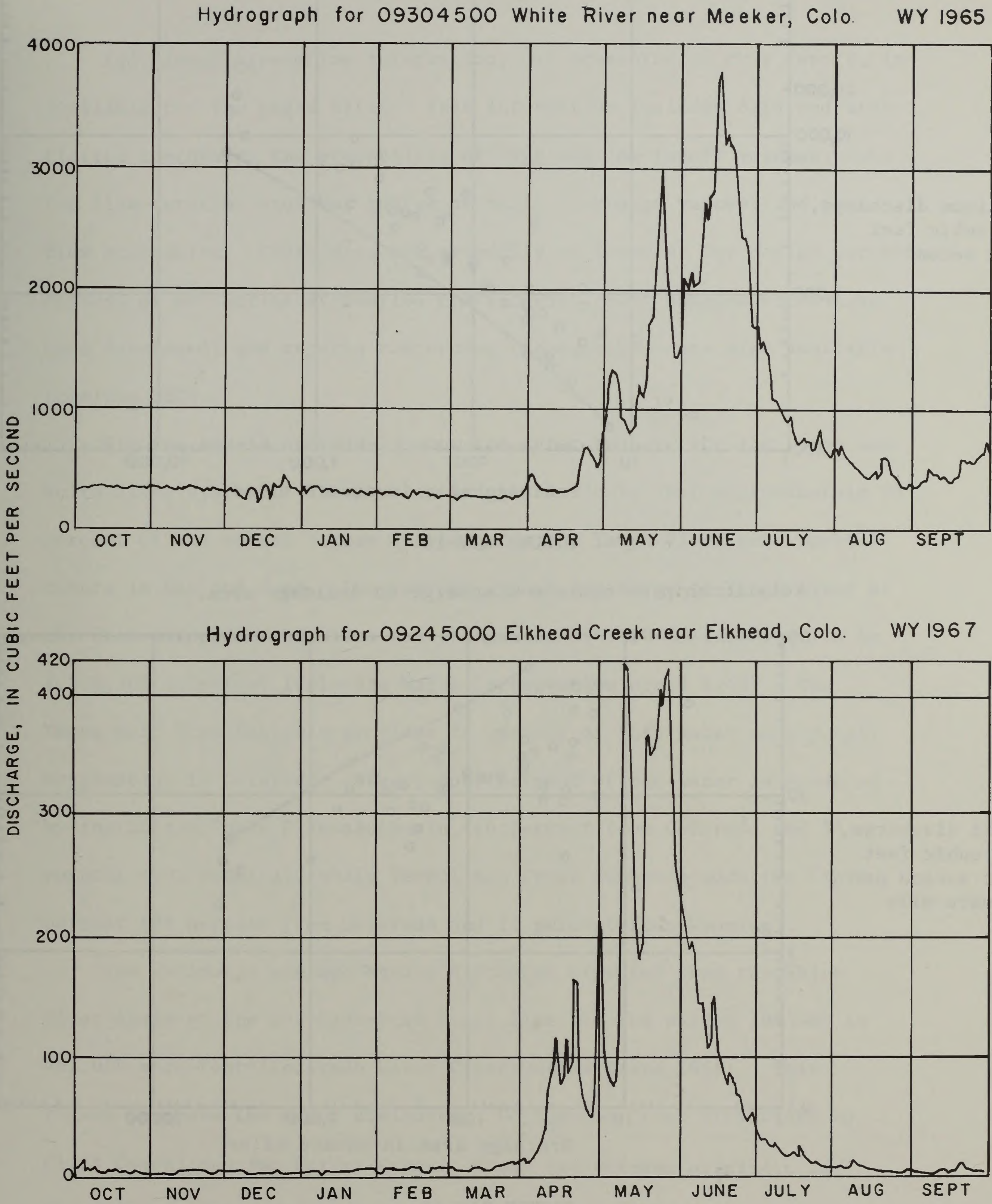


FIGURE RIV-9

Seasonal pattern of runoff in the Green River Basin.

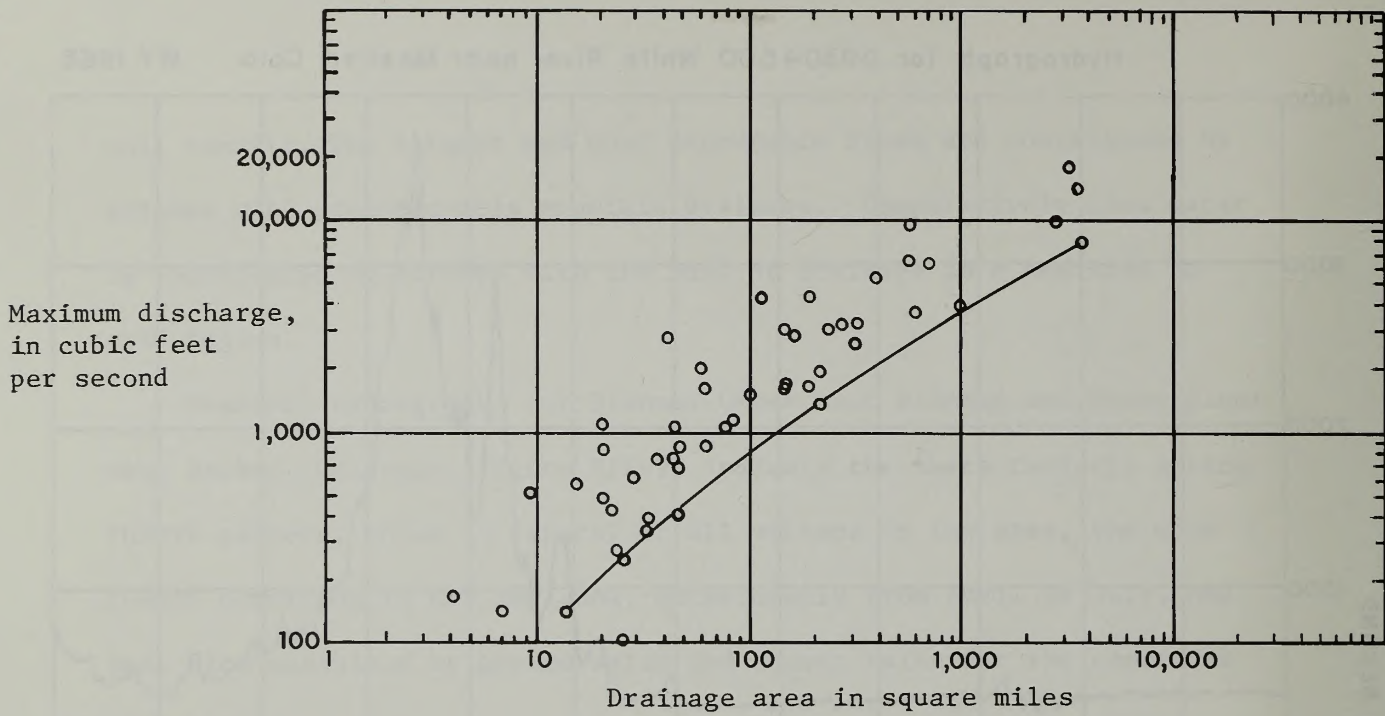


FIGURE RIV-10

Relationship of maximum discharge to drainage area.

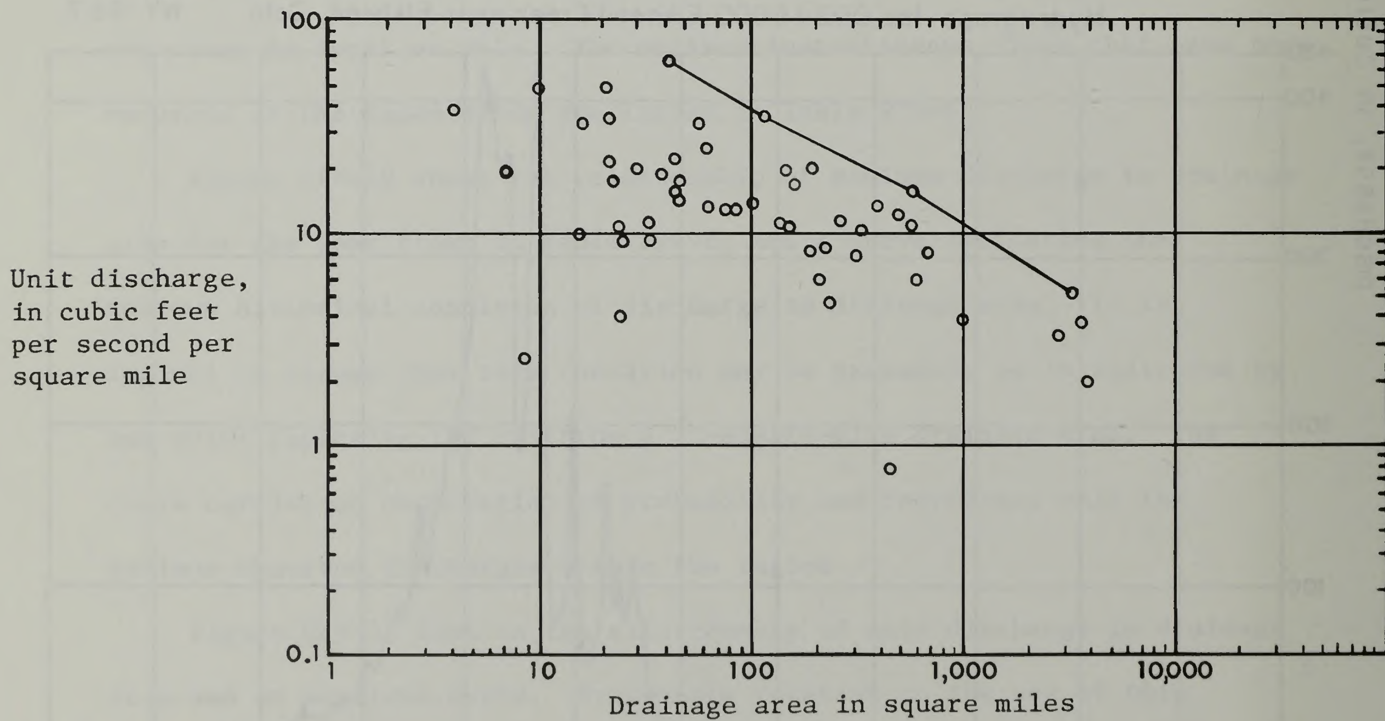


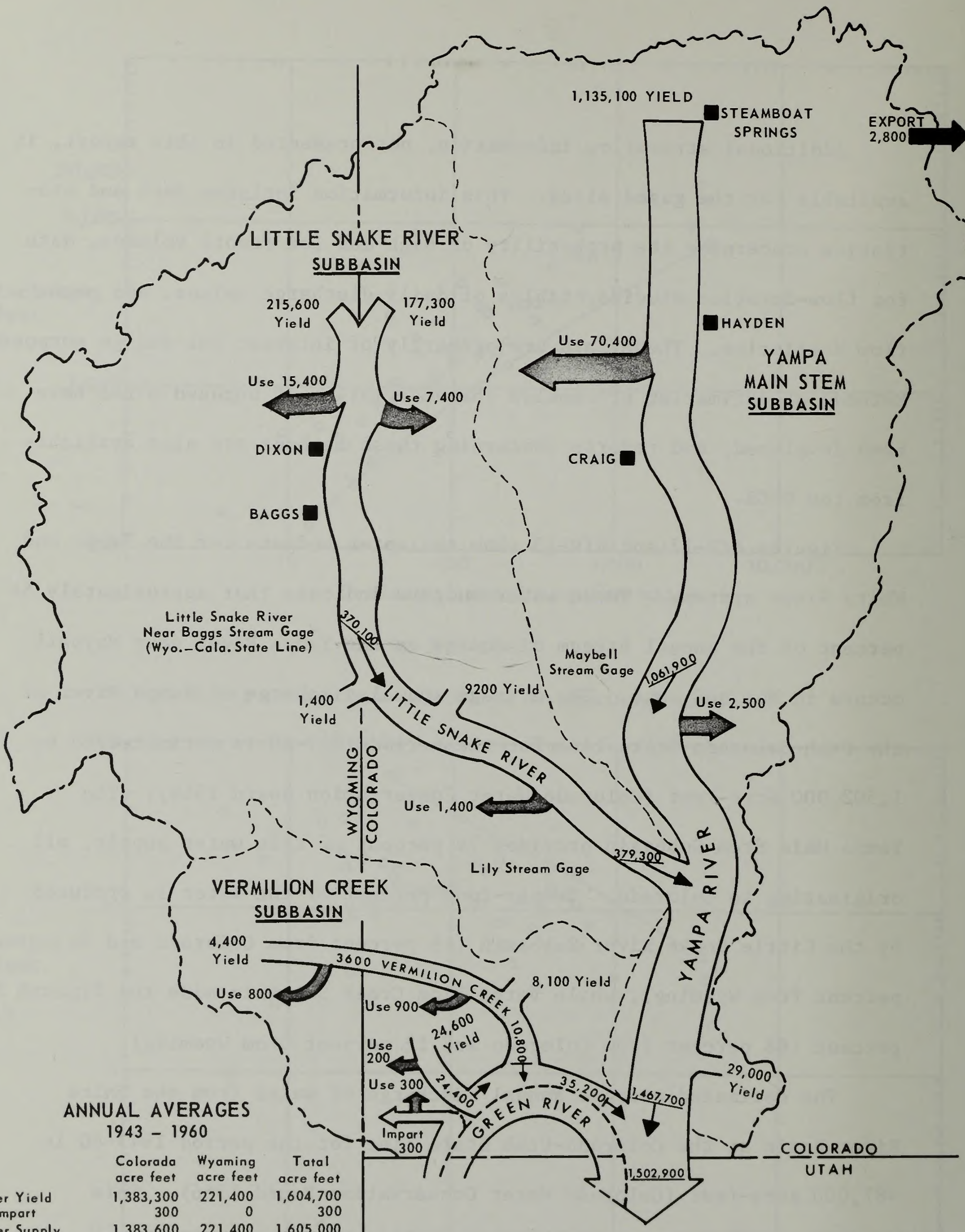
FIGURE RIV-11

Maximum observed unit discharge and envelope curve.

Additional streamflow information, not presented in this report, is available for the gaged sites. This information includes data and statistics concerning the probability of high and low runoff volumes, data for flow-duration studies, tables of daily discharge values, and peak flow statistics. These data are primarily of interest for design purposes. Methods of estimating streamflow characteristics at ungaged sites have been developed, and reports concerning these methods are also available from the USGS.

Figures RIV-12 and RIV-13 show the water budgets for the Yampa and White River systems. These water budgets indicate that approximately 64 percent of the annual stream discharge on the Yampa River near Maybell occurs in May and June. The average annual discharge of Yampa River at the Utah-Colorado State line for the period 1943-60 is estimated to be 1,502,900 acre-feet (Colorado Water Conservation Board 1969). The Yampa Main Stem Subbasin provides 74 percent of this water supply, all originating in Colorado. Twenty-four percent of the water is produced by the Little Snake River Subbasin (46 percent from Colorado and 54 percent from Wyoming), while Vermillion Creek Subbasin adds the final 2 percent (88 percent from Colorado and 12 percent from Wyoming).

The estimated average annual discharge of water from the White River Basin at the Colorado-Utah State line for the period 1943-60 is 487,000 acre-feet (Colorado Water Conservation Board 1966). This figure includes two minor drainages: Cottonwood Creek (tributary to Cliff Creek) and Two Waters Creek. These two streams originate in Colorado and enter the Green and White Rivers in Utah.



ANNUAL AVERAGES
1943 – 1960

	Colorado acre feet	Wyoming acre feet	Total acre feet
Water Yield	1,383,300	221,400	1,604,700
Impart	300	0	300
Water Supply	1,383,600	221,400	1,605,000
In Basin Use	83,100	16,200	99,300
Export	2,800	0	2,800
Stream Depletion	85,900	16,200	102,100
State Line Discharge	1,297,700	205,200	1,502,900

FIGURE RIV-12

Water budget for the Yampa River Basin.

SOURCE: Colorado Water Conservation Board, 1969

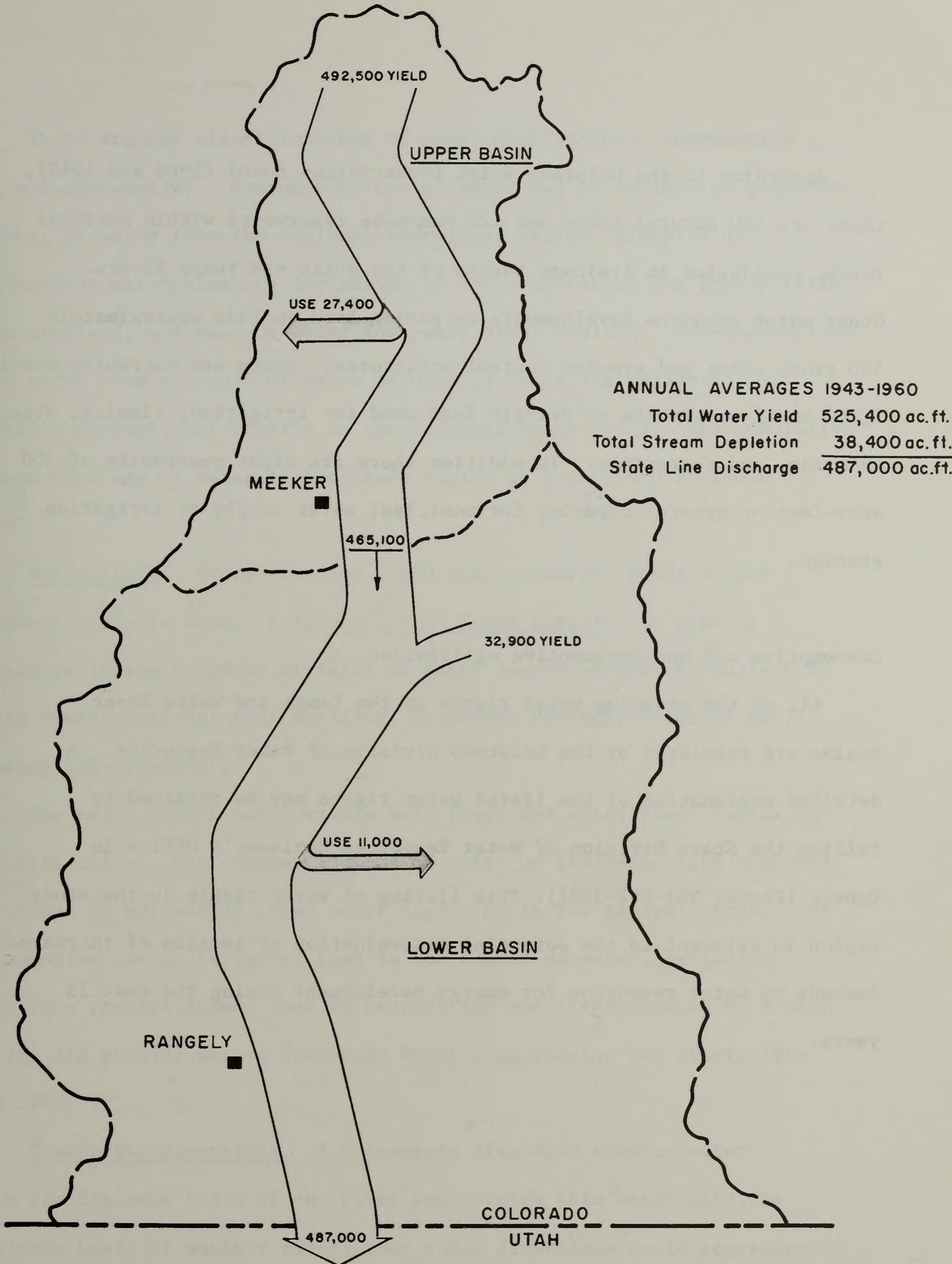


FIGURE RIV-13

Water budget for the White River Basin.

SOURCE: Colorado Water Conservation Board, 1966

According to the Colorado Water Conservation Board (1966 and 1969), there are 160 natural lakes and 122 man-made reservoirs within National Forest boundaries in drainage basins of the White and Yampa Rivers. Other water resource developments on public land include approximately 550 stock water and erosion control structures. There are currently about 5,700 small reservoirs on private land used for irrigation, fishing, stock watering, and recreation. In addition there are eight reservoirs of 500 acre-feet or greater capacity for municipal water supply or irrigation storage.

Consumptive and non-consumptive utilization

All of the existing water rights in the Yampa and White River Basins are tabulated by the Colorado Division of Water Resources. A detailed explanation of the listed water rights may be obtained by calling the State Division of Water Resources Engineer's Office in Denver (Phone: 303-892-3581). This listing of water rights in the study region is relevant to the potential determination of impacts of increased demands on water resources for energy development during the next 15 years.

There are two classifications of water utilization: consumptive and non-consumptive. Consumptive use of water may be defined as permanent removal of water from the regional hydrologic cycle. Examples of consumptive water uses are irrigation of and evaporation and transpiration from cropland, and make-up water for power plant cooling. Non-consumptive uses occur when a volume of water is used by man's activities for a specific purpose, but remains in the regional water cycle. The cumulative consumptive use of water in the study region is quantified in Table RIV-7.

Agriculture. There are over 1,000 stock-watering ponds in the regional analysis area. A Tabulation of Stock Dams in the area is available in the Colorado Division of Water Resources Office, Suite G-1, Routt County National Bank Building, Steamboat Springs, Colorado 80477 (Phone: 303-879-0272).

The major use of water within both Yampa and White River Basins is for irrigation. Net consumptive use of water on irrigated land accounts for about 72 percent of total water depletion in the analysis area. Net consumptive use on irrigated land is the amount of water, excluding effective precipitation, used in evaporation and transpiration by a crop during its growing season (Colorado Water Conservation and others 1966 and 1969)

Transbasin diversions. A transbasin diversion removes water from the drainage basin of one river and carries this water into the drainage basin of another river; thus these diversions would represent a consumptive water use with respect to the drainage basin from which the water was removed.

TABLE RIV-7

Sources and Estimates of Dissolved Solids and Downstream Effects without the Proposed Actions

		1975	1980	1985	1990
1	Total undepleted supply (ac-ft):	1,702,400 [1]	1,702,400 [1]	1,702,400 [1]	1,702,400 [1]
2	Consumptive use:				
3	Irrigation (ac-ft)	69,700 [2]	69,700 [2]	86,500 [3]	88,000 [4]
4	Reservoir evap. (ac-ft)	9,300 [5]	9,300 [5]	49,300 [6]	54,300 [7]
5	Riparian vegetation (ac-ft)	18,000	20,400	20,800	21,200
6	Power Plants (ac-ft)	4,000	19,000 [8]	19,000 [8]	19,000 [8]
7	Export from basin (ac-ft)	2,800	2,800	45,000 [9]	45,000 [9]
8	[10]Net discharge without action (ac-ft)	1,598,600	1,581,200	1,481,800	1,474,900
9	Water quality (polluting sources) without action:				
10	Natural sources (tons)	343,400	343,400	343,400	343,400
11	Irrigation (tons)	80,000	80,000	98,000	100,000
12	[11]Municipal (tons)	620	760	890	950
13	Mining operations (tons)	150	200	200	200
14	Less load due to power plants and exports (tons)	-2,000	-6,500	-22,800	-22,800
15	Dissolved solids in Yampa (tons) lines 10 thru 14				
16	Increase in dissolved solids in Colorado River below Hoover Dam without action (mgl)	0.4	1.3	3.8	3.8

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[1] Irons and others, 1965

[2] 71,400 - (2,390 x 0.7) = 69,700

71,400 ac-ft = 102,000 ac x 0.7 (ac-ft water applied per acre)
2,390 = Irrigated acreage on Vermillion Creek (from Division of Water Resources.)

[3] 86,500 = 69,700 + (24,000 x 0.7)

24,000 = Estimated increase in irrigated land

[4] 88,000 = 86,500 + 1,500

1,500 = estimated increase in irrigation water consumption due to Juniper Reservior.

[5] From CWCB & USDA, 1969

[6] 49,300 = 9,300 + 40,000
Juniper Reservoir: 33,000 ac-ft
Saver-Pot Hook Reservoir: 7,000 ac-ft

[7] Increase due to Cross Mountain Reservoir: 5,000 ac-ft

[8] Increase in evaporation when Hayden enlargement and Craig 1 and 2 come on line.

[9] Increased export of water from basin when High Mountain Line Company and Rawlins diversions begin.

[10] No action other than power plants under construction

[11] Based on 100 gallons of sewage per day per person and increase in dissolved solids load of 200 mg/l.

During the 1943-1960 period the Egeria Creek Diversion exported an average of 2,800 acre-feet annually, from the Bear River in the Upper Yampa Main Stem to Egeria Creek in the Colorado River Basin, via the Stillwater Ditch (Colorado Water Conservation Board and others 1969). According to the annual report of the Colorado Division of Water Resources (1974), the transbasin diversion via Stillwater Ditch during 1974 amounted to 581 acre-feet. Hog Park Diversion is a basin export which transports 7,800 acre-feet annually from the Little Snake River drainage to the North Platte River Basin; this basin export began in 1967. The Dome Creek Ditch diverted 170 acre-feet of water from the Yampa River Basin to the Colorado River Basin in 1974. The Four Counties Water Users Diversion is presently a conditional right which would divert 50,000 acre-feet of water annually from the Yampa River Basin across the Continental Divide into the North Platte drainage.

Reservoirs. Existing reservoirs and their storage capacity in the analysis area are listed in Appendix D (Colorado Division of Water Resources 1974). Steamboat Lake, Pearl Lake, and Stillwater Reservoir are the only reservoirs in Yampa River Basin with more than 5,000 acre-feet of storage capacity, while Lake Avery is the only such reservoir in White River Basin. The reservoirs in the analysis area were constructed for a variety of purposes: water storage for irrigation, flood control, generation of hydroelectric power, and water-based recreational activities. Many of these reservoirs are considered to be multiple-use, with each providing several services to the local area.

Legal constraints to utilization

The problem of regulation of water resource distribution of the Colorado River Basin was anticipated during the first half of the twentieth century. Legislation regarding the apportionment of the Colorado River's water supply in seven western states and Mexico was formulated during this period in order to avoid incessant legal hassles over water rights. Future energy development in northwestern Colorado will be constrained by the water apportionments stated in these laws:

Colorado River Basin Compact of 1922. The Colorado River Basin Compact approved by Congress on August 19, 1921, is an agreement between the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming regarding the use and distribution of waters of the Colorado River. Article III of the Compact states that the "Upper Basin" (those parts of the States of Arizona, Colorado, New Mexico, Utah, and Wyoming within and from which waters naturally drain into the Colorado River System above Lee Ferry, Arizona) and the "Lower Basin" (those parts of the States of Arizona, California, Nevada, New Mexico, and Utah within and from which waters naturally drain into the Colorado River System below Lee Ferry) are each entitled to exclusive beneficial consumptive use of 7,500,000 acre-feet of water/year from the Colorado River System. In addition the states of the "Upper Basin" will not cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75,000,000 acre-feet for any period of ten consecutive years (Radoesevich and Hamburg 1971).

Mexican Water Treaty of 1944. This treaty guarantees Mexico an annual quantity of 1,500,000 acre-feet of water from the Colorado River System (Radoesevich and Hamburg 1971).

Upper Colorado River Basin Compact of 1948. The major purpose of this compact is to provide for equitable apportionment of waters of the Colorado River System which have been allocated to the Upper Basin among the States of Arizona, Colorado, New Mexico, Utah, and Wyoming as follows: (1) Arizona, 50,000 acre-feet; then following deduction of Arizona's 50,000 acre-feet: (2) Colorado, 51.75 percent, (3) New Mexico, 11.25 percent, (4) Utah, 23 percent, (5) Wyoming, 14 percent (Radoesevich and Hamburg 1971). Article XIII provides that the State of Colorado will not cause the flow of the Yampa River at the Maybell gaging station to be depleted below an aggregate of five million acre-feet for any period of ten consecutive years (Colorado Water Conservation Board and others 1969).

One of the study region's major problems is the need for a dependable irrigation water supply throughout the growing season. The present area under irrigation in the Yampa River Basin totals about 100,200 acres/year. During the 1968 growing season, approximately 48,000 acres of this were short of late season water (Colorado Water Conservation Board and others 1969).

Water and related land resource problems

The major existing water resource problems in the study region (i.e., soil erosion) and their causes are highlighted in order to provide an indication of the additive impacts resulting from the proposed actions. These existing problems will form a basis for the discussion of some of the regional impacts.

Erosion damage. Much of the study region is subject to moderate erosion damage. Of the 187,300 acres of dry cropland, only 71,300 acres have adequate erosion control measures. In addition 430,400 acres of rangeland are being overgrazed in the Yampa River drainage (Colorado Water Conservation Board and others 1969).

Soils derived from the Mancos and Lewis Shales and shaley parts of other formations are subject to gullying and piping; these soils are characterized by high silt content and clays that easily go into suspension with runoff water. Streambank erosion is a fairly common problem in the study region because of these widely distributed friable soil types (Colorado Water Conservation Board and others 1969).

Sediment damage. The greatest portion of sediment load in streams in the study region is derived from the more arid lower elevations. Vegetative cover begins to be sparse in areas with less than ten inches of total precipitation. Friable streambank soil types coupled with poor range management practices, improper land use, and lack of a protective vegetative cover account for high sediment yields which characterize some of the streams in the Yampa River drainage at lower elevations.

Floods. Floodwater damage in the study region is the result of two distinct occurrences. The first is snowmelt runoff in the early spring, which characteristically produces relatively large volumes of water over a period of several days but does not produce high peak flows. Occasionally the severity of the flooding produced by snowmelt will be intensified by ice jams. Spring snowmelt floods cause streambank erosion, damaging erosion to low-lying fields, damage to crop stands, and delay in crop growth. The second type of flood damage is caused by summer thunderstorms which tend to produce flash floods in localized areas with high peak flows but low total volume. The erratic random pattern of these intense summer thunderstorms results in local damage to cropland and to facilities such as roads, bridges, and irrigation structures.

Salinity. Most of the water in the study region originates in mountainous areas; however most of the dissolved solids emanate from runoff in the lower, more arid parts of the region. These salts readily go into solution because the soils of the arid parts of the study region are generally undeveloped and not leached due to the low precipitation in these areas. Consequently these salts are easily transported to the water courses when precipitation does occur.

Irrigation water quality in the study region is generally good, as most irrigation water originates in the Yampa River or its major tributaries near the mountainous parts of the basin. As indicated in the following total dissolved solids section, none of the major irrigation areas in the Yampa River Basin have water rated higher than a medium salinity hazard (Colorado Water Conservation Board and others 1969).

Strip mining. The bulk of strip mining activity in the study region to date has been south of the Yampa River in Routt County. Many existing strip mined areas have not been reclaimed; however due to the rocky character of the spoils there has been little erosion or stream sedimentation.

According to a report prepared by the USGS (Wentz 1974) coal-mine drainage is not a problem in Colorado, apparently because of the low-sulfur content of the state's coal.

Road construction. The recent thrust for energy development has resulted in increased exploration for energy resources in the study region.

Many portions of the study region are criss-crossed with roads constructed by major industries in their search for oil, natural gas, and coal reserves. The BLM has specific regulations governing the construction and reclamation of these roads; nevertheless the sediment load in many of the streams in the study region has increased as a result of erosion problems created by road construction.

Quality.

The water quality parameters most likely to be impacted by the proposed actions are: turbidity (i.e., stream sedimentation), total dissolved solids (TDS), temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), and pH. Turbidity is the term used to describe the degree of light penetration produced in water by materials suspended in the water. It must be emphasized that any impact on a specific water quality parameter will simultaneously produce changes in other water quality parameters due to their interrelated nature. For example, an increase in turbidity in a stream resulting from increased sedimentation will concurrently produce an increase in water temperature and a decrease in dissolved oxygen content. The quantification of the total impacts of changes in certain water quality parameters of a stream is also difficult because of synergism. Synergism occurs when a change in a specific water quality parameter produces much greater than expected or predicted changes in other water quality parameters due to unique interrelationships between parameters. Attempts at quantification and prediction of impacts on the total aquatic ecosystem as a result of impacts or changes in certain water quality parameters is risky, even with sufficient baseline data. Baseline water quality data for the study region are sparse. The only data available apply to the larger streams (e.g., Yampa River) in the region. The reader should note that these data are not sufficient to afford an accurate analysis of the water quality in the anticipated impact areas. Additional water quality information for the study region should be available following the completion of investigations by the USGS (Water Resources Division, Denver Federal Center), Colorado State Department of Health (4210 E. 11th Ave., Denver, CO), and the Routt County Health Department (116 6th Ave., Steamboat, CO).

Critical water quality parameters. As mentioned beforehand, only those water quality parameters which would be impacted by the proposed action will be discussed in detail. For an extensive discussion of the complex interrelationships of all water quality parameters refer to McKee and Wolf (1963).

-Dissolved oxygen. DO is the measure of the oxygen content of a volume of water. Oxygen dissolved in water is derived from the air and from the oxygen given off in the process of photosynthesis by aquatic plants (Brown, Skougstad, and Fishman 1970). The State standard for DO, established by the State Department of Health-Water Quality Control Commission, is a minimum of six milligrams/liter (mg/l). The dissolved oxygen content of the water in the study region, ranging between five and ten mg/l, is generally above minimum standards and is indicative of minimal organic pollution in the area and healthy aquatic communities.

-Total dissolved solids (TDS). Water with several thousand milligrams/liter of dissolved solids is generally not palatable. The U.S. Public Health Service (1962) recommends that the maximum concentration of dissolved solids not exceed 500 mg/l in drinking and culinary water on carriers subject to Federal quarantine regulations, but permits 1,000 mg/l if no better water is available (Brown, E., Skougstad, M.W. and M.J. Fishman 1974). Reported livestock tolerances range from 3,000 mg/l to 15,000 mg/l. The blood of freshwater fish has an osmotic pressure equal to about 7,000 mg/l of sodium chloride; therefore any water that has an osmotic pressure greater than six atmospheres can be expected to be lethal. Industrial tolerances for dissolved solids differ widely, but few industrial processes will permit more than 1,000 mg/l. Any natural water containing dissolved solid concentrations exceeding 1,000 mg/l is classified as saline. The classification series is:

Less than 1,000 . . . Nonsaline

1,000 to 3,000 . . . Slightly saline

3,000 to 10,000 . . . Moderately saline

10,000 to 35,000. . . Very saline

Over 35,000 . . . . . Brine

The Colorado Department of Health (Water Quality Control Commission) has not adopted a standard regarding salinity. Therefore Colorado proposes where possible to maintain salinity concentrations at or below present levels while gathering additional data, so that meaningful numerical salinity standards can be established at some future date (Colorado Department of Health 1974).

Stream TDS measurements in the study region may be expected to vary from highs of 300-500 mg/l during the fall and winter to lows of 50-100 mg/l during spring runoff periods. These TDS figures are indicative of generally high quality water for human utilization, particularly irrigation. Table IV-7 provides information on the concentration of dissolved solids in the Yampa River Basin.

-Temperature. Water temperatures in streams in the study region follow a typical cycle with the lowest temperatures occurring during winter months, a gradual increase during spring to summer highs, and cooling again with onset of fall. State standards specify that water temperatures maintain a normal pattern of diurnal and seasonal fluctuations and not change abruptly. Temperature must not be increased above 68°F for coldwater streams, and 90°F for warmwater streams, by any other than natural means.

-pH. This parameter is a measure of solution acidity and alkalinity. The pH scale ranges from zero (most acid) to fourteen (most alkaline) with seven as the neutral value. In water solution, deviations in pH from seven are primarily the result of the hydrolysis of salts or the presence of strong bases and weak acids, or vice versa. Dissolved gases such as carbon dioxide, hydrogen sulfide, and ammonia also affect the pH appreciably. Because carbonates are prevalent in nature, many natural waters are slightly basic with an overall normal pH range between 6.0 and 8.0.

The State standard requires that pH values should not be lower than 6.5 nor higher than 8.5. Generally the pH in the study region can be expected to be basic, ranging from 7.5 to 8.5. The State standard maximum pH of 8.5 is often exceeded in the study region. Colorado Department of Health (1974) data indicate that there is no seasonality to this condition, and the quantity of flow appears to have little effect on pH. The geology of the headwater areas of both the Yampa and White Rivers yields predominantly calcium bicarbonate-type water, and the high pH values appear to be a natural condition that would be difficult to modify.

-Sedimentation. Data in Appendix D indicate the discharge of suspended sediment for some of the major streams in the study region in thousands of tons/year. Sediment loading in streams in the study region follows a typical cycle, with the greatest measurements occurring during the spring runoff. Sedimentation tapers off to minute amounts during the low flow periods in late summer and fall.

Under natural conditions most of the sediment in the Yampa River comes from the dryer part of the region where there is insufficient vegetation to fully protect the soil from erosion. Any activity such as heavy livestock grazing which further depletes the vegetation would tend to aggravate the condition of already relatively high sediment yield.

Under natural conditions the wetter parts of the study region have good vegetative cover of native grasses, shrubs, and trees and yield little sediment to the streams. Most of the proposed coal-related developments are in these wetter parts of the region. The greatest disturbance of natural vegetation in the wetter part of the region results from the raising of grain, principally wheat. The other crop produced in the area is hay which provides the soil with a continuous protective cover of vegetation.

The amount of land in the region that is devoted to grain production is difficult to determine. Most grain crops are planted in alternate years and kept plowed during intervening years to conserve moisture for the following year. The only records that are kept are on the acreages planted, and these records are apt to be conservative, because much of the wheat is not covered by government allotments. Based on available data and estimates of people in the farming business, there are probably about 100,000 acres of land devoted to grain production in the study region.

The erosion from most of this land is probably in excess of five tons/acre/year and, much of the land is eroding at a rate in excess of 50 tons/acre. Fortunately only a small part of this sediment reaches the main streams, the bulk of it being deposited along the way. If an average of as little as three tons/acre reached the Yampa River it could account for the entire 300,000 tons average sediment load in the river during the 1950-1958 period when the sediment load in the Yampa River was measured at the Maybell Station. The actual contribution of sediment from agricultural lands is not known; however it can safely be assumed that it is a very large amount, and probably constitutes most of the sediment load in the river.

Other man-caused sediment production such as municipal, industrial, and transportation-related sediment sources are small by comparison to the sediment generated by agriculture. Paradoxically the sediment generated by past strip mining activities is even smaller; mine spoils are so rocky that they erode very slowly if at all. It is only when spoils are reshaped and covered with topsoil that any considerable erosion can take place; then the amount of erosion from the reclaimed topsoil is not likely to be any greater than that from most grain fields.

As only a few hundred acres of surface-mined land have been reclaimed up to the present time, it can be assumed that sediment from this source is presently negligible.

Numerical standards for sedimentation are seldom derived, as this parameter typically exhibits extreme seasonal and annual variations.

The Colorado Department of Health (1974) states that wastes of other than natural origin should not cause the turbidity of water to be increased by more than ten Jackson Turbidity Units (JTUs) or its equivalent. Turbidity is the term used to describe the degree of opaqueness produced in water by suspended particulate matter. While the nature of the materials contributing to the turbidity is responsible for the color quality, the concentration of the substances, if sufficiently high, determines the transparency of the water by limiting the light transmission within it (Reid 1961). A JTU is a measurement of turbidity made by the use of a Jackson Turbidimeter, based upon the degree of light penetration in a water sample. When a Jackson Turbidimeter is used, the assumption is made that one JTU is equal to one part/million (PPM) on a silica scale. Other methods of calculating turbidity give readings directly in ppm or milligrams/liter (mg/l) (Bell 1973).

Sedimentation is a result of the settling-out or deposition of suspended materials in a stream. Sedimentation forms the bed load (i.e., material composition of the stream bottom) of a stream. The particles which cause bed load or turbidity may be deposited or suspended, depending on water velocity and the specific gravity of the particles.

-Biochemical Oxygen Demand (BOD 5-day). Biochemical oxygen demand tests are used for determining the relative oxygen demand requirements of municipal and industrial wastewaters (Environmental Protection Agency 1971). The application of this test to organic waste discharges allows calculation of the effect of the discharges on oxygen resources of the receiving water. Data from BOD tests are used for the development of engineering criteria for the design of wastewater treatment plants. The BOD test is a procedure which measures the dissolved oxygen consumed by microbial life while assimilating and oxidizing the organic matter present. The actual environmental conditions of temperature, biological population, water movement, sunlight, and oxygen concentration cannot be accurately reproduced in the laboratory. Results obtained must take into account the above factors when relating BOD results to stream oxygen demands. In a BOD test, the sample of waste, or an appropriate dilution, is incubated for five days at 20°C in the dark, hence the designation BOD 5-day. The reduction during this incubation period yields a measure of the BOD.

The parameter limitation established by the State for BOD 5-day for a volume of water is 30 mg/l for a 30-day average (Colorado Department of Health 1975). The 30-day average is defined as the arithmetic mean of a minimum of three or more samples taken on separate calendar weeks during a 30 consecutive-day period. The Department of Health also specifies that the 30-day average for suspended solids in waste water discharges shall not exceed 30 mg/l and that the pH shall remain within the limits of 6.0 to 9.0.

Data in Appendix D provide an analysis of the waste water discharges from sewage treatment plants in the study region.

General causes of alterations in water quality. River flows in the analysis area fluctuate widely. Spring snowmelt produces high discharges, while late summer flows may be only a small fraction of the annual average flows. The White and Yampa River flows are essentially unaltered by impoundment, but they are materially affected by irrigation diversions during the summer growing season. Low river flows are of critical importance in surface water quality studies since they limit a river's capacity to assimilate pollution loads.

Table RIV-8 (Colorado Department of Health 1974) describes the point water pollution sources in the analysis area. Storm runoff water and agricultural return flows specifically were excluded from this list. Several of the point sources listed in Table RIV-8 either discharge to infiltration beds, or are located a sufficient distance from the main stream that their impact is considered minimal. A detailed description of each of these point pollution sources is available in the Colorado Department of Health's publication of 1974 entitled Water Quality Management Plan for the Green River Basin. There are four major non-point discharges which affect water quality in the analysis area: (1) runoff from wintertime cattle feed areas, (2) irrigation return flows, (3) seepage of saline ground water, (4) erosion from shale outcrops, and (5) septic tank effluents.

During winter months ranchers along White and Yampa Rivers confine cattle in one pasture or corral for up to five months for feeding. The feeding area is usually located next to a stream to make drinking water

TABLE RIV-8

Point Discharge Sources in the Study Region

Discharge Source	Distance Up Main River To Discharge Source or Tributary -Miles	Distance Up Tributary To Discharge Source-Miles	Tributary
(1)	(2)	(3)	(4)
Yampa River Drainage			
Morrison Creek Dist., STP	222.7	1.1	Little Morrison Creek
Timbers, STP	208.1	2.2	McKinnis Creek
Oak Creek, STP	205.7	14	Oak Creek
Abandoned Coal Mine	205.7	13	Oak Creek
Siegrist Construction Gravel	205.2		
Mr. Werner Dist., STP	200.2		
Fish Creek Park, STP	200.0		
Bear Pole Ranch, STP	198.4	2.0	Butcherknife Creek
Whiteman School, STP	198.1	3.0	Soda Creek
Mineral Springs at Steamboat Springs	198.0		
Steamboat Springs, STP	196.5		
KOA Kampground, STP	194.7		
Sleepy Bear Park, STP	194.5		
Steamboat II Dist., STP	192.8		
Yampa Valley Industries Gravel Pit	192.0		
Steamboat Lake Dist., STP	188.3	26	Willow Creek
Bear River Gravel Pit, ND	187.3		
Colorado Ute Electric - Hayden Station	176.3	0.5	Sage Creek
Hayden, WTP	167.2		
Hayden, STP	166.1	0.3	Dry Creek
Craig Sand and Gravel, ND	147.2		
Craig, WTP	143.9		
Big Country Meats, STP	143.6		
Craig, STP	142.6		
Silengo Coal Mine	133.5	1.0	Williams Fork
Juniper Hot Springs	94.8		
Dixon, Wyoming, STP, ND	51.2	73	Little Snake
Baggs, Wyoming, STP, ND	51.2	67	Little Snake

TABLE RIV-8 (cont.)

Point Discharge Sources in the Study Region

Discharge Source	Distance Up Main River To Discharge Source or Tributary -Miles	Distance Up Tributary To Discharge Source-Miles	Tributary
(1)	(2)	(3)	(4)
<u>White River Drainage</u>			
Meeker Well	105.0		
Meeker, STP	101.5		
Rangely, STP	24.0		
California Oil Camp	18.7	4.0	Stinking Water Creek
Texas Oil Camp	18.7	2.0	Stinking Water Creek
Dinosaur Natl. Monument, STP, ND	5.5	15	Rock Creek
Dinosaur, STP, ND	5.5	15	Rock Creek

Note: ND, Not discharging at Present
STP, Sewage Treatment Plant
WTP, Water Treatment Plant

SOURCE: Colorado State Health Department, 1974 available. When spring snowmelt occurs, manure accumulation is washed into the streams; this pollution inflow usually occurs for about a month in late April or early May and is high in BOD_5, nitrates, and bacteria.

Irrigation of river-bottom lands along Yampa and White Rivers results in consumption and subsequent return of water with an increased concentration of salt to the rivers. According to the Environmental Protection Agency (1971), irrigation returns add 103 tons/day of salt in the Yampa drainage (0.2-0.3 tons/year/acre), and 20 tons/day in the White drainage (0.2 tons/acre/year). Seepage of saline ground water into White River occurs along the Meeker dome east of Meeker, and along the north edge of the Piceance Basin. The discharge from the Meeker dome area results in a very noticeable increase in chloride concentration and a load of about 160 tons of salt/day.

Erosion from shale formations causes river pollution in the western half of the analysis area. Arid climatic conditions in the western sector have resulted in poor vegetative cover over Mesozoic and Tertiary shale outcrops; consequently there is a very rapid inflow of silt and salts into the rivers when thunderstorms do occur.

Another non-point source of pollution in the analysis area is the effluent from septic tanks in concentrated population areas like Yampa, Phippsburg, Milner, and Maybell on Yampa River drainage, and Buford and Rio Blanco on White River drainage. While there is no current indication of river pollution from this source, there are established instances of ground water pollution in these population centers (Colorado Department of Health 1974).

A ranking of stream segments according to the severity of pollution (Colorado Department of Health 1974) is as follows - the most polluted stream segment is listed first in each instance:

<u>Yampa River</u>

Classification B_1

Steamboat Springs to Elk River
Craig to Williams Fork
Elk River to Sage Creek
Sage Creek to Craig
Morrison Creek to Steamboat Springs
Yampa to Morrison Creek

Classification B_2

Williams Fork to Spring Creek
Spring Creek to Little Snake River
Little Snake River to Green River

<u>White River</u>

Classification B_1

Meeker to Piceance Creek
Buford to Meeker
Trappers Lake to Buford

Classification B_2

Rangely to State Line
Spring Creek to Rangely
Yellow Creek to Piceance Creek
Piceance Creek to Yellow Creek

Class A waters are defined as including all waters "suitable for all purposes for which raw water is customarily used, <u>including</u> primary contact recreation, such as swimming and water skiing." Class B waters differ in that they include waters "suitable for all purposes for which raw water is customarily used, <u>except</u> primary contact recreation, such as swimming and water skiing." The specific criteria used in this classification system are as follows:

TABLE RIV-9

Criteria Used for Water Classification of Colorado Waters

Class	Bacteriological Count (coliform groups/100 ml.)	Dissolved Oxygen (mg./liter)	pH	Temperature
A_1	$\leq$ 200 fecal and/or 1000 total (MPN)	$\geq$ 6	6.5-8.5	$\leq$ 68°F
A_2	$\leq$ 200 fecal and/or 1000 total (MPN)	$\geq$ 5	6.5-8.5	$\leq$ 90°F
B_1	$\leq$ 1000 fecal and/or 10000 total (MPN)	$\geq$ 6	6.0-9.0	$\leq$ 68°F
B_2	$\leq$ 1000 fecal and/or 10000 total (MPN)	$\geq$ 5	6.0-9.0	$\leq$ 90°F

Specific water quality investigations. Appendix D presents water quality parameters as measured at specific stream sites throughout the analysis area. This information was gathered by the USGS (Wentz 1974) and presented in a publication entitled Effect of Mine Drainage on the Quality of Streams in Colorado, 1971-72. A detailed discussion of values tabulated for the analysis area, compared to similar values for the State of Colorado, is available in Wentz's publication. The total dissolved solid (TDS) values for these sites may be approximated from these tables by multiplying the specific conductance value by six-tenths (0.60). The trace element values are not discussed herein, as no impact involving these water quality parameters is anticipated.

Climate

The climate of Northwestern Colorado is characteristic of semi-arid steppe regions. Typical of the mid-latitudes, winds prevail from the west. However, the protective topography of the Sierra Nevada Mountains to the west and the Rocky Mountains to the east greatly modifies the climate from those characteristics which are typical of the mid latitudes.

Pacific maritime air loses most of its moisture in passing the Sierra Nevadas. Similarly, moist air from the Gulf of Mexico is blocked by the Rocky Mountains. Stagnant high pressure systems often persist over the region for days, their passage being blocked by the Rocky Mountains to the east. This causes an abundance of clear, sunny days with large diurnal (daily) temperature variations. Low pressure systems causing abrupt changes in the weather typically by-pass the area, crossing the mountains at lower elevations to the north or far south in New Mexico.

It is difficult to generalize the climate of Routt, Rio Blanco, and Moffat Counties as a whole because of local topographical changes. Therefore, in the following sections discussing moisture, temperature, winds, and thermal structure, lines of constant concentrations (isopleths) are presented when the data base for a climatological parameter is large enough to permit area distinctions.

Moisture

Precipitation varies from less than 25 centimeters (8 inches) in the far western portion of the State to greater than 76 centimeters (30 inches) near the Continental Divide. The precipitation pattern as shown in Figure RIV-14 is strongly dependent on local topography and elevation. Isopleths

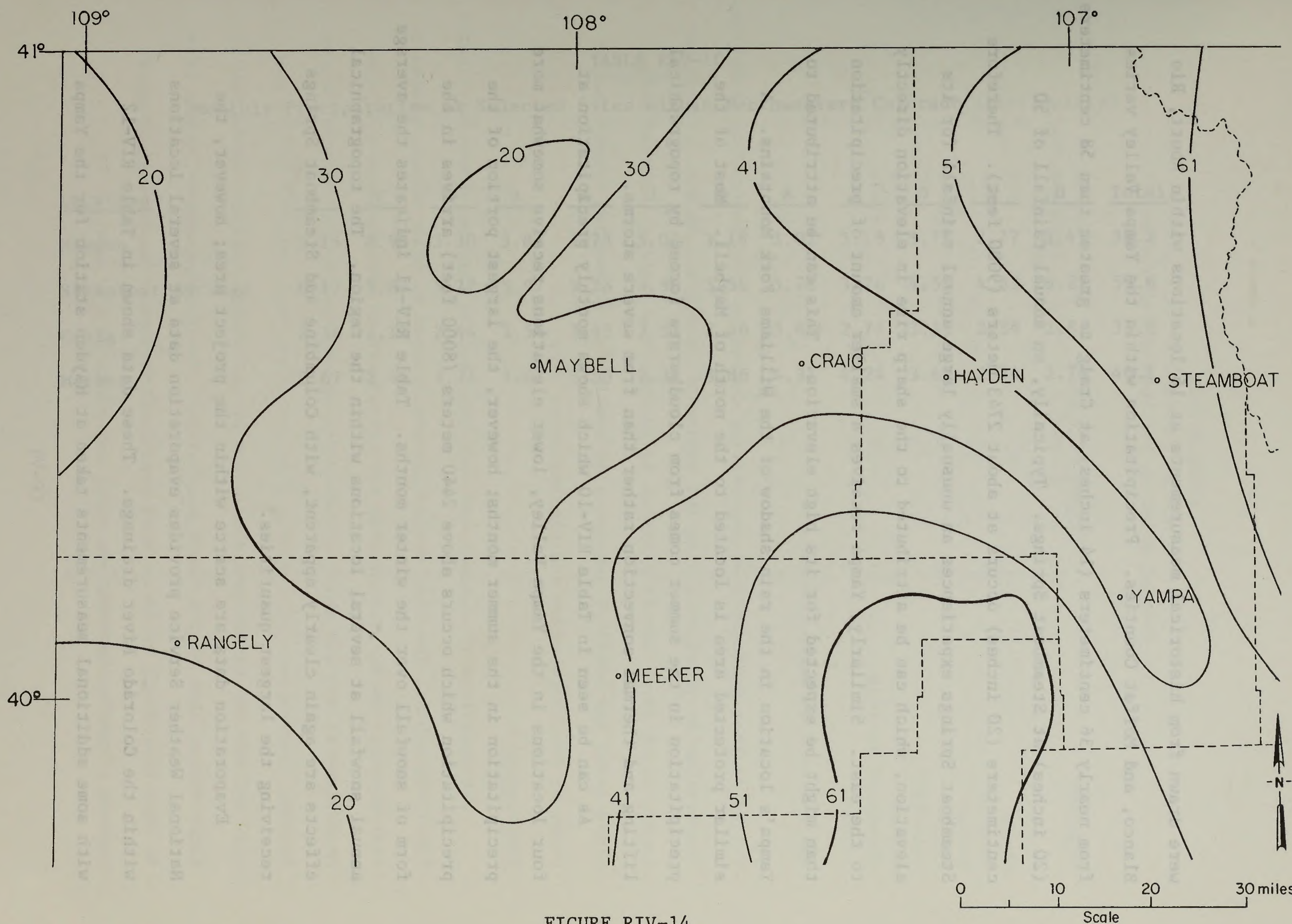

FIGURE RIV-14

Isopleths of annual average precipitation (centimeters) in northwest Colorado.

were drawn from historical measurements at 16 locations within Routt, Rio Blanco, and Moffat Counties. Precipitation within the Yampa Valley varies from nearly 36 centimeters (14 inches) at Craig to greater than 58 centimeters (20 inches) at Steamboat Springs. Typically, an annual rainfall of 50 centimeters (20 inches) occurs at about 2743 meters (9000 feet). Therefore Steamboat Springs experiences an unusually large annual rainfall for its elevation, which can be attributed to the sharp rise in elevation directly to the east. Similarly, Yampa receives a smaller amount of precipitation than might be expected for its high elevation. This can be attributed to Yampa's location in the rain shadow of the Williams Fork Mountains. A similar protected area is located to the north of Maybell. Most of the precipitation in the summer comes from cloudbursts forced by topographical lifting and thermal convection rather than from severe storms.

As can be seen in Table RIV-10 which shows monthly precipitation at four locations in the Yampa Valley, lower elevations receive somewhat more precipitation in the summer months; however, the largest portion of the precipitation which occurs above 2440 meters (8000 feet) arrives in the form of snowfall over the winter months. Table RIV-11 indicates the average annual snowfall at several locations within the region. The topographical effects are again clearly apparent, with Columbine and Steamboat Springs receiving the largest quantities.

Evaporation data are scarce within the project area; however, the National Weather Service provides evaporation data at several locations within the Colorado River drainage. These data shown in Table RIV-12 with some additional measurements taken at Hayden station for the Yampa

TABLE RIV-10

Monthly Precipitation at Selected Sites within Northwestern Colorado (centimeters)

Location	J	F	M	A	M	J	J	A	S	O	N	D	Total
Hayden	3.15	2.90	3.30	3.81	3.73	3.07	3.18	3.02	3.15	3.71	2.77	3.45	39.2
Steamboat Springs	6.12	5.87	5.77	5.97	5.23	3.96	3.56	3.78	3.76	4.55	4.83	6.22	59.6
Craig	2.34	2.11	2.44	3.56	3.45	3.51	2.46	3.84	2.77	3.35	2.39	2.82	35.0
Meeker	2.67	2.44	3.71	3.81	3.58	2.31	3.86	4.37	4.24	3.68	2.74	2.74	40.1

TABLE RIV-11
Annual Snowfall
At Several Sites in Northwestern Colorado

Location	Period of Record (years)	Snowfall* (centimeters)
Craig	37	157
Rangely	14	104
Meeker	33	177
Pagoda	21	270
Columbine	21	460
Hayden	51	248
Steamboat Springs	79	424
Yampa	14	195

*Data from U.S. Weather Bureau.

Valley project indicate that evaporation decreases with increasing elevation. Evaporation is greatest during the months of June and July and, correspondingly, cloud cover can be expected to be the least during these months. Cloud cover and humidity generally increase with increasing elevation, as shown by the evaporation and precipitation data.

Temperature

The isopleths of January and July temperature extremes shown in Figures RIV-15-18 exhibit the wide variations which occur on both annual and daily time scales. These fluctuations are attributed to topography and to the predominantly dry air which allows rapid solar surface heating and cooling. Average temperatures on mountain tops are often less than 0°C (32°F) and high valleys can be extremely cold during the winter months. Table RIV-13 shows freeze data within the Yampa Valley. The growing season ranges from 94 days near Craig to 28 days in Steamboat Springs. In the high mountain regions, freezing weather can occur any month of the year.

TABLE RIV-12

Evaporation Data from Six Stations within the Colorado Drainage Region
(centimeters)

Station	Length of Record (years)	Elevation (meters)	Apr.	May	June	July	Aug.	Sept.	Oct.
Grand Junction	12	1,436		32.7	44.0	44.3	37.2	29.4	18.3
Montrose	33	1,777	14.4	19.5	24.8	24.6	19.4	15.8	9.6
Vallecito	25	2,332	9.3	14.2	17.8	17.0	16.0	12.9	8.3
Green Mt. Dam	24	2,359			19.2	18.3	15.6	13.1	6.9
Grand Lake	23	2,526			21.3	21.0	17.6	14.7	
Near Hayden * Station	Sept. 71- Oct. 72			14.6	18.1	22.4	20.4	15.5	15.7

* Data from Yampa Project Sampling Network. All other data from U.S. Dept. of Commerce.

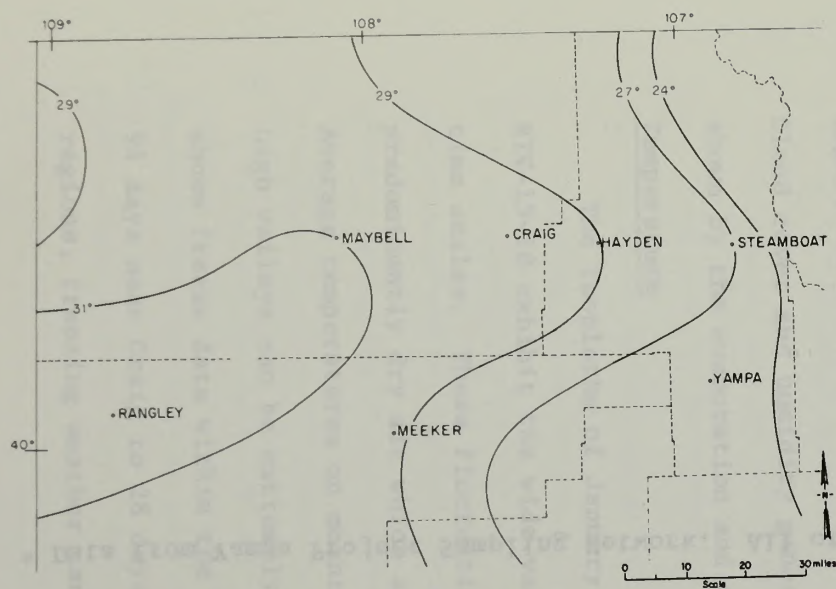

FIGURE RIV-15

Maximum July temperatures (°C)

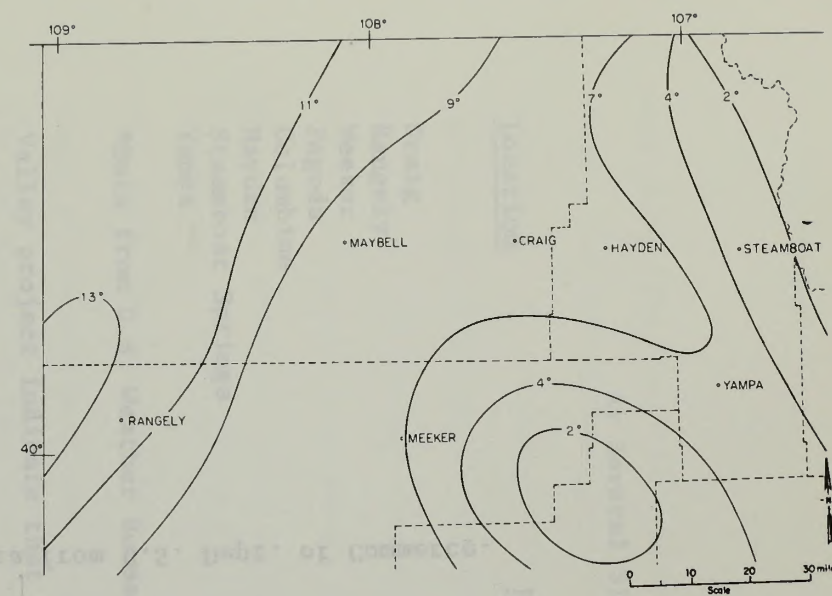

FIGURE RIV-16

Minimum July temperatures (°C)

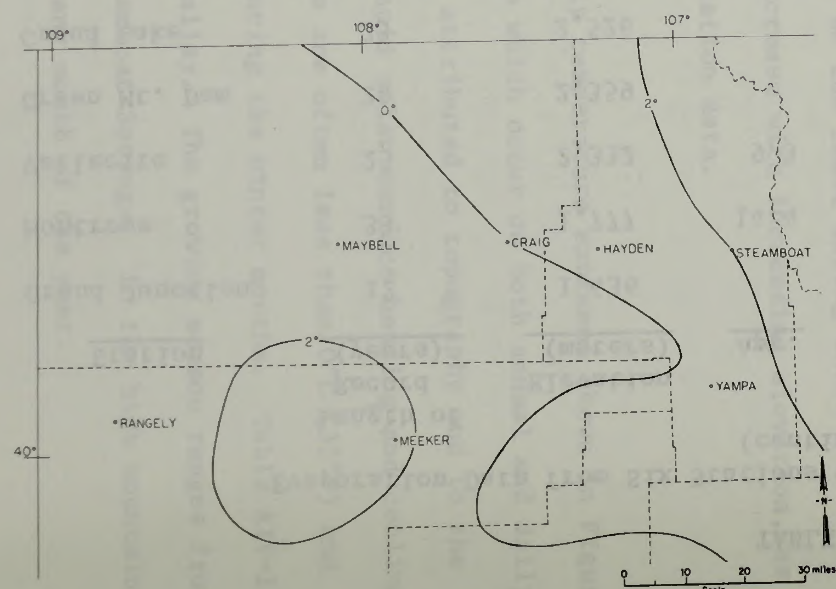

FIGURE RIV-17

Maximum January temperatures (°C)

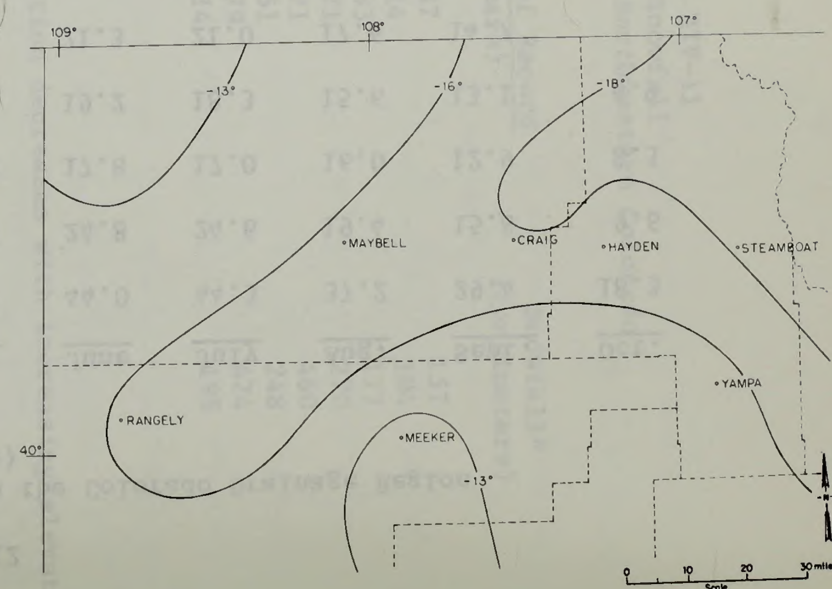

FIGURE RIV-18

Minimum January temperatures (°C)

TABLE RIV-13

Freeze Data at Selected Sites in Northwestern Colorado

Location	Freeze Temperature	Mean Date of Spring Occurrence	Mean Date of Fall Occurrence	Mean Number of Days Between Dates	Years of Record
Craig	0.0° C	6-08	9-10	94	10
	-2.22°	5-24	9-21	120	10
Hayden	0.0°	5-27	8-26	76	29
	-2.22°	5-27	9-16	112	29
Meeker	0.0°	6-11	9-10	91	30
	-2.22°	5-23	9-23	123	30
Steamboat Springs	0.0°	6-23	7-21	28	30
	-2.22°	6-08	8-27	80	30

Wind fields

Wind fields in the study area are complicated by local terrain features as well as the Rocky Mountain barrier. However, three distinct scales of motion can be observed: global, regional, and local.

On a global scale, above the atmosphere's first kilometer, air flow is from the west to southwest. Data from the National Weather Service in Grand Junction indicate that upper level winds are from the southwest quadrant nearly 50 percent of the time and average eight meters per second (18 mph). The strength of prevailing westerlies depends on the strength and location of major weather patterns. Westerly winds can be observed within the surface layer overcoming terrain-forced regional and local flow patterns.

On a regional scale, the general slope of the Rocky Mountain barrier may cause nightime flow to the northwest. While the westerly flow is well documented by upper air measurements at the surrounding primary weather stations, the suggested southeast flow has only been observed from a few upper air studies near Craig and is not firmly documented on a statistical basis.

Wind fields in the surface layer are strongly influenced by local terrain. Local mountain-to-valley flow is forced by thermal patterns at different elevations. During the day higher elevations heat more rapidly than valleys, causing an up-valley air flow. At night, higher elevations cool more rapidly than the valleys, and the temperature gradient causes down-valley flow.

Mountain-valley flow is clearly visible in all surface wind data available within the study area. Two weather stations were installed for the Yampa project in 1970, one near Hayden and one near Craig. In addition, the Steamboat Springs Airport reports wind data to the National Weather Service. Wind roses for these stations are shown in Figures RIV-19- to 22. A wind rose is a frequency distribution of possible wind directions.

The Steamboat Springs data are from the local airport which only reports during the day. Afternoon data show the predominance of up-valley westerly flow. At 10 A.M., there is often no wind at all, indicating that this is the transition period between up-valley and down-valley flow.

Hayden station data are from all times of day and therefore provide a better understanding of the Yampa Valley air shed. While up-valley flow is prominent, down-valley flow from the east is more frequent. This is because drainage flow endures for a longer period of the average day and can persist for several consecutive days during the winter months. The average wind speed at Hayden Station was 2.9 mps (6.5 mph) and winds less than 1 mps (2 mph) occurred 18.9 percent of the time.

Craig station was located about 10 kilometers (6 miles) to the southwest of Craig within the Williams Fork River drainage. Northeast drainage flow from the Williams Fork Valley is shown in the wind rose. This air shed joins the Yampa Valley air shed to the north of the station. The average wind speed observed at Craig was 2.7 mps (6 mph), and, as in Hayden, a high frequency of calm conditions was observed. This is attributed in part to the sheltering effect of the local terrain.

Diurnal variations of the wind speed observed at Craig and Hayden stations are shown in Figure RIV-23. Wind speeds reach maximum values in the late afternoon. Nighttime down-valley flow is weaker. The high frequency of calm conditions noted above usually occur at night or in the early morning.

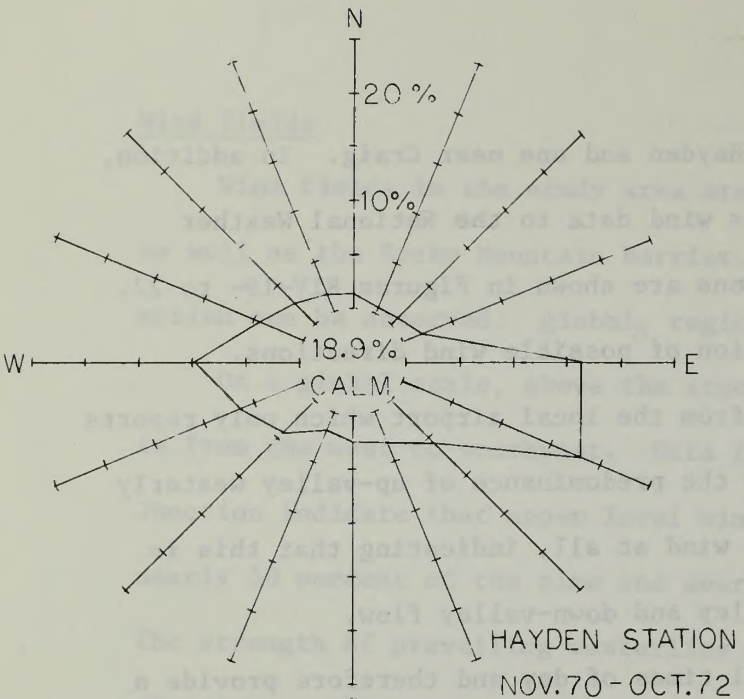

FIGURE RIV-19

Hayden power station wind rose.

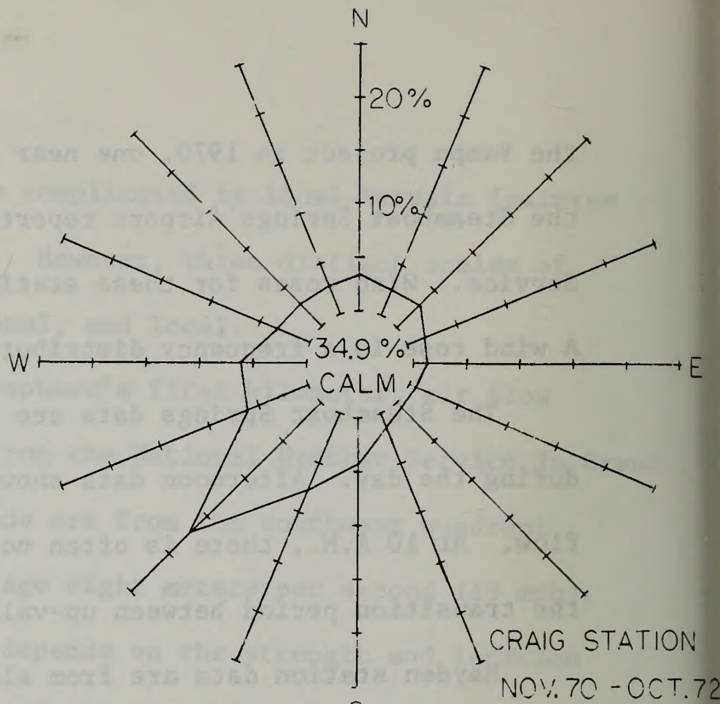

FIGURE RIV-20

Craig power station wind rose.

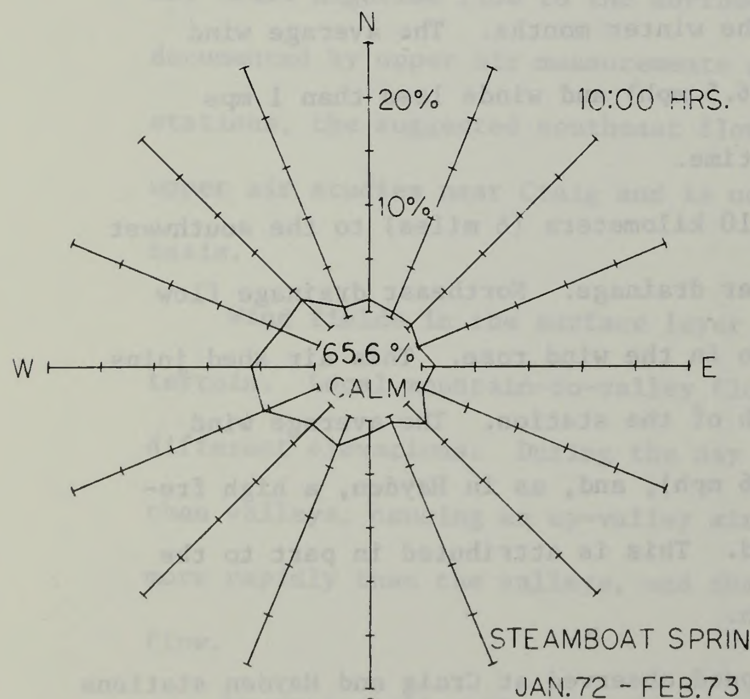

FIGURE RIV-21

Steamboat Springs 10 a.m. wind rose.

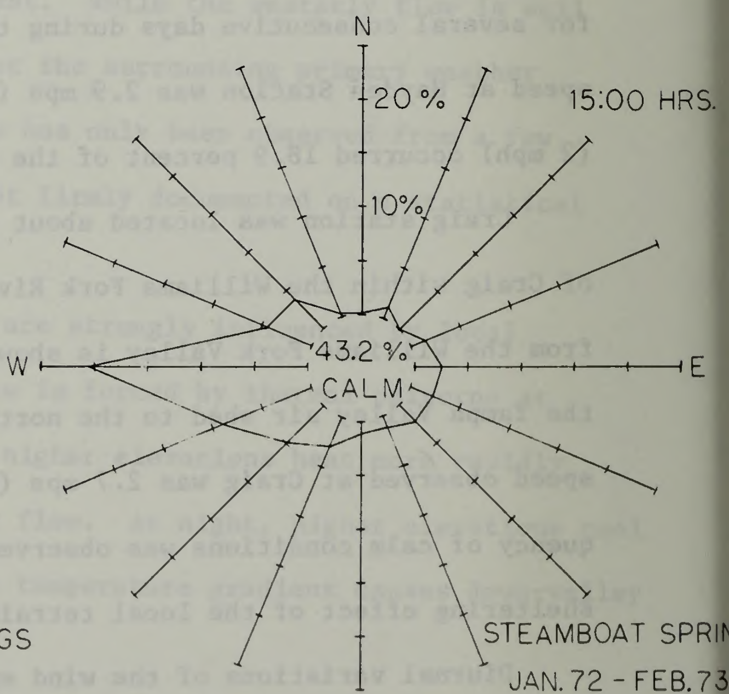

FIGURE RIV-22

Steamboat Springs 3 p.m. wind rose.

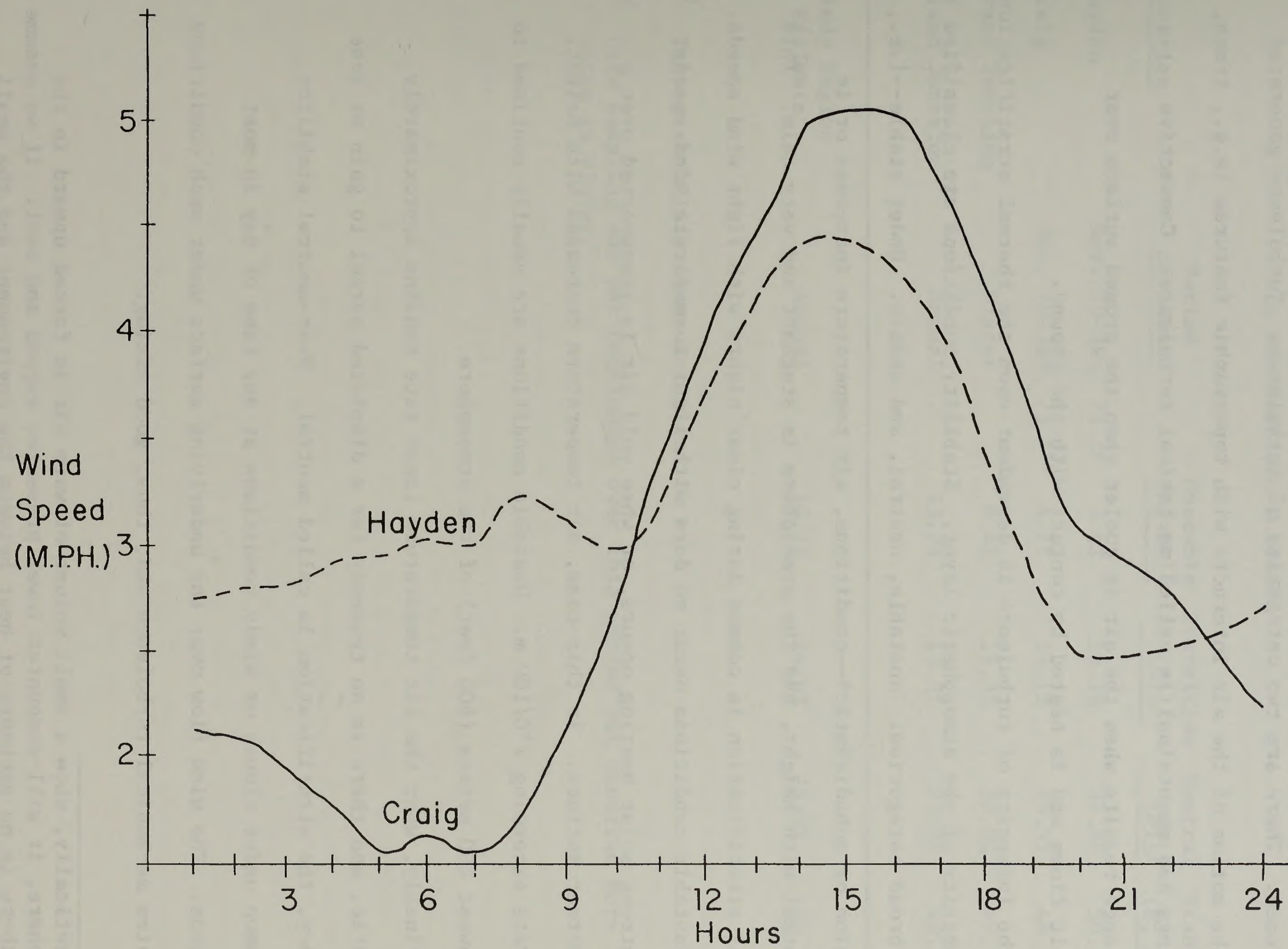

FIGURE RIV-23

Average hourly wind speed measured near Craig and Hayden; November 19,1970 - October 19, 1972.

Thermal structure

The thermal structure of the atmosphere is related to atmospheric turbulence. There are two categories of turbulence. Turbulence generated when the motion of the air interacts with topographic features (e.g., trees, buildings and mountains) is called mechanical turbulence. Convective turbulence results when the air is cooler than the ground surface over which it flows and is heated by contact with the ground.

The intensity of turbulence is dependent upon the thermal stratification or stability of the atmospheric layer. Stability conditions are classified in three broad categories: unstable, neutral, and stable. Under stable--i.e., inversion or subadiabatic*--conditions, air temperature increases or is isothermal with height, and the atmosphere is stagnant and very calm. This thermal stratification is common during clear nights with light wind speeds.

Unstable conditions occur on days with light to moderate wind speeds, when strong solar heating occurs, or when cold air is transported over a much warmer surface. In this case, air temperature decreases with height, at a rate exceeding 1°C/100 m. Unstable conditions are usually confined to the lowest 200 meters (600 feet) of the atmosphere.

Finally, when the air temperature lapse rate remains approximately adiabatic, and there is no tendency for a displaced parcel to gain or lose buoyancy, the stratification is called neutral. Near-neutral stability is common under cloudy or windy conditions at any time of day in most locations. The wind flow over the underlying surface under such conditions generates mechanical turbulence and, thus, good mixing.

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*Theoretically, when a small volume of warm air is forced upward in the atmosphere, it will encounter lower pressure, expand and cool. If we assume that there is no exchange of heat between the environment and the small volume, we can define the rate at which cooling occurs during the ascent as the dry adiabatic lapse rate (-9.8°C/Km).

TABLE RIV-14

Frequency of Stability Classes at Several Locations in Northwestern Colorado

Location	Period of Record	Unstable (A, B)1/	Transition (C)1/	Neutral (D)1/	Stable (E, F)1/
Hayden	Nov. 70-Jan. 73 2/	2.6%	15.1%	31.8%	50.5%
Craig	Nov. 70-Jan. 73 2/	4.1%	15.1%	29.5%	48.3%
Grand Junction	Winter	8.4%	12.3%	30.0%	49.3%
Grand Junction	Annual	13.2%	13.9%	32.8%	40.1%
Study Region Estimate	Annual	10.1%	14.6%	28.3%	46.2%

1/ Turner stability class notation

2/ Data sampling was not continuous over this period but occurred more often in winter.

The most direct method for determining local stability (and, thus, the dispersive capability of the atmosphere) entails frequent soundings to monitor the actual temperature gradient to a height of several hundred meters. Temperature soundings and wind speed measurements were made for a period of two years near Craig and Hayden for the Yampa project. The experiments involved balloon and aircraft soundings over Hayden and Craig during the following months: November 1970; March, May, September, November 1971; February, June, November 1972; and January 1973. Unfortunately the months selected biased the data in favor of fall and winter conditions. Four stability categories were recognized: stable, neutral, unstable, and transition. The transition category included all fumigation conditions, conditions where stable atmosphere is changing to unstable in the morning hours.

The frequency of occurrence of each class is shown in Table RIV-14. Similar data from NWS in Grand Junction are given for comparison. Reported occurrences of unstable conditions are unusually small from the Yampa project experiments. This is attributed to the method of evaluating transition conditions which are typically reported as unstable conditions at the other stations. After this is accounted for, the frequencies agree quite well with the fall and winter data from Grand Junction.

Stable conditions occur between 40 percent and 50 percent of the time in the study region. Generally, calm or light nighttime drainage winds prevail in stable layers. Upper level soundings show that the depth of the nighttime stable layer averages 335 meters (1100 feet) near Craig and 488 meter (1600 feet) near Hayden. Neutral conditions are observed when the large-scale westerly flow reaches the surface layer and is therefore accompanied by faster wind speeds. Unstable conditions are typical of afternoons, particularly in the summer, and are therefore accompanied by up-valley flow and increased wind speeds. Vertical mixing is greatest during unstable conditions. According to Holzworth (1972) the depth of the mixing layer averages 380 meters (1250 feet) in the morning and 2.6 km (1.6 miles) in the afternoon.

Air Quality

Ambient air quality standards

Federal regulations

The ambient air quality of the study region falls under the standards established under the provisions of the Federal Clean Air Act and its amendments of 1970, as well as the standards promulgated by the State of Colorado. The national and State ambient air quality standards for the six regulated pollutants are listed in Appendix D. Both the primary and secondary Federal standards are listed. The former are designed to protect public health and are projected to be met by mid-1975, while the latter are established to protect welfare and are to be met within a reasonable time after 1975.

Of the six regulated air pollutants--sulfur oxides, particulate matter, carbon monoxide, photochemical oxidant, hydrocarbons, and nitrogen oxides--only photochemical oxidant is produced inclusively in the atmosphere. This pollutant is normally dominated by the gas called ozone. Ozone is produced in the atmosphere from a complicated chain of sunlight-induced chemical reactions involving nitrogen oxides and hydrocarbon vapors. Ozone and other oxidants such as peroxyacetyl nitrate (pan) are hazardous at trace concentrations. Sulfur dioxide, nitrogen oxides, and carbon monoxide are identified largely with the burning of fossil fuels, but other sources may exist, including natural ones from biological processes. The nitrogen oxide gases include nitric oxide (NO) and nitrogen dioxide (NO_2). Adverse health effects are identified with the latter gas. Mostly nitric oxide is emitted from combustion; this gas is oxidized in the atmosphere to nitrogen dioxide as part of the ozone forming processes.

Although hydrocarbon vapors are not toxic in themselves at low concentrations, they are an important precursor for oxidant. Of the hydrocarbon gases, methane is most common in the air and is the least chemically reactive. Other hydrocarbons, the non-methane fraction (NMHC), are considered a useful measure of reactive species.

The remaining regulated pollutant consists of small particles suspended in air. These suspensions, generally known as aerosols, are often referred to as haze, dust, or smoke. Presently this material is measured and reported by weight per unit volume of air flowing through a filter. Aerosol particles come from many different "primary" sources, including blowing finely divided dirt, motor vehicle exhaust, blasting, and fossil fuel burning. Recently, evidence has accumulated that a major fraction of the collected particulate material comes from "secondary" processes in the atmosphere itself. An important pathway for removing pollutant gases, such as sulfur dioxide and nitrogen dioxide, from the atmosphere is through aerosol particle formation. The resulting mixture containing sulfate and nitrate particles is suspected to be linked to respiratory effects in humans.

The varied character of aerosol particles is further complicated by their wide range in size. The larger particles, such as dust particles, remain in the air only a limited time and are normally trapped in the upper respiratory tract where they are believed to be limited in hazard. The smaller particles, less than a micrometer in diameter, come mainly from combustion sources or from atmospheric chemical reactions. These tiny particles penetrate the lower reaches of human lungs and are believed to be most significant as hazardous materials, particularly in the presence of pollutant gases. The submicrometer particles remain in the atmosphere potentially for several days and create substantial visibility degradation if they are present in sufficiently high concentrations.

Aside from effects on human health, the regulated pollutants are known to affect animals and vegetation. Fallout of particulate matter containing acid sulfate or nitrate may create conditions for material degradation, including metal corrosion.

Non-degradation of undeveloped areas

The Federal EPA criteria governing significant air quality degradation (Federal Register, 39, 42510, Dec. 5, 1974) are applicable to the public lands in the study area. The northwest Colorado region has been designated a Class II area, wherein. . ." deterioration normally accompanying moderate well-controlled growth would be considered insignificant." In such areas, pollutant concentrations can be allowed an incremental increase shown in Appendix D over baseline concentrations.

The public lands in the study region can be reclassified to Class I or Class III. "Class I applies to areas in which practically any change in air quality would be considered significant". Class III applies to those areas where . . ." deterioration up to the national standard would be considered insignificant". The incremental increase restrictions for Class I and Class II areas are shown in Appendix D.

The northwestern Colorado region is considered a "non-designated" area where stringent sulfur dioxide (SO_2) and total suspended particulate (TSP) regulations have been promulgated. A non-designated area in Colorado refers to all regions not covered by the urban development on the eastern side of the Rocky Mountains between Fort Collins and Colorado Springs. There the Colorado regulations assume an extremely low baseline condition and carefully controlled growth to maintain air quality. The constraints are quite severe for the development of all rural areas in Colorado.

Baseline conditions

The study area is rural in nature, so there is a meager amount of information to estimate the baseline conditions of air quality. The available information comes from monitoring and surveillance in the study area itself and surrounding locations.

Sulfur dioxide

There are essentially no historical continuous sulfur dioxide measurements available in the study area. A few observations have been reported near the Hayden power station. These indicate a level of less than 5 ppb (as low as 0.1 ppb) in this area, which is the expected "global" background for this gas. Interpretation of sulfation plate data taken near the plant show a similar level for the sulfur oxides.

Just to the south in Rio Blanco County, continuous observation of total atmospheric sulfur are being made on the Federal lease oil shale tracts. Some of these data are summarized in Table RIV-15. These data suggest that, on the average, the sulfur dioxide levels in non-urban sites

TABLE RIV-15

Summary of Total Sulfur ($\mu g/m^3$) as SO_2 in Rio Blanco County, Colorado and Northeastern Utah

Location	Period of Record	Average	Max 24 Hour Value
Ca Oil Shale Lease Tract	February 1975		
Site 1		10.4	13.0
Site 2		7.8	13.0
Site 3		2.6	20.8
Cb Oil Shale Lease Tract	Sep 1974-Nov 1974		
Trailer 20		3.8	103.6
Trailer 21		3.0	136.0
Trailer 22		6.0	113.5
Trailer 23		1.8	17.2
Ua Oil Shale Lease Tract	Dec 1974-Jan 1975		
Site A2		5.0	15.0
Ub Oil Shale Lease Tract	Dec 1974-Jan 1975		
Site A6		5.0	15.0

in northwestern Colorado are generally at background levels of 15 μg/m^3, or less. Significantly larger 24-hour maxima have been reported at the Cb tract sites along the Piceance Creek, but these may be in error when compared with the averages reported in the area. In any case, the instrumentation used in these studies has a detection limit of 15 μg/m^3, so reported values less than this are not reliable.

With the uncertainties in the available data, a background concentration of 15 μg/m^3 is adopted as characteristic of average sulfur dioxide concentrations in the study area. In communities such as Steamboat Springs, where domestic and industrial fossil fuel burning are common, the sulfur dioxide levels may be an order of magnitude larger for 24-hour periods, particularly during the non-summer seasons.

Suspended particulates (TSP)

The available observations are more extensive for TSP in the study area than for other regulated pollutants. The data are summarized in Table RIV-16. Averaged values are reported for the period between 1971 and 1973 for nine different sites. All of these are in populated areas except for Rio Blanco, which is located on the oil shale tract area. The observations indicate systematically higher values of TSP in populated areas compared with the remote site. The latter is characteristic of values expected for the natural aerosol background. The highest concentrations are reported at Steamboat Springs, at the upstream end of the Yampa River Valley. TSP at Steamboat Springs exceeds the national standards, while other communities are safely below this level. On the other hand, Craig, Steamboat Springs,

TABLE RIV-16

Summary of Suspended Particulate Data Within Study Region ($\mu g/m^3$)

Station	Quarterly Arithmetic Average				Yearly		
	1	2	3	4	Arith. Ave.	Geom. Ave.	Max.
Town of Craig							
1971	71	85	70	63	72	63	190
1972	67	80	68	57	68	64	202
1973	76	77	70	86	77	67	220
Craig Power Station							
1971	-	73	31	21	47	34	155
1972	17	34	35	-	30	25	87
Town of Hayden							
1971	31	47	54	24	39	36	146
1972	26	41	33	20	30	25	120
1973	24	35	46	26	33	27	82
Hayden Power Station							
1971	-	40	38	15	30	24	116
1972	17	33	30	21	26	22	163
Kremmling							
1971	64	98	100	95	90	-	244
1972	84	83	90	69	82	-	246
1973	67	89	79	92	82	70	208

TABLE RIV-16 (Cont.)

Summary of Suspended Particulate Data Within Study Region (μg/m^3)

Station	Quarterly Arithmetic Average				Yearly		
	1	2	3	4	Arith. Ave.	Geom. Ave.	Max.
Town of Steamboat Springs							
1971	123	137	106	92	114	90	358
1972	126	136	115	111	122	100	429
1973	128	130	125	136	130	108	469
Town of Meeker							
1972	62	60	61	48	58	56	201
1973	68	60	61	88	67	44	227
Town of Rangely							
1972	48	36	33	27	36	31	125
1973	31	31	41	40	36	36	168
Town of Rio Blanco							
1972	17	28	35	9	22	14	98
1973	7	21	23	29	20	16	144

and Kremmling appear to be exceeding the Colorado standard for non-designated areas.

It is not known why Steamboat Springs has high TSP levels. However, they may be related to constraints in upslope airflow at the base of the mountains combined with local uses of fuels by stationary sources and motor vehicle traffic.

As a regional baseline, the annual arithmetic average concentration of 20 $\mu g/m^3$ is assumed to be characteristic of rural areas. Backround for each of the towns in the area will be based on measured values. These conditions are well beyond those expected for a truly rural backround.

Carbon monoxide

There are no measurements available for carbon monoxide in the study region. Therefore, a rural-suburban baseline concentration of 400 $\mu g/m^3$ is adopted for the study region.

Nitrogen oxides (NO_x)

Only one limited series of measurements of NO_x have been found in the study area. These were reported from an environmental study near the Hayden power station. A maximum 24-hour averaged value of approximately 2 $\mu g/m^3$ was reported in February 1972.

In adjacent areas a limited amount of continued NO_x data are available from the oil shale tracts and from baseline studies of the Panhandle Eastern Pipeline Company in Converse County, Wyoming. These are listed in summary in Table RIV-17. The total NO_x concentrations reported range from 4 $\mu g/m^3$ to

34 μg/m^3, with approximately half being nitric oxide. These levels are characteristic of global background concentrations. A uniform annual average concentration of NO_x corresponding to 15 μg/m^3 is adopted for the study area, which is well below the national standard.

Non-methane hydrocarbons (NMHC)

Measurements of the non-methane component of hydrocarbon vapors are made by the difference between total vapor concentration and methane. These measurements are generally uncertain because of ambiguous calibration procedures currently available. The only available observations of NMHC relevant to the study area are taken from adjacent locations, as indicated in Table RIV-17. The methane concentrations reported are consistent with natural background values, and the oil shale tract values of NMHC appear to be reasonable for background, except for the Utah Ub site, which is much larger than Ua and is larger than the national standard. The values reported in Wyoming also are high and may be related to transport to that site from oil production areas upwind in the Casper area.

As a baseline in the study area, a rural NMHC concentration of 50 μg/m^3 as a methane equivalent is assumed. This value is expected to be a factor of two larger in populated areas resulting from present motor vehicle emissions and stationary sources.

Photochemical oxidant

It is assumed that the principal component of oxidant in the study area is ozone. No observations of ozone (or oxidant) have been reported for the study area, so the values from adjacent sites must be used again here. These are listed in Table RIV-17. The maximum one-hour concentrations of ozone reported in remote sites in Colorado and Wyoming are very high, approaching or exceeding the national standard.

Consistent with values in Table RIV-17, a regional baseline of 120 $\mu g/m^3$ maximum one-hour oxidant concentration is assumed for the study area. Twenty-four hour values of oxidant are substantially lower and are taken to be 60 $\mu g/m^3$ in the study area.

Visibility and non-regulated pollutants

There are several "indicators" of air pollution that currently do not fall under a regulatory framework. These include visibility degradation and a number of non-criteria pollutants, such as particulate sulfate and nitrate, and trace elements. In the latter category, lead, manganese, vanadium, silicates, arsenic, fluoride, cadamium, berylium, mercury, etc. are considered of interest.

Visibility

Degradation in visibility depends strongly on light scattering by aerosol particles. The intensity of light scattering is strongest for particles in the submicron size range between 0.1 and 1.0 microns in diameter. Visibility is affected by humidity, rain, fog, and snow as well as particulate concentrations in the atmosphere. Local airports report an annual average visibility of about 25 kilometers (15 miles). As a crude first approximation, neglecting water vapor, light scattering in the atmosphere and hence the visibility, is inversely proportional to the TSP concentration. In particular, Charlson and co-workers (1969) have found that the visual range can be expressed as

TABLE RIV-17

24 Hour Average Background Measurements of Rural Hydrocarbons, Nitrogen Oxides and Ozone in the Rocky Mountain Region ($\mu g/m^3$)

Location	Period of Record	THC	NMHC	NO_x	NO	O_3	Max 1 hr. O_3
Oil Shale Tracts							
Ca Site 1	February 1975	928	59	13.1	9.4	64.5	113.3
Cb Trailer 20	Sept.-Nov. 1974	899	73	7.0	1.7	47.3	139.4
Ua Site A2	Dec. '74-Jan.'75	1,082	42	34.3	14.0	50.0	190.0
Ub Site A6	Dec. '74-Jan.'75	1,285	225	15.0	6.3	110.0	200.0
Panhandle Eastern Pipeline Co.							
Converse County, Wyoming	January 1974	1,170	250	15.0	6.0	75.0	100.0
	March 1974	1,302	456	< 4.0	<4.0	82.0	119.0

$$L_v\ (km) = \frac{1.8\,^{+1.8}_{-0.9} \times 10^3}{TPS\ (\mu g/m^3)}$$

for (a) relative humidities less than 70%, (b) particle size distributions having a power law form (Junge, 1963), and (c) constant light scattering over the observer's line of sight. This relation can be used readily to estimate the maximum visual range from TSP observations. On the average, the maximum visual range is expected to be about 90-100 km (62 miles), except for the Steamboat Springs area which should have a 10-20 km (6-12 miles) visual range on the average.

Particulate sulfate and nitrate

As de facto criteria, there is increasing pressure to examine the impact of sources on concentrations of airborne sulfate; this pressure also is likely to develop for nitrate. In the study area, it is estimated that the baseline average sulfate and nitrate concentrations are respectively 2 $\mu g/m^3$ and 1 $\mu g/m^3$ over the entire study area. These values are based on a variety of non-urban observations reported in the National Air Data Bank and recent studies by Altshuller (1973) and Frank (1974).

Trace elements

Because of their potential interest in inducing adverse health effects, the trace element baseline is estimated for this study region; they are shown in Table RIV-18. These background concentrations are estimated from National Air Surveillance Network information, combined with summaries from the Atmospheric Aspects Work Group Report of the Northern Great Plains Resource Program and

TABLE RIV-18

Trace Metals

Metal	Average Maximum Observation of 149 Urban Stations (1968) μg/m³	Average Maximum Observation of 2 Urban NGPRP Stations (1968) μg/m³	Average Maximum Observation of 28 Non-Urban Stations (1968) μg/m³	Maximum Observation of 1 Non-Urban Black Hills Station (1968) μg/m³
Beryllium	.005	.0004	.0002	<.0000
Cadmium	.016	*	.002	.007
Chromium	.065	.031	.010	<.002
Cobalt	.005	*	.001	.002
Copper	.50	.11	0.40	.450
Iron	8.03	4.60	1.07	<.03
Lead	3.39	1.36	0.20	.024
Manganese	.50	*	.03	<.01
Nickel	.11	.01	.01	<.002
Tin	.02	*	.005	<.0003
Titanium	.23	.05	.05	<.003
Vanadium	.21	*	.02	<.001

* Observations less than minimum detectable concentrations.

recent research studies in California (Hidy et al, 1975). The baseline levels for the trace elements are highly uncertain for the study region and are considered tentative. They are included primarily for reference purposes.

Living Components

Soils

Soil results from soil formation factors: (1) climate, (2) topography, (3) vegetation, (4) parent material, and (5) time. Each soil is the product of these factors and any one factor's contribution depends upon the others and upon location. The soil associations (soil mapping units) of the study region have been grouped into five categories at the "order" level of soil taxonomic classification: Alfisols, Aridisols, Entisols, Inceptisols and Mollisols. These orders are shown for the study region on Map Foldout 8 in Appendix B. The soil associations within each order are described in Appendix D, as are the environmental characteristics important to soil formation and reclamation potential of the soil orders found in the study region. A brief discussion of each of the soil forming factors and how they relate to soils of the region follows.

Climatic factors

The dominant climatic factors in soil formation are precipitation and temperature; each of these factors exhibits marked differences with changes in elevation and slope aspect. These changes essentially occur in a southwest-northeast direction across the study region.

Precipitation ranges from 8-20+ inches; it is lowest during the summer months, with August generally the driest. November is the wettest month. Heaviest snowfall is in December with highest elevations receiving most for the longest period of time (NOAA 1973). The amount of precipitation affects the degree of leaching that occurs in soil.

The driest soils in the study region are Aridisols and Entisols; they occur in a precipitation zone of 8-15 inches. Entisols are those soils that have little or no evidence of development. The only evidences of soil formation are slight accumulations of organic matter in the surface depth for a few inches, and a slight loss of carbonates in the surface layer. Aridisols are those soils that do not have water available to mesophytic plants for long periods. During times when soil is warm enough for plants to grow, water is held at a tension greater than 15-Bars, i.e., the water is not available to plants, or it is salty, or both. There is no period of three months or more when moisture is continuously available when the soil is warm. These soils do have slight organic matter accumulation resulting in a darkened surface layer. There is a translocation and accumulation of salts, carbonates or silicate clay, or of cementation by carbonates or silica.

As precipitation increases, soil forming processes are enhanced. Mollisols occur in the more than 15-20 inch precipitation zone. These soils have dark-colored organic matter enriched surface layers that are 7-20+ inches thick. There is an increase in silicate clays in the subsoil; carbonates and salts are translocated, and accumulation occurs at greater depths than in Aridisols. These base-rich soils exhibit a good potential for reclamation due to good surface layer qualities and sufficient moisture for good vegetative growth.

In the 20+ inch precipitation zone most salts and carbonates are leached to great depths or removed by water out of the area. Rocks are weathered to greater depths than those in lesser precipitation zones in the area. These soils are Alfisols. They exhibit light-colored low organic matter content surface layers, moderate to high base saturation, clay accumulation in subsoil, and water is held at less than 15-Bars during at least three months each year when the soils are warm enough for plant growth.

Inceptisols soils are also in the 20+ inch precipitation zone. These soils have altered horizons that have lost bases or iron and aluminum but retain weatherable minerals. Horizons of accumulation are silica, iron, or bases. In northwest Colorado the most common features of Inceptisols are accumulations of organic matter in surface layers and bright-colored subsoils; they are closely related to mountain glaciated areas. These soils are the coldest in the study region and have either permafrost or dry frost in the lower horizons.

The growing season is strongly influenced by elevation and variations in topography. There appears to be a correlation between the length of the growing season and amount of precipitation, soil temperature, direction of the prevailing wind, elevation, and topography. The longest growing season (120-140 days) occurs where precipitations and elevations are lowest, at lowest elevation in the southwest part of the study region. It becomes decreasingly shorter to less than 30 days in a northeast direction, as average regional elevations rise and precipitation increases.

Air temperature is strongly influenced by elevation and variations in topography. Soil temperatures are closely related to air temperatures. The mean annual soil temperature (measured at a standard depth of 20 inches) is generally 2°F-4°F higher than the mean annual air temperature. Soil associations on the general soil map in Appendix B reflect temperature conditions from place to place. Those soils that are the warmest (mesic) have a mean annual soil temperature that is more than 47°F but less than 59°F. Those soils that are cool (frigid) have a mean annual soil temperature that is less than 47°F, and the difference between summer and winter temperatures is more than 9°F. Those soils that are cold (cryic) have a mean annual soil temperature that is more than 32°F but less than 47°F. Those soils that are coldest and also occur in the highest elevations have a pergelic temperature regime. These soils have a mean annual soil temperature less than 32°F. They have permafrost if they are moist, or dry frost if excess water is not present.

Topographic factors

The topography has many distinctly different landforms that provide different environmental landscapes for the formation of soil. Data in Appendix D show the environmental characteristics that relate to kinds of topography coupled with climate. Warm (mesic) soils are located at lowest elevations (5-8,000 feet) where landforms are represented by mesas, terraces, low hills, breaks, and canyon walls. Precipitation is lowest (8-15 inches) and growing season is longest (120-140 days). Aridisols and Entisols are represented.

Cool (frigid) soils of the region are located in intermediate elevations (6-9,000 feet). Landforms are variable and are represented by alluvial fans, hills, plains (upland), valleys, benches, floodplains, mesas, breaks, and mountain slopes. Precipitation ranges from 8-20 inches; average is 12-15 inches. Growing season is 60-120 days; average is 60-90 days. Aridisols and Entisols are represented in drier parts of the area, especially on south and west-facing slopes. Mollisols are represented in more moist parts of the area and on gently sloping landforms. Some Alfisols are represented on steep north and east-facing slopes.

Cold (cryic) soils of the region are located in higher elevations (7-11,000 feet). Landforms are dominated by mountain slopes, mesas, and benches. Precipitation ranges from 12-20+ inches; average is 15-20 inches. Growing season is 30-90 days, and averages 30-60 days. Alfisols are represented on north and east-facing slopes, Mollisols on gently sloping to sloping south and west-facing slopes, and Entisols and rock outcrop on steep south and west-facing slopes.

Coldest (pergelic) soils of the region are located in highest elevations (over 11,000 feet). Landform is represented by steep mountain tops; precipitation is 20+ inches. Growing season is less than 30 days.

Vegetative factors

Vegetation influences soil formation usually through addition of organic matter from leaves, stems, and roots. Vegetation in northwestern Colorado varies widely; kind and amount is closely associated with climate and topography. Precipitation amount and seasonal distribution have a direct affect on vegetation; in this area highest precipitation is in highest elevations of the eastern part, and lowest is in lower elevations of the west.

Major woodland areas in northwest Colorado occur in high mountains (over 8,000 feet) where climate is cold (cryic and pergelic) and precipitation is more than 20 inches. Part of the area is above timber line. The dominate vegetative type is conifer. Dominate soils are Alfisols, Inceptisols and Mollisols. Aspen areas have an understory of assorted grasses, forbs, and shrubs. Usually organic matter content is highest and thickest in soil formed under aspen; dominate soils are Mollisols; aspen is a good indicator of topsoil for reclamation. Woodland areas at lower elevations (5-8,000 feet) that have a drier (8-20 inches) and warmer (mesic and frigid) climatic condition, occur on shallow or skeletal soils, usually located on south and west slopes. The dominant vegetative type in these areas is pinyon-juniper woodlands. Dominate soils are Aridisols and Entisols.

Areas dominated by the mountain shrub vegetative type occur in middle elevations (6,500-8,000 feet) that have a range of cool (frigid) and cold (cryic) temperatures and in a precipitation zone of 12-20 inches. This vegetative type is in complex with sagebrush, aspen, river bottom and pinyon-juniper vegetative types. Dominate soils are Mollisols and Alfisols; minor soils are Aridisols and Entisols.

A mountain shrub vegetative type consisting of bitterbrush (Purshia tridentata) near Maybell is unique, in that it occurs on deep eolian sandy soils in a cool (frigid) 12-15 inch precipitation zone at an elevation of 6,000-6,500 feet. The dominate soils are Entisols.

The areas dominated by the sagebrush vegetative type occur at 6-9,000 feet elevations in a range of cool to cold (frigid to cryic) temperatures where the precipitation is 12-15 inches. Dominate soils are Aridisols and Mollisols with inclusions of Entisols.

Areas dominated by a complex of big sagebrush and greasewood occur at 5,000-8,000 feet elevation in warm (mesic) to cool (frigid) temperatures where the precipitation is 8-12 inches. Dominate soils are Entisols and Aridisols. Natragids were observed; they are associated with saltbush and greasewood vegetative types. Natragids are Aridisols that have high concentrations of sodium in the subsoil; these soils will definitely affect vegetative growth and survival. They were generally observed outside the presently coal mined areas.

Parent material

Parent material for all soils initially came from rock. It is therefore important to know about different kinds of rocks and material weathered from them to understand the soils that formed. When consolidated rocks are chemically and physically broken down by weathering, some soluble constituents are lost to leaching while others are accumulated. This remaining unconsolidated mass is the parent material for soils.

Kinds of minerals in rocks, their grain size, and their chemical makeup are important properties which determine resulting particle size (texture) of soils. Rocks that become parent material for soils are made up of minerals composed of basic structural units of oxygen, silica, and aluminum with other elements to give stability to the units.

Common light-colored minerals in soils are quartz, which is mostly silicon, mica and feldspar; common dark-colored minerals in soils are mostly pyrozenes and amphiboles which contain iron and magnesium as stabilizing elements.

The most common rocks that serve as a source of parent material for soils in the study region are igneous and sedimentary rocks that have been altered by wind, water, and ice. Soils have developed in residuum, alluvium, colluvium, glacial drift, and eolian deposits. Generally coarse-grained igneous rocks give rise to coarse-grained soils dominated by sand; fine-grained igneous rocks give rise to fine-grained soils dominated by clay; the common mineral is iron. These igneous rocks are minor in the region.

Sedimentary rocks consist of sandstones, shales, mudstones, and siltstones. Sandstones are dominant in the area and weather to soils that are loamy in texture, dominated by sand. Shales weather to soils that are clayey in texture, dominated by clay. Mudstones and siltstones weather to soils that are silty or loamy in texture. The alluvial valleys are a mixture of sediments from coarse-grained sandstone to fine-grained shales; the resulting mixture is loamy soils. Thin loess (silt) deposits are located on terraces, mesas, benches and north-facing mountain slopes; they are most pronounced in the southeast part of Moffat County. Glacial drift is pronounced in high mountains along the eastern part of the study region; these soils are deep, very stony, or bouldery. Glacial outwash is minor in extent and occupies local valley systems associated with glaciated high mountains.

Time

If the kind and magnitude of all other forces active in soil formation are equal, the parts of any given landscape that have been subjected to this activity for the longest period will have the strongest degree of soil development. It is difficult, however, to determine the chronological age of a soil, for obviously no such uniformity exists among the soil forming forces. The degree of horizon development in a soil profile may have resulted from differences in the intensity of factors other than time. Consequently, the degree of development alone is not a reliable criterion.

Unless specific dating can be accomplished by archeological means or by evaluating the decay of radioactive substances, the soil scientist must rely upon geomorphic studies of landscape evolution to arrive at relative dates for particular landscapes. Unfortunately, good geomorphic studies require skilled geomorphologists. In his daily work however the soil scientist can arrive at some of the more general relationships within his area.

In such comparisons care is needed in interpreting the chronological age of a soil from the degree of genetic development. Genetically young soils often occur in deposits of great chronological age where, for example, natural erosion has prevented the development of a mature soil by yearly removal of soil material throughout the ages. Only the most advanced degree of development can be considered as a reasonable indication of relative age.

In the northwest Colorado area the problem of dating soils is made more difficult by the nature of the terrain. The landscape is one of mountains, valleys, and plains where the forces of natural erosion are extremely active. Geologic erosion cycles are of relatively short duration. Landforms shaped by one cycle can be obliterated or badly dissected by subsequent cycles so the untrained observer cannot readily reconstruct the landscape of any one period in time.

As a result of these difficulties the influence of time on soil development in the northwest Colorado area is poorly understood. Only a few of the most obvious differences are mentioned in the paragraphs that follow.

The lack of specific geomorphic age classifications makes it impossible to specifically relate any one landform with any degree of solum development. In localized areas, where all forces of soil formation are approximately equal, it can be assumed that differences in degree of horizon development can be partially attributed to differences in age.

The Entisols, youngest in development (Soil Taxonomy 1973), occur in any climate under any vegetation. There are no discernable horizons as they are dominated by mineral soil material associated with discernable recent age deposits or actively geologic eroding slopes.

The Aridisols are more mature than Entisols. The unique properties common to Aridisols are: a lack of water available for mesophytic plants for very extended periods, one or more pedogenic horizons, a surface not significantly darkened by humus, and an absence of deep wide cracks caused by high clay contents.

The Mollisols reflect stronger soil development and are more mature than the Aridisols. In the study region their unique properties are: a combination of dark-colored surface layers more than 10 inches thick, a dominance of calcium among the extractable cations, and a dominance of crystalline clay minerals of moderate to high cation-exchange capacity. These soils characteristically form under grass in climates that have a moderate to pronounced seasonal moisture deficit. Age of the soils outside the glaciated areas may be as old as mid-Pleistocene or earlier; they have clay accumulations of reddish hues.

The Alfisols have marks of processes that translocate silicate clays without excessive depletion of bases, or a dominance of processes that lead to humus accumulation in the surface layers, clay accumulation in the subsoil, a medium to high supply of bases in the soil, and water available to mesophytic plants more than three months during the growing season. The problem with these soils is poor tilth caused by the lack of organic matter in the surface layers. The age of these soils is generally Late-Pleistocene.

The oldest soils in the study area are the Inceptisols. Their unique properties are: a combination of water available to plants during the warm season, one or more pedogenic horizons of alteration or concentration without accumulation of translocated materials other than carbonates or amorphous selica, texture finer than loamy sand, some weatherable minerals, and moderate to high capacity of the clay fraction to retain cations. Most Inceptisols are on relatively young geomorphic surfaces, late Pleistocene or Holocene.

Terrestrial Flora

Nine primary and two secondary vegetative types are found in northwestern Colorado. The primary types are: grassland, sagebrush, mountain shrub, conifer, barren pinyon-juniper, saltbush, greasewood, and cropland; the secondary types are aspen and river-bottom. Type designations and numbers are those used by the BLM as described in BLM Manuals.

The vegetation of this region is a complex mosaic where soils, climate, aspect, altitude, grazing, and general land use history are the controlling factors in plant distribution. Moisture is most often the general limiting factor for the distribution of vegetation on the western slope of the Rocky Mountains (James and Marr 1966).

Conifer type is marginal in the study area and usually occurs in areas of highest elevation, coolest soils, and highest annual precipitation, and often in areas of the most snow accumulation. In some areas this type is confined to north slopes where aspect creates microclimatic conditions suitable for a coniferous forest.

Aspen type occurs in areas where soils are well-developed and soil moisture conditions are good; it is often a transition zone between the mountain shrub and conifer types.

At lower elevations (5,000-7,000 feet) the mountain shrub type develops where snow collects and lies late, or where moisture is adequate throughout spring and early summer. Soils associated with this type are deep and well-drained, but not as deep as those under aspen type. On sites where moisture is somewhat limiting, scrub oaks of the mountain shrub type lose their dominance in the community and the stands become dominated by serviceberry. Brown (1958) points out that the absence of coniferous species on many north-facing slopes is strong evidence supporting the premise of ecological stability of mountain shrub communities. He also suggests that the extent and density of the scrub oak vegetation type in west central Colorado is probably not much different today than it was in the late 1800s.

Progressing toward the drier lower end of the scale, it is evident that on deep well-drained soils, sagebrush communities dominate all locations where moisture limits other vegetative types.

Pinyon-juniper type, often referred to as pigmy forest, is located in areas where precipitation is similar to sagebrush type, but soils are very shallow or nearly nonexistent. Physiologically, these coniferous species are unable to tolerate accumulation of fine soil particles around the roots, so they occur where bedrock is close to the surface or outcrops. Woodbury (1974) demonstrated that sagebrush is adapted to fine deep soils, and juniper to coarse porous soils; these vegetation types are segregated on that basis. In much of northwestern Colorado the occurrence of pinyon is limited in this vegetation type, probably due to the fact that this area is near the northern limit of the species, or possibly due to historic disturbances such as fire or disease. Juniper is often found to recover from disturbance more readily than pinyon (Woodbury 1947).

Northwest Colorado is also the approximate southern limit of the sagebrush type in the Rocky Mountain region. Therefore the slopes around the basins of northwest Colorado are a tension zone between two distinct semi-desert vegetation types, sagebrush and pinyon-juniper.

Saltbush and greasewood types are found in the areas of the region with lowest precipitation and elevation. They occur where the soils are saline-alkaline, poorly drained, and often underdeveloped. Greasewood type dominates where soils are the most saline-alkaline, and are poorest drained.

The grasslands occur on sites that range from deep soil, wet mountain meadows to dry, rocky hillsides. Grassland types of the region are much deteriorated, and have become increasingly less important to the biological systems of the area. Some areas that were formerly grassland types have been converted to sagebrush by historic over-grazing by cattle.

Barren areas are primarily rock outcrops and other areas where very little soil has developed because annual precipitation is very low.

Descriptions of each type follow, and locations of each type are found on Map Foldout 9 in Appendix B. The vegetative descriptions and map were primarily developed from the following BLM Unit Resource Analyses: Meeker 1975, Rangely 1975, Williams Fork 1974, Vermillion 1972, and Great Divide 1972.

Grassland, type 1

In northwestern Colorado native grassland vegetation consists primarily of scattered small native grass meadows and numerous small patches on windswept ridge tops and uppermost south slopes. This type is usually found on shallow soil of exposed ridges, in deep mesa soils, on gentle sloping foothill terraces, and on alluvial fans in the valley bottoms.

Grassland areas created by vegetative manipulation and/or wild-fires are also considered in this type if they are unirrigated. Some of the deep soils in the valley bottoms have been successfully converted to perennial grass pasture. Several areas of pinyon-juniper type have also been successfully converted to grassland type.

Grasslands of the study region are composed mostly of perennial bunch-grasses intermixed with forbs, half shrubs, occasional shrub species, and when in a deteriorated condition, annual grasses. The native grasslands of the eastern part of the region are dominated by: needle-and-thread grass (*Stipa comata*), Columbia needlegrass (*Stipa columbiana*), green needlegrass (*Stipa viridula*), brome grasses (*Bromus* spp.), and timothy grass (Phleum pratense). Associated species are: cheatgrass (Bromus tectorum), wheatgrasses (Agropyron spp.), scarlet globemallow (Sphaeralcea coccinea), and broom snakeweed (Xanthocephalum sarothrae).

The dominant species of the central and western grassland types are: western wheatgrass (Agropyron smithii), needle-and-thread grass, June grass (Koleria cristata), bluegrass (Poa spp.), sedge (Carex spp.), and Indian ricegrass (Oryzopsis hymenoides).

Associated species are: three-awn (Aristida spp.), beardless bluebunch wheatgrass (Agropyron inerme), cheatgrass, broom snakeweed, rabbitbrush (Chrysothamnus spp.), and big sagebrush (Artemisia tridentata).

Seeded areas of the grassland type are mostly introduced wheat-grasses, in the western part of the study region, and bromes and timothy in the eastern part.

Sagebrush, type 4

This type occurs throughout northwest Colorado in stands that range from a few plants to an area approximately 1,500 square miles in north-central Moffat County. This type can be found adjacent to all other types throughout the study area. At lower elevations the sagebrush community is found primarily on deep well-drained soils, and at higher elevations where soil moisture retention becomes limiting to other plant communities. An example of this type is shown in Figure RIV-24.

The growth form of this type is a mixture of low-growing shrubs (1-6 feet) dominated by big sagebrush with a variable understory of perennial grasses and forbs; the annuals fluctuate from year to year depending on

FIGURE RIV-24

Examples of vegetative types: (4) sagebrush, (9) pinyon-juniper and (20a) riverbottom.

spring temperatures and moisture conditions. Type over-story varies from very open to completely closed stands.

The dominant species of this type are: basin big sagebrush (*Artemesia tridentata tridentata*), Wyoming big sagebrush (*Artemesia tridentata wyomingensis*), low sagebrush (*Artemesia arbuscula*) and black sagebrush (*Artemesia nova*).

Associated species are: western wheatgrass, bluebunch wheatgrass (*Agropyron spicatum*), Indian ricegrass, needlegrasses (*Stipa* spp.), June grass, cheatgrass, bluegrass, arrowleaf balsamroot (*Balsamorhiza sagitta*), buckwheat (*Eriogonum* spp.), rabbitbrush and broom snake-weed.

Sagebrush type of northwestern Colorado is an important food source for both native and domestic ungulates of the region.

Mountain shrub, type 5

A typical mountain shrub type of the study region supports a dense stand of shrubs 2-8 feet in height. This type usually exists as a transition zone between aspen and sagebrush types in the eastern part of the study region (Figure RIV-25). In the western part of the region mountain shrub type occurs on the sandiest soils and on areas of most favorable soil moisture conditions, and is usually bordered on all sides by sagebrush. Mountain shrub community is usually found on slopes, whereas sagebrush is usually on the flatter, deeper, heavier soils. Perhaps nothing characterizes vegetation of the mountain shrub type as much as its variability; a single species does not dominate the type for very large areas. Inconsistency of the vegetation is due to variability of soil moisture conditions and soil depths that are found on the mountain slopes of the region. Soils of this type are well-drained.

The common species are: Utah serviceberry (*Amelanchier utahensis*), western serviceberry (*Amelanchier alnifolia*),and Gambel oak (*Quercus gambelii*).

Associated species are: true mountain mahogany (*Cercocarpus montanus*), snowberry (*Symphoricarpos* spp.), antelope bitterbrush (*Purshia tridentata*), big sagebrush, common chokecherry (*Prunus virginia*), western wheatgrass, mountain brome (*Bromus marginatus*), June grass, bluegrass, western yarrow (*Achillea lanulosa*), aster (*Aster* spp.), sedge, buckwheat, milkvetch (*Astragulus* spp.), and fleabane (*Erigeron* spp.).

A unique community of nearly pure antelope bitterbrush approximately 40 square miles in size, occurs just west of Maybell on an excessively drained sandy soil, also unique in the study region.

Relative forage value of this type depends largely on plant density, species composition, and season of use. This type provides important big game winter range where snow depth does not prohibit access; its primary value to livestock is as summer range for cattle and sheep. When understory vegetation is crowded out by heavy grazing, this vegetative type will often close into dense stands of one or more less desirable browse species, such as Gambel oak or rabbitbrush.

Conifer, type 6

Small inclusions of conifer forests occur throughout most of the study region where soil moisture is increased above the requirements of the mountain shrub community, often due to aspect (Figure RIV-26).

Dominant species of the conifer type in the eastern part of the

FIGURE RIV-25

Examples of vegetative types: (5) mountain shrub, (7) barren (rock outcrop) and (10a) aspen.

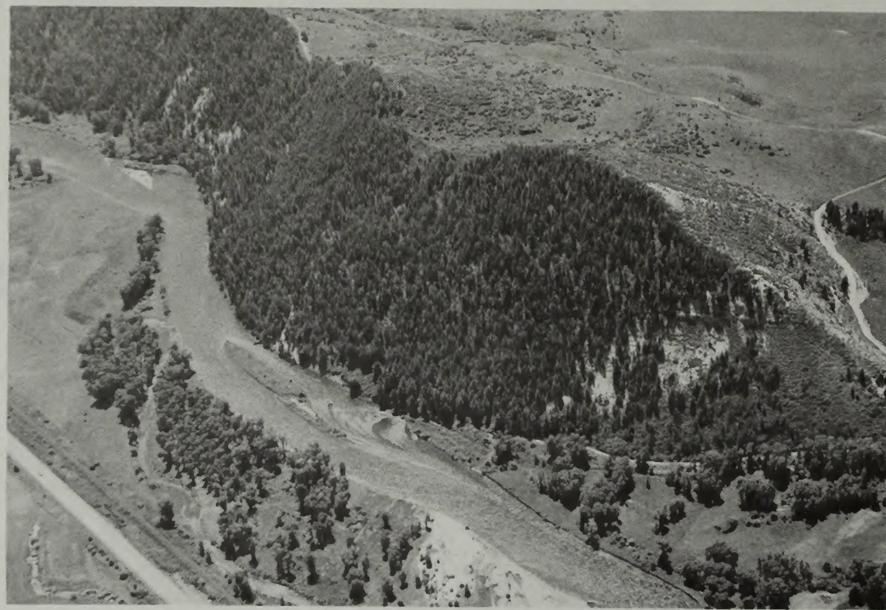


FIGURE RIV-26

Examples of Conifer Type Found on North-Facing Slopes in the Eastern Part of the Region.

study region include: Douglas fir (Pseudotsuga menziesii), Engelmann spruce (Picea engelmannii), and subalpine fir (Abies lasiocarpa). The dominant species of the western conifer type are Douglas fir, lodgepole pine (Pinus contorta), and ponderosa pine (Pinus ponderosa).

Depending upon location in the region, associated species include: quaking aspen (Populus tremuloides), snowberry, huckleberry (Vaccinium spp.) true mountain mahogany, elk sedge (Carex geyeri), and Utah juniper (Juniperus oteosperma).

Understory vegetation varies with stand location, density, and stage of succession. Conifer type in the east and southern portions of the region are usually very dense with little or no vegetative ground cover. This type provides cover for livestock, deer, and elk. Shrubby vegetation is found where openings occur in the conifer type, consisting of the same species as the mountain shrub type. The conifer types in this area are usually marginal on sites where they occur. This vegetative type is often found on steep slopes, and in these cases the type is very important for soil stability (Figure RIV-26).

Barren, type 7

The barren areas are primarily outcrops of the Trout Creek and Twentymile sandstones in the eastern part of the study region (Figure RIV-25), and areas of bentonite in the western part of the region. Little vegetation grows in these areas, but in the eastern part of the region the species associated with this type are: mountain mahogany, serviceberry, buckwheat, fringed sagewort (Artemesia frigida), and Junegrass, while the associated species in the western part are juniper and saltbush (Atriplex spp.).

Many small areas of this type are scattered throughout the study region, and usually are too small to be mapped differently from surrounding vegetation.

Areas in the western part of the region receive least precipitation of the study area, and where juniper is the associated species, parent material is usually evident on the ground surface.

Pinyon-Juniper, type 9

Pinyon-juniper type occurs throughout most of northwestern Colorado, and is quite extensive in the south and far west portions. The east edge of the study region is approximately the eastern limit of this type in western Colorado. The growth form of this type is open-to-closed overstory of pigmy woodland conifers 8-20 feet in height, with a thin understory of shrubs and herbaceous species, occurring on topography that varies from rolling to rugged (Figure RIV-24). This community is typically found on well-drained, poorly-developed, shallow gravelly soils.

Dominant species of this type are: pinyon (Pinus edulis), Utah juniper, and Rocky Mountain juniper (Juniperus scopulorum).

Associated species are: big sagebrush, low sagebrush, rabbit-brush, true mountain mahogany, broom snakeweed, prickly pear (Opuntia spp.), serviceberry, antelope bitterbrush, western wheatgrass, beardless bluebunch wheatgrass, Indian ricegrass, phlox (Phlox spp.), and goldenweed (Haplopappus spp.).

Considerable variation exists within the pinyon-juniper type, depending upon soil moisture conditions and/or soil texture. Some areas contain nearly all juniper, as the northern part of the study region is the northern limit of pinyon trees. The understory of this type is extremely sparse in closed stands, and increases largely in shrubs as the stand opens up. On very steep slopes and rock outcrops, the trees may be the only perennial vegetative layer present.

Open stands of pinyon-juniper provide forage for cattle and deer, whereas closed stands usually supply little more than cover.

Aspen, type 10a

This type occurs as open-to-very-dense stands of deciduous trees, relatively small in size at higher elevations, on north or protected slopes in the southern and eastern portions of the study region (Figure RIV-25). These trees are often clonal in habit, sharing a common root system. Because of its sprouting characteristics, aspen reproduces vigorously in cutover or burned areas in conifer types. Some isolated pockets of this type are plainly the result of extra moisture from snow accumulation on the leeward sides of hills; on these sites the aspen trees tend to be dwarfed and twisted. Soils of the aspen type are usually deep to moderately deep, and are often well-developed.

Quaking aspen is the dominant species of this type. Associated species are: snowberry, mountain ninebark (Physocarpus monogynus), mountain brome, pinegrass (Calamagrostis rubescens), bluegrass, columbine (Aguilegia spp.), geranium (Geranium spp.), lupine (Lupinus spp.), and eriogonum.

Understory production varies inversely with overstory density. Open stands often support an appreciable quantity of shrubs and grass-forb understory vegetation.

This type is important for the production of water, shelter for wildlife and livestock, and to a minor degree, forage production. The aspen communities that have received heavy use show signs of decadence, with little or no resprouting of clones.

Saltbush, type 13

The saltbush type is found in the south and west portions of the study region in large rolling semi-arid basins, and lower foothill slopes along the drainage bottoms (Figure RIV-27). This type occurs as mixed stands of low-growing shrubs with a grass-forb understory. Understory vegetation exhibits considerable variation within the type, often depending upon range condition. Stands in poor condition often have a high percentage of annual grasses and forbs and increase in perennial grasses and forbs as range condition improves.

The saltbush type occurs on soils that are moderately saline-alkaline and are slightly better drained than those supporting the greasewood type. This type appears to be strongly competitive on lower saline-alkaline soils in low precipitation zones. The effects of aspect on distribution of the saltbush type along the White River drainage are evident on lower

FIGURE RIV-27

Example of the Saltbush Type in Northwestern Colorado

foothill slopes where warm south exposures extend the semi-arid microclimate to higher elevations. The ability of sagebrush to strongly compete with other vegetation on well-drained soils is probably a major limiting factor to the extent of the salt-bush type in this region.

Dominant species of this type are: Nuttall saltbush (Atriplex nuttallii), shadscale (Atriplex confertifolia), fourwing saltbush (Atriplex canescens), black sagebrush, big sagebrush, spineless horse-brush (Tetradymia canescens), and spiny hopsage (Grayia spinosa).

Associated species are: Indian ricegrass, western wheatgrass, saline wildrye (Elymus salinus), cheatgrass, halogeton (Halogeton glomeratus), broom snakeweed, death camas (Zigadenus spp.), and grease-wood (Sarcobatus vermiculatus).

Saltbush type is generally regarded as valuable winter range for sheep, cattle, antelope, and deer, since it occupies lower elevations that do not accumulate large amounts of snow. Forage value is dependent on the species of both the browse overstory and the grass-forb understory. Heavy grazing and/or improper season of use will selectively decrease the quantity of desirable plant species, and often produces an increase in poisonous plants.

Greasewood, type 14

Greasewood type is found in low elevation drainage bottoms, alluvial fans, and basin floodplains in the south and west parts of the study region (Figure RIV-28). This type is found in areas where the soils are very saline-alkaline and very poorly drained. Greasewood type is primarily composed of fairly dense stands of medium height shrubs (2-5 feet) with a grass-forb understory, usually quite sparse.

The primary dominant of this type is greasewood. Other shrubs appearing in more open stands are: rabbitbrush, fourwing saltbush, Nuttall saltbush, and big sagebrush.

Associated species are: western wheatgrass, bottlebrush squirreltail (Sitanion hystrix), slender wheatgrass (Agropyron trachycaulum), and cheatgrass.

Dense stands of nearly all greasewood provide very little forage for grazing animals; greasewood is a poisonous plant to cattle and sheep if grazed in sufficient quantities in absence of other forage. Areas occupied by this type are in many cases natural livestock concentration areas near water. Heavy use of the palatable species in this type near watering areas tends to produce very dense stands of greasewood with little forage value.

FIGURE RIV-28

Example of the Greasewood Type,
as it Commonly Occurs in Bottom Lands

Cropland, type 19

The croplands of the study region are composed of natural meadows, subirrigated valley bottoms, and adjacent mesas and slopes along the river basins (Figure RIV-29). Areas immediately adjacent to rivers and streams are used for hay production, and mesas and foothill slopes are used for production of small grains, mostly winter wheat (Triticum aestivum), by the summer fallow method. The haylands are composed mostly of bromes, timothy, wheatgrasses, orchard grass (Dactylis glomerata), ryes (Elymus spp.), clovers (Melilotus spp.), and alfalfas (Medicago spp.)

These areas are limited in production by the short growing season and short supply of late season moisture from either natural precipitation, or irrigation where facilities are available. In a few areas where irrigation water is plentiful, salt accumulation in low places has produced small areas unsuitable for plant growth.

Most of the areas used for small grain wheat production were formerly sagebrush lands. Sheet, rill, and gully erosion are quite prevalent on small grain and fallow lands. Most of these areas are steep and unprotected from wind and water erosion.

Cropland provides a significant amount of forage used by livestock during times when grazing lands are unavailable.

Riverbottom, type 20a

This type occurs along main drainages throughout the study region. (Figures RIV-24, 29). It essentially occurs along the entire distance of

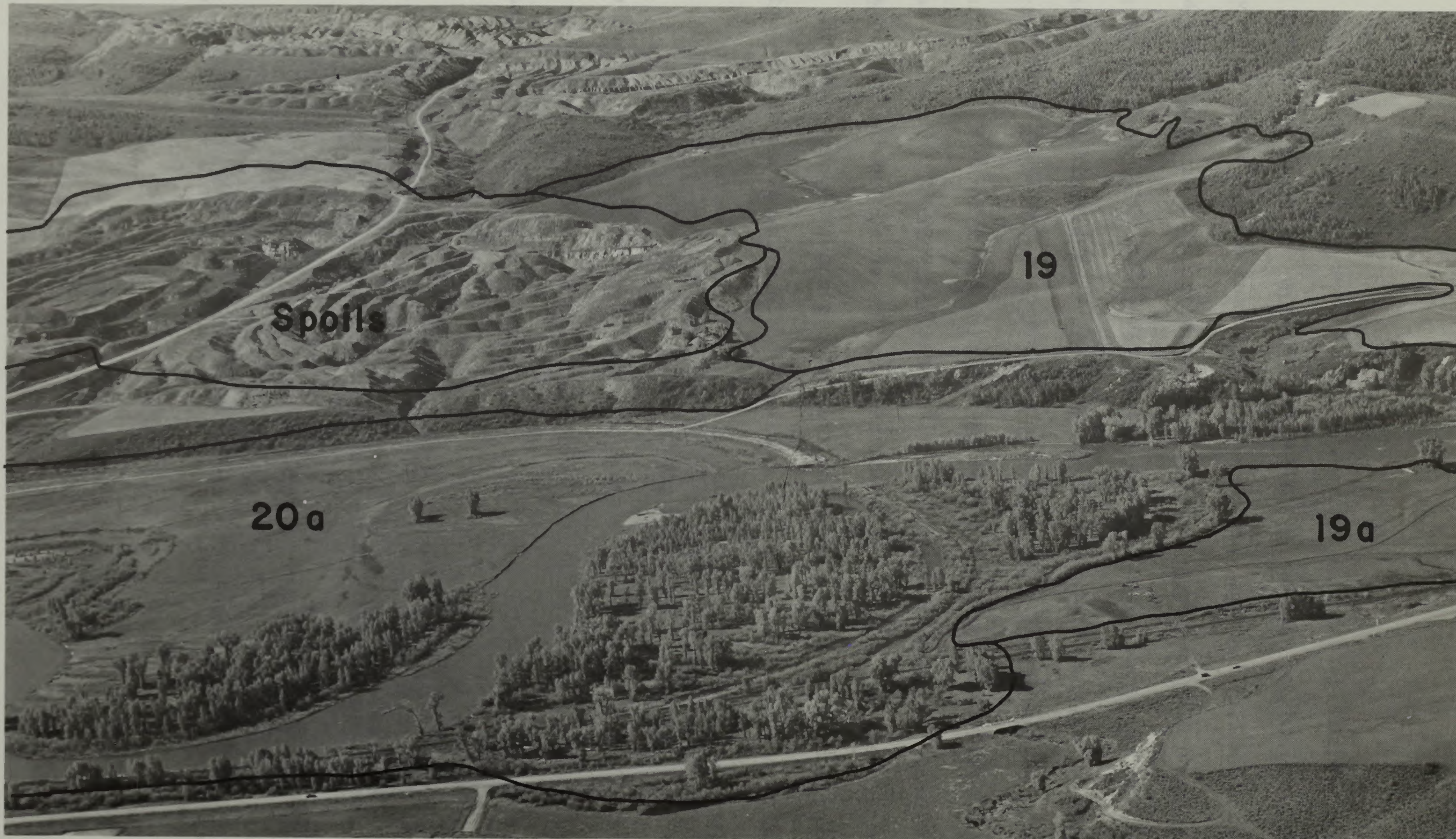


FIGURE RIV- 29

Examples of vegetative types: (20a) riverbottom, (19) summer fallow cropland (19a) hayland and (spoils) the rivers, but is usually too small to be differentially classified from the surrounding vegetative types. Included in this type are: groves of dense deciduous trees, marshlands, open grasslands, and rocky canyons with very little vegetation.

Groves of trees included in this type contain mostly narrowleaf cottonwood (Populus angustifolia), and a small amount of boxelder (Acer negundo).

Dense thickets of willow (Salix spp.), with red-osier dogwood (Cornus stolonifera), and hawthorn (Crataegus spp.) are sometimes associated with cottonwood groves. Ninety-five percent of the trees in these riverbottom communities are cottonwoods. This species grows in two distinct size and age-class groupings, with groups of old large individuals comprising over half of the stand. Hawthorn grows only under older trees, probably because its shade and moisture requirements are not met under the younger cottonwoods. A luxuriant ground cover, primarily consisting of Sandberg blue-grass (Poa secunda), inland saltgrass (Distichlis stricta), western wheatgrass, smooth brome, rushes (Juncus spp.), and sedges is found in this type.

Poorly-drained, wet, marshy areas extend from the river into adjacent flatlands. The major vegetative species of these areas are: rushes, cattails (Typha latifolia), sedges, squirreltail, cheatgrass, June-grass, and needle-and-thread grass.

The open grasslands usually contain inland saltgrass, western wheatgrass, carex, Sandberg bluegrass, and squirreltail. As these areas become more saline-alkaline and the water table becomes deeper, the vegetation often changes to a shrub type with a significant amount of greasewood.

The rocky canyon areas of this type are usually very small, and are seldom differentially classed from surrounding types on vegetative maps. These areas usually contain little vegetation, and often the only perennial plant species is juniper.

Some areas of this type have been converted to croplands, usually for hay production.

The riparian areas of this type provide valuable nesting areas for raptors and other birds; it also provides food and cover for many species of wildlife.

Terrestrial Fauna

Wild fauna

The wildlife of northwestern Colorado form a diverse matrix of mammals, birds, amphibians, reptiles, and insects. Although these classes of wildlife interact to such a degree that their functions within the ecosystem cannot be considered independently, it is worthwhile to examine certain groupings before analyzing the entire biological component of the study region.

Soils, vegetation, climate, and other environmental factors influence the distribution, composition, and population structure of the fauna within any given area; these components must be understood before a meaningful analysis of the fauna can be undertaken.

To analyze the impacts of coal development on on the wildlife of northwestern Colorado, the ecology of each species involved must be understood. Data required for this understanding are food and water requirements, breeding habits, inter- and intra-specific tolerance, seasonal and key habitat components, climatic limitations, predators, population trends and status, and any other factors that exert an influence on the carrying capacity of a given habitat.

While some animals may be tied closely to a particular plant community, vegetative type, or soil association, others range more widely and may be found in a variety of ecosystems depending on the time of year.

Generally ecological information is limited for the majority of the wildlife species found in the study region. More information is available for species of higher recreational and/or economic value to man, than for those species that lack these values. Because of these limitations the majority of the wildlife species covered in this statement will be dealt with from the synecological viewpoint; when adequate information is available the autecological approach will be used.

Mammals (See Appendix D)

Order: Insectivora (shrews & moles). The only members of this order that have presently been identified in the study region are three species of shrews; their distributions are described by Armstrong (1972). At least one of these three species may be found in almost any terrestrial site, from the lower elevations dominated by sagebrush or grasslands, to the mountainous wet meadows surrounded by coniferous forests.

These small burrowing mammals spend the majority of their time underground, occasionally coming out of their holes tc feed. The shrews " . . . feed primarily on insects and other invertebrates" (Martin 1951). Some use is made of mammals larger than themselves, such as mice. It has also been observed that small amounts of plant material are often taken by shrews.

Colorado shrews have been studied and appear to exhibit marked fluctuations in their populations. Few shrews are expected to survive past their first birthday; "Two years is a ripe old age for any of the shrews found in Colorado" (Lecheitner 1969).

Shrews do little damage to human values and are beneficial to the extent that they aid in insect control and, to a lesser degree, in rodent control.

Order: Chiroptera (bats). Ten species of bats have been identified as occurring in the study region (Armstrong 1972). Not much is known about bats' activities in Colorado. Of the these ten species that inhabit this area only three are known to over-winter; it is believed that the others migrate out of the area, "All bats within area covered are nocturnal" (Burt 1952).

All ten of these flying mammals are insect feeders and should generally be considered beneficial to humans.

Bats of one species or another can be found at any elevation and within any vegetative type within the project area. At least two species can normally be found in the arid or semi-arid portions of northwestern Colorado; a greater species diversity can normally be found at the mid-higher elevations, in or over the coniferous forest, or mountain shrub vegetative types.

Few cave dwelling bats are believed to inhabit the area; most roost in trees or rock crevices; some roost in old buildings or under bridges. Bats of northwestern Colorado may be found roosting solitarily, in small clusters or large colonies, depending on the species and time of year.

Order: Lagomorpha (rabbits & hares). The study region provides suitable habitat for five species of lagamorphs; three are classified as small game and are hunted by sportmen and meat hunters. These are the desert cottontail (Sylvilagus audubonii), Nuttalls' cottontail (Sylvilagus nuttallii), and the snowshoe hare (Lepus americanus). The other two species, the black-tailed jackrabbit (Lepus californicus) and white-tailed jackrabbit (Lepus townsendii), are generally considered undesirable by local stockmen because they compete with domestic livestock for available forage; as such they are hunted as a varmint by many local residents. A varmint is defined as an animal which sometimes causes significant damage to public or private property or is a nuisance to human values. Jackrabbits are harvested under the Colorado Division of Wildlife's (Colorado DOW) varmint hunting regulations; harvest data are not presently available for jackrabbits, however local hide dealers indicate that they are getting fewer hides in the past year.

Although quantitative data are not available, estimates from Colorado DOW conservation officers indicate that lagamorph populations were very low during 1974. Lagamorphs, especially the snowshoe hare, are known to exhibit a pattern of population fluctuations. " The snowshoe hare in the more northern portions of its range is quite cyclic in abundance. Although it appears to fluctuate greatly in numbers in Colorado, there is not sufficient evidence to support a 10 year periodicity in its numbers over any considerable area" (Lechleitner 1969).

The principal food items for species of this order are grasses and forbs when available, and tree and shrub bark, twigs, and leaves during the winter. One or more of these five species may be found at any elevation and in any habitat type within the study region.

Order: Rodentia (rodents). This order comprises the most diverse and numerous of all mammalian orders found within the study region; distributions are presented in Armstrong (1972).

Rodents range in size from the tiny deer mouse (*Peromyscus maniculatus*) to the larger white-tailed prairie dog (*Cynomys leucurus*), porcupine (*Erethizon dorsatum*), and beaver (*Castor canadensis*).

A number of niches are filled by rodents within the region. Some are carnivourous or insectivorous, while others are strictly herbivorous; some rodents vary their diet depending on availability of their preferred food.

Rodent habitats are as varied as the number of niches; they may be found in extremely dry sites within the region as well as in aquatic habitats. They inhabit trees and the earth's surface and sub-surface. Some species, such as the beaver, have restricted habitat requirements: they require significant amounts of standing water; while others like the Ord's kangaroo rat (*Dipodomys ordii*) require no free water to fulfill their life functions.

The beaver is an example of a rodent that is prized by humans because of its fur, while such species as the porcupine, prairie dog, and pocket gopher (*Thomomys talpoides*) are scorned because of the damage they do to vegetation, and the competition between them and man's domesticated animals.

Although rodent species have been identified and species lists tabulated for northwestern Colorado, few studies have been published concerning population densities, trends, or competition within this area. The work that has been completed has normally been directed at gathering information concerning beaver or a few species that can cause problems to humans or their life style.

Perhaps the most important aspect of rodent populations within the study region is their function within the food web. Rodents within the subject area act as both primary and secondary consumers, helping to control undesirable insects. The rodents in turn are preyed upon by a variety of higher level consumers such as coyote (*Canis latrans*), fox, and bobcat (*Lynx rufus*), as well as several species of hawks.

Order: Carnivora (dogs, cats, bears, weasels, skunks, etc.) Members of this order represent the higher energy levels within the study region. Fourteen species contained in this order are known or believed to occur within the region; several others are thought to be extinct as far as northwestern Colorado is concerned.

Members of this order are known for their meat eating characteristics. However, some species, such as the black bear (*Ursus americanus*), are significantly omnivorous.

Carnivores range in size from the small mustelids through the medium-sized fox, coyote, (Canis latrans), and bobcat (Lynx rufus) to the larger mountain lion (Felis concolor), and bear. Each species preys upon those animals within its limits to catch and subdue. Rodents and lagomorphs are the most common prey for animals of this order. Deer, pronghorn antelope, and domestic livestock are also taken in varying degrees depending on the time of the year, species preferences, and the age and physical condition of both the predator and the prey.

Carnivores are of significant importance to humans from the economic standpoint. All members of this order are to some degree sought by man for their pelts. In addition mountain lions and bear are classified as big game and have added economic interest to the sport of hunting. Coyote, bobcat, gray fox (Urocyon cinereoargenteus), red fox (Vulpes fulva), and mountain lion also exert an adverse impact on some human values because of the predation on big and small game and on domestic livestock.

Carnivores may be found at any elevation or in any vegetation type within the study region. Some species are limited to specific habitats, such as the river otter (Lutra canadensis) to areas with free flowing water, and black-footed ferret (Mustela nigripes) to prairie dog towns. Other species such as the coyote may occur in a wide spectrum of habitats.

The river otter and the black-footed ferret are on various endangered or threatened species lists, such as the List of Endangered and Threatened Species of Colorado, and the Bureau of Sport Fisheries and Wildlife's 1973 publication, Threatened Wildlife Species of the United States. The status of these two species within the region is not known, but both have been reported in the area in the past five-ten years.

Order: Artiodactyla (deer, elk, pronghorn antelope, etc). Six species of this order have been identified as occurring at least occasionally within the study region. Of these only the mule deer (*Odocoileus hemionus*) is distributed over the entire region. Elk (*Cervus canadensis*) and pronghorn antelope (*Antilocapra americana*) are commonly seen in certain areas of the region but are not found unit-wide (see Appendix D). Bighorn sheep (*Ovis canadensis*) are known to occur only in the Dinosaur National Monument. Moose (*Alces alces*) are believed to be a rare transient through the northern portion of the region. The exact distribution of the white-tail deer (*Odocoileus virginianus*) is not known; some individuals have been sighted, as reported in Ecology Consultants, Inc. Yampa Valley analysis (1972).

Species of this order are herbivores and should be considered primary consumers. Some animals are primarily browsers, such as mule deer, while some others utilize grass and forbs to a greater degree, an example being the elk. However the majority of the subject area provides winter range for species of this order, and browsing is of major importance to all artiodactyles in the region.

Components of the winter range are generally recognized as being the limiting factors for species of this order. Severe winter weather and the quantity and quality of food of the winter range normally limit the carrying capacity of a range.

All species of this order are classified as "big game" by the Colorado DOW. Mule deer, elk, and antelope are hunted extensively within the region. Moose are not hunted, and the white-tail deer harvest is not known because of the small population size expected for this area.

Birds (See Appendix D)

Order: Gaviiformes (loons). The common loon (gavia immer) is the only species of this order known to occur in the study region. This loon species is a rare spring and fall migrant through the area and is not known to nest in this part of North America. Loons feed entirely on animal matter such as insects, fish, and crustaceans. Few birds of this species are found in the region, but when seen, are normally on large open bodies of water such as Steamboat Lake.

Order: Podicipediformes (grebes). Four species of grebes are known to spend some time in the study region. Of these four, two are rare migrants and only one, the eared grebe (Podiceps nigricollis), is considered common.

Two species, the eared grebe and the western grebe (Aechmophorus occidentalis) may possibly breed in northwestern Colorado.

All four are found on large or small open bodies of water. The food supply of the grebe is linked to these bodies of water. "They eat proportionately less fish than loons, filling in the balance of their diet with crayfish, aquatic insects, mollusks and small crustaceans" (Martin 1951).

Order: Ciconiiformes (herons and allies). These birds are long-legged, long-necked, long-billed wading birds; five species of this order are known to use the study region to some degree. Birds of this order feed primarily on fish, insects, frogs, and crustaceans, and to a limited degree on mice and snakes. These waders are seldom found away from lakes, rivers, or small ponds and irrigation ditches. Only one species, the great blue heron (*Ardea herodias*), is known to nest in northwestern Colorado. A great blue heron rookery can be seen a few miles west of Steamboat Springs, Colorado. Other birds in this order possibly nest in the region, but no nesting sites have been identified.

Order: Anseriformes (ducks, geese, mergansers, etc.) This order contains many of the "game birds" that are hunted in the study region; there are 24 species of this order that have been found within the region. One species of swan, three goose species, eight dabbler duck species, nine diving ducks, and three species of mergansers make up the species composition.

All species of this order are found in association with aquatic ecosystems. The diving ducks and swan species are normally found on the larger bodies of water and rivers. The dabblers, geese, and mergansers will also be found in these areas, but in addition will be found on small ponds, irrigation ditches, and small streams.

Waterfowl except the mergansers feed primarily on aquatic vegetation; domestic seed crops are also used when available. Animal matter makes up a small portion of the total diet for most waterfowl; it is taken most often in the spring and consists largely of insects, mollusks, and various small crustaceans.

Mergansers are known as fish duck because of their preference for fish as their staple food. They also take frogs, crustaceans, and insects to a smaller degree. "Plant food is generally negligible" (Martin 1951).

Only nine species of waterfowl are known to nest in this area. All nests will generally be found within a few hundred yards of aquatic ecosystems.

All of these birds are ground nesters; their nests are often found in marsh or immergent aquatic vegetation.

Order: Falconiformes (hawks, eagles, falcons, and vultures). Fifteen species of this order have been identified as occurring within the study region: one vulture, three Accipiter hawk species, one species of Harrier, six species of Buteos, and four Falcon species.

Some of the hawks are winter residents that move north in early spring; they are replaced by summer residents moving up from the south. All of Accipiters and the Harrier are winter residents along with the rough-legged hawk (*Buteo lagopus*), the bald eagle (*Haliaectus leucocephalus*) and the pigeon hawk (*Falco columbarius*). The vulture, (*Cathartes aura*), Swainson's hawk (*Buteo swainsoni*), and the other three falcon species are primarily summer residents. The red-tailed hawk (*Buteo jamaicensis*) and the other three falcon species are primarily summer residents. The red-tailed hawk and the golden eagle are year-long residents, although population fluctuations indicate at least some of the birds move out of the region in response to seasonal changes.

All of the birds in this order are flesh eaters. The vulture feeds primarily on carrion; other species of this order will also feed on carrion to some degree. The accipiters are generally "bird-hawks" in that their principal food source is other birds, primarily from the Order: Passeriformes or Galliformes. The Harrier's principal prey are rodents, with small birds taken to a limited extent.

The Buteos are primarily rodent and lagamorph predators; each species of broad-winged hawk will specialize in taking certain rodents or will operate in specific habitat types. Prey for this subfamily will vary from the smallest rodents to larger mammals; sometimes animals as large as deer or antelope fawns may be taken. Some species, such as the Swainson's hawk, prey upon insects to a significant degree.

The falcons are swift flyers that feed on a wide range of prey, depending on the species of falcon and the time of year. Insects, rodents, waterfowl, small songbirds, and shorebirds are the staple diet for birds of this family.

Six species of this order are known to nest in northwestern Colorado; several others are probable nesters. The goshawk (*Accipiter gentilis*), Cooper's hawk (*Accipiter cooperii*), red-tailed hawk, American kestrel (*Falco sparverius*), golden eagle (*Aquila chrysaetos*), and turkey vulture (*Cathartes aura*) are known nesters. The Swainson's hawk, marsh hawk (*Circus cyaneus*), and prairie falcon (*Falco mexicanus*) are examples of species that possibly nest in the region.

Order: Galliformes (grouse, chicken, pheasant, etc). Within the study region, seven species of this order have been known to occur or have occurred in the recent past; three of the species are exotic, having been introduced into the area by man in recent years. All birds of this order are classified by the DOW as upland gamebirds and are hunted within this part of the State.

Each species in this order has a characteristic set of habitat preferences; however some overlap does occur in distributional ranges because of overlap of one or more preferred habitat components. At least one member of this order can be found in almost any portion of the region.

Sage grouse (Centrocercus urophasianus) is the most common species of this order to be found in the lower elevational sagebrush vegetative type. The feeding habits of this species are made up of sagebrush with small amounts of other vegetation and insects taken. "Nearly three-fourths of this bird's food consists of the leaves and flower clusters of different species of sagebrush" (Martin 1951).

The mating habits of this species are important in that they return to the same traditional "strutting grounds" each year to carry out their mating rituals. Rogers (1964), Girard (1937,) and Patterson (1952) suggest that a disruption of sage grouse traditional strutting grounds cause the birds to move from the area, and either move to another established strutting ground or establish small, displaced strutting grounds; furthermore they infer that the disruption may affect overall breeding performances the following year.

Blue grouse (Dendragapus obscurus) remain in conifer stands during the winter; these areas provide both winter food and cover. Nesting birds have occasionally been sighted in the pinyon-juniper vegetative types. Habital preferences are also indicated for aspen stands with a good understory comprising a variety of shrub and grass species. The Blue Grouse in Colorado by Glen E. Rogers gives a good account of this grouse and its habitat preference.

Sharptail grouse (Pedioecetes phasianellus) occurrence within the subject area corresponds closely with the grassland vegetation. "Sharptail grouse in Colorado inhabit areas where grass is dominant or subdominant, with light interspersion of shrubs, wheat and trees" (Rogers 1969). The primary food items for this species are made up of a variety of plant species with a few insects occasionally taken. "The leaves, seeds and buds of individual plants may all be eaten, or the birds may use any single part" (Rogers 1969). Cover is of major importance for this species in northwestern Colorado. "Rather than lack of cover, vegetation that is too dense appears to be a major problem in many areas of Colorado" (Rogers 1969).

The ruffed grouse (Bonasa umbellus) is known to occur in the study region only in the Dinosaur National Monument and the area to the west.

The three exotics released into the area are the chukar (Alectoris chukar), ring-necked pheasant (Phasianus colchicus), and the gray partridge (Perdix perdix). The pheasants have become established in the area and so have some of the released chukar populations; the status of the partridge is not certain, but few have been seen since their release.

Order: Gruiformes (cranes, rails, coots, etc.). One crane, two rails and a coot make up the species diversity for this order.

The greater sandhill crane (Grus canadensis) has been put on the State of Colorado's "endangered species list". This crane arrives in the study region around March each year (see Appendix D). Shortly after their arrival the cranes begin their mating ritual, known as dancing. When the snow in the surrounding nesting site has melted sufficiently, usually by mid-April, the congregated flock begins to break up and mated pairs move to selected nesting areas. The birds found in the study region are the only significant nesting population known for Colorado.

The sandhills are primarily vegetarians although some animal matter is taken, such as insects, frogs, snails, fish, and small rodents. A wide range of plant species are taken, including both marsh plants and domesticated plants, such as wheat.

Other birds of this order are generally summer migrants or residents of the region. All species are associated with marshy areas, usually made up of thick stands of immergent aquatic vegetation.

Order: Charadriiformes (gulls, phalaropes, sandpipers, etc.) This is one of the most diverse orders of birds found in the study region. Within this order there are 16 species of what are commonly referred to as "shorebirds", three species of gulls, and two species of terns for a total of 21 species.

The shorebirds are primarily waders and except for the phalaropes, do little swimming. These species feed most intensively on animal matter, mainly worms, insects, small fish, snails, and crustaceans.

Several of the shorebirds are known to nest within the region, and several more are expected to nest here, although nests have not been located. Although shorebirds usually maintain a close association with aquatic sites, some of these birds may nest great distances from water.

Gulls and terns are known to migrate through northwestern Colorado. These birds, like most other charadriiformes, feed primarily on animal matter in the form of grasshoppers, crickets, ants, beetles, and some fish and crustaceans. None of these birds are known to nest in the study region.

Order: Columbifromes (doves and pigeons). Three species of this order are found in the study region on a seasonal basis. The rock dove (Columba livia) mourning dove (Zenaida macroura), and the band-tailed pigeon (Columba fasciata) are summer residents.

The mourning dove is the only species that has widespread distribution over the region. The band-tailed pigeons are generally restricted to the high, mountainous, coniferous forested areas. The rock dove is generally recognized as the common domestic pigeon; they are known to inhabit the urbanized areas of the region.

Mourning doves may be found in any portion of the region from April to October; concentrations of this species are often found in weedy fields or the riparian vegetation type, especially if a domestic seed crop is found nearby. Weed seeds make up the staple of the mourning dove's diet. Some animal matter is taken, especially in the spring when the breeding and brood-rearing cycle is at its peak. These birds are classified as a game species in Colorado and are hunted; however many doves have moved out of this area to the south by the beginning of hunting season.

Order: Cuculiformes (cuckoos and allies). Only one species of this order is known to occur within the study region. The yellow-billed cuckoo (Coccyzus americanus) is an uncommon resident of the region; it is most often seen in the pinyon-juniper vegetation type and also in the willows and cotton-woods along rivers and streams. The cuckoos are entirely insectivorous. "About two-thirds of the diet consists of caterpillars" (Martin 1951). No nesting by this species has been recorded for the subject area.

Order: Strigiformes (owls). Seven species of owls have been sighted within the study region; only two are known to be relatively common. Species of this order may be found from the semi-desert areas around Rangely to the high mountain forest.

Owls are birds of prey and feed entirely on meat; their prey species are related to the size of the owl. The smaller owls feed on insects and small rodents, such as mice. The larger owls feed on such prey as rabbits, rats, squirrels, gamebirds, and other large to medium birds.

Only two species are known to nest in the region, the great horned owl (*Bubo virginianus*) and the burrowing owl (*Speotyto cunicularia*). The great horned owls are most often found in cottonwood, riparian stands, or other broadleaf vegetation types. The burrowing owl is a bird of the lowlands, desert, or semi-desert areas, and is a ground nester. They most often use prairie dog holes as a nesting site.

Order: Caprimulgiformes (night hawks and poor-wills). Only two species of this order are found within the study region, the night hawk (*Chordeiles minor*) and the poor-will (*Phalaenoptiles nuttallii*). Both are common summer residents and are feed primarily on flying insects that are picked out of the air while still in flight. Flying ants, moths, grasshoppers, mosquitoes, and beetles are commonly eaten. Both species are active at night, but the common night-hawk is also often active during the day.

The poor-will is most common in the mountain shrub and pinyon-juniper vegetation types; the common nighthawk seems to prefer the areas with lower-growing vegetation and level topography. Both species nest in northwestern Colorado.

Order: Apodiformes (hummingbirds and swifts). There are four species of this order that are known to occur in the study region--one species of swift and three hummingbird species.

The swift (Aeronautes saxatalis) is a summer resident and a known nester in the subject area; nests are located on steep cliffs. This bird is strictly insectivorous, feeding primarily on flying insects which it catches in mid-air.

Like the swift, the three species of hummingbirds are also summer residents. These birds may be found in mountain meadows, along rivers and streams, or in semi-arid regions near stock tanks or other sources of water. The exact diet of these small birds is not known. Insects are taken and the nectar of some flowers is also taken, although what portion of the hummingbird's diet is made up of nectar is not certain. All three hummers nest within the region.

Order: Coraciiformes (kingfishers). The belted kingfisher (Megaceryle alcyon) is the only species of this order that is known to occur in the region. The kingfisher is a summer resident that inhabits the areas along rivers, lakes, and small ponds; they feed on fish, crustaceans, frogs, and a few lizards. The belted kingfisher is known to nest within the statement area.

Order: Piciformes (woodpeckers and sapsuckers). Woodpeckers and sapsuckers make up this order; there are seven species known to occur within the study region.

Wooded streams and aspen groves are the most common areas used by birds of this order. Occasionally they may be found in coniferous forest but the deciduous woods are their preferred habitat. The common flicker (Colaptes auratus) may be found in semi-arid regions in the vicinity of cottonwood-ringed ponds or stock tanks.

Species of this order are generally omnivorous. The most common animal matter taken is in the form of ants and aphids; other insects, spiders, and a variety of larvae are also taken. The wood and sap of a variety of trees found in the region serve as plant food.

The common flicker is the only bird of this order that is known to nest within the study region; however other species probably also nest here.

Order: Passeriformes (sparrows, jays, wrens, etc.). This order is a complex combination of families, each exhibiting different habitat preferences. This order is represented by 107 species in the study region; they include such groupings of birds as the fly catchers, swallows, jays, crows, blackbirds, wrens, shrikes, vireos, warblers, finches, and sparrows.

Some species within this order are insectivorous; others are herbivorous and still others are omnivorous; all have feet that are well adapted for perching.

The flycatchers are primarily insectivores, often catching their prey in mid-air. They may be found in a variety of vegetation types from the dense coniferous forests to the scattered woodlands and riparian areas; most of these species are summer residents and some nest within the region.

Swallows are common summer residents and can often be seen in great flocks, flying over ponds or meadows, catching flying insects or scooping them off the surface of the open water; several species probably nest in the area.

Jays are commonly seen in the oak-mountain shrub vegetation types and up through the pinyon-juniper into the pine and fir forests. Magpies, crows, and ravens are also members of this family. Birds of this family feed on a wide variety of food stuffs ranging from seeds, acorns, grains, fruits, and eggs to insects and carrion; most of these species nest within the subject area.

Four species of wrens occur in the region as summer residents. Preferred habitat for wrens extends from the dry rocky areas into the pinyon-juniper and pine forests. Their primary food is insects and spiders, while some plant material may be taken.

Shrikes are found in northwestern Colorado during the summer; they are generally solitary. These birds are highly predatory, feeding on insects, small rodents, birds, and to a lesser degree, lizards. Their preferred habitat consists of "semi-open or open country with lookout posts" (Peterson 1961).

Vireos and warblers are birds of the woodlands and brush. Greatest numbers and species diversity occur along rivers and streams in the riparian vegetation. These birds are primarily insect feeders: they normally catch their prey in the trees and occasionally on the ground within the wooded areas; some of these birds nest within the region.

Blackbirds, cowbirds, and grackles are found within the area during the summer. Some species are tied closely with marshes or cattail ringed ponds; other species are found in grassland or meadow associations. These birds feed on a variety of seeds, insects, and fruits; most of the species that make up this order nest within the study region.

Finches occur within the area in a wide variety of habitats from the coniferous forests to the brushlands, and even into the urban population centers. Finches are primarily seed eaters with some buds, fruits, and a small amount of animal matter taken in the form of insects.

Sparrows are most common in the grasslands and lower elevational shrub lands. Their food consists of a variety of seeds, and when available, insects are taken, sometimes in fairly large numbers. Thirteen species of sparrows are found in the subject area, and several of these probably nest there.

Amphibians (See Appendix D)

Order: Caudata (salamanders). Only one species of this order is found within the region, the tiger salamander (*Ambystoma tigrinum*). This species is rarely seen except during the brief breeding season. During the majority of the year these salamanders may be found under logs in the dampest portions of the coniferous forest, or in ground squirrel, gopher, or badger burrows at the lower elevations. Distribution and food habits information for this species is limited.

Order: Salienta (toads and frogs). Four species of this order are found within the study region: two toad species and two species of frogs.

The toads are known to inhabit a wide variety of habitats from the semi-arid streams and ponds up into the mountain meadows. They appear to be most common along the rivers and streams that have a good understory beneath the riparian trees; these two species appear to favor sandy soils.

Breeding takes place "... in quiet water of streams, marshes, lakes, fresh water pools and irrigation ditches ..." (Stebbins 1966).

The two species of frogs occur in grassy pools, cattail marshes, along rivers and streams, and any other place where there is a permanent water supply.

Adequate distribution and food supply data are lacking for these species within the subject area.

Reptiles (See Appendix D).

Order: Squamata (lizards and snakes). This order includes both lizard and snake species; there are seven species of lizards and six species of snakes known to occur within the region. Only one of these 13 species is venomous, the western rattlesnake (Crotalus viridis).

Species of this order may be found in a variety of habitat types within the region. However the greatest species diversity is expected to occur in the lower mountains of the southwestern portion of the subject area.

Species of this order feed on animal matter, the primary food sources being insects, small rodents, and other species within this order. Additional data on distribution and food habits are not available at the present time.

Threatened or endangered fauna

Four "endangered" wildlife species are known or believed to inhabit the study region; these are classified as "endangered" by the State of Colorado. One species, the American peregrine falcon (Falco peregrinus), is also on the U.S. Department of the Interior's list of endangered fauna.

River otter (Lutra canadensis). The range of the river otter, as described by D.M. Armstrong (1972), indicates that this species is found in Moffat County along Little Snake River, and Yampa River in Yampa Canyon. In Rio Blanco County, there is a record of a specimen in the White River Valley. These are past records and there is some doubt as to the continued existence of this species in the region. "I doubt that the otter now exists in Colorado, save perhaps as occasional wandering individuals" (Armstrong 1972).

River otters are sociable animals and often two or more otters are seen together. They are normally found along large rivers and lakes and are seldom found far from water. River otters' principal food is made up of a variety of animal matter; fish, invertebrates, amphibians, reptiles, birds, and small mammals may be taken, with fish making up a major portion of the diet.

Black-footed ferret (Mustela nigripes). Several recordings of black-footed ferret have been made in Moffat and Rio Blanco Counties in the past years. The most recent reported sighting was in Rio Blanco County along the Utah line (see Map Foldout 18, Appendix B).

Black-footed ferrets are found in prairie dog towns, their primary source of food. "Most authors are in agreement the M. nigripes never has been common in Colorado" (Armstrong 1972).

Greater sandhill crane (Grus canadensis). See "Birds" section of this narrative. For additional information see Diane J. Blake's report (1974) on file with the DOW.

American peregrine falcon (Falco peregrinus). Peregrine falcons are occasionally sighted within the study region, but not on a regular basis. Although there is the possibility that this species nests in northwestern Colorado, no nests have been located within the study region and only migration and hunting activities have been noted.

Invertebrates

Many different species of invertebrates are known to inhabit the study region; most of these species are active for a relatively short period each year during spring and summer months.

Very little professional work has been completed in species classification of invertebrates in northwestern Colorado. However based on the limited information available some generalities and gross taxonomic groupings can be made.

Species diversity includes species of millipeds, centipeds, a variety of spider, ticks, and mites. Ticks that transmit Rocky Mountain Spotted Fever and Colorado Spotted Fever occur within the region.

Dragonflies, several species of grasshoppers, crickets, ants, beetles, true bugs, moths, flies, bees, earwigs, and butterflies have been seen within the statement area; however reliable taxonomic identification have not been completed on these species.

Domestic fauna

Livestock have grazed in the study region to some degree since the settling of the Yampa Valley by the white man. The number of animals and class of livestock in the area in any one year is dependent on market and/or forage conditions. Many livestock operations have been shifting from sheep to cattle in recent years for economic reasons.

The major classes of livestock that utilize this region are cattle (Bos sp.) and domestic sheep (Ovis sp.); there are approximately 112,500 cattle and 200,000 sheep within the area. Of these about 38,700 cattle and 200,000 sheep use national resource lands during some portion of the year.

Some horses (Equus sp.), domestic as well as wild and free-roaming, are also found within the region. Population estimates made in the spring of 1975 indicate a total of about 500 horses. Map Foldout 16 in Appendix B indicates the major classes of livestock and general seasons of use in northwestern Colorado.

Most operations rely on native range to winter livestock. Imported protein and vitamins are used to supplement the locally grown hay and native forage. In many cases, hay is saved and used only during critical winter periods as prices in the market reach premium levels; winter forage is therefore a critical limiting factor to the livestock within the study area.

Terrestrial faunal ecosystem

In previous sections the terrestrial fauna was reviewed in general terms and by specific taxonomic segments. Although it is important to understand the function of each of these faunal segments within the study region, the most meaningful use of this information is how each taxanomic group of wild animals interrelate with each other and with the surrounding non-faunal elements of the ecosystem.

The ecosystem approach emphasizes the obligatory relationship and interdependence of each faunal segment on all other segments of the system. All faunal segments of the study area are made up of the generalized category of heterotrophic organism known as consumers. Animals within this category may be further broken down into units and classified as herbivorous, omnivorous, or carnivorous species. All faunal components of the subject area are dependent, either directly or indirectly on the producers of the area, the plant life. Table RIV-19 will help explain this dependency. This biomass pyramid illustrates the loss of energy from one trophic level to the next. The higher the trophic level, the less the total loss from the next lower level.

The farther away a species niche is located from the direct utilization of the producer level organisms, the fewer numbers or less biomass can be produced and sustained within a given area. This is explained by the "second law of thermodynamics", which may be stated that energy (the ability to do work), in this case the ability to produce or maintain a given biomass, is never transferred at 100% efficiency.

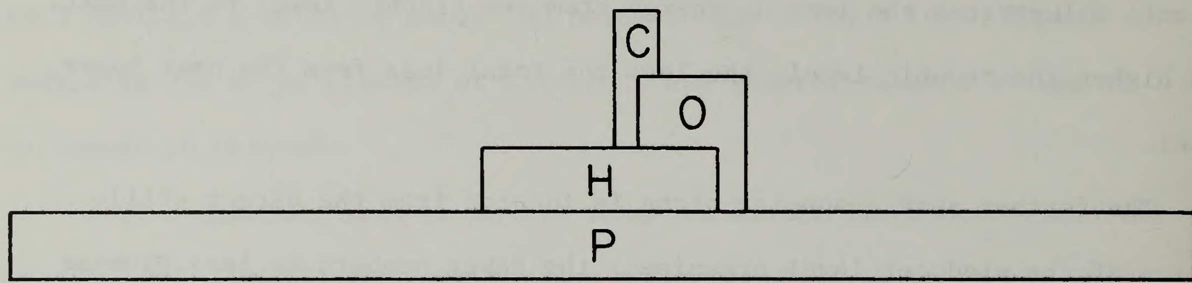
The producers maintain the bottom trophic or energy level within the region, getting their productive energy directly from the sun. The next trophic level is occupied by the herbivores. Above the herbivores come the carnivore levels.

The producers are a combination of all the vegetation that provides a source of food to any faunal species. As indicated in Table RIV-30, a given animal species may occupy one or more trophic levels. The level the species maintain may depend on the time of year, climatic conditions, or availability of preferred foods.

Closely tied with the pyramid illustrated in Table RIV-19 is a matrix of what is commonly referred to as the "food web", Table RIV-20. The fewer the number of energy transfers needed to meet an animal's dietary requirements, the greater the available energy which can be converted into biomass.

TABLE RIV-19

Biomass Pyramid



(H) Principal Herbivores found within the region	(O) Principal Omnivores found within the region	(C) Principal Carnivors found within the region
Beaver	Black bear	Mountain lion
Porcupine	Raccoon	Shrews
Lagomorphs	Skunks	Bats
White-tailed antelope ground squirrel	Fox	Mustelids
Northern pocket gopher	Coyote	Northern grasshopper mouse
Kangaroo rat	Chipmunks	Loon
Wood rat	Tree swallow	Nighthawk
Voles (meadow mouse)	Vireos	Shrikes
Mule deer	Warblers	Hawks & Falcons
Elk	Blackbirds	Cuckoo
Pronghorn	Woodpeckers	Owls
Bighorn sheep	Hummingbirds	Swallows (except tree swallow)
Mourning dove	Crows & Ravens	Insects
Insects	Jays	
	Magpie	
	Waterfowl	
	Wrens	
	Insects	

(P) For information on producers see vegetation section of this statement.

TABLE RIV-20

Food Web Matrix

Consumed \ Consumers	Producers	Mountain Lion	Shrew	Shrike	Hawks & Falcon	Pronghorn	Mule deer	Pocket gopher	Insects	Kangaroo rats	Voles	Waterfowl	Coyote	Skunk	Warblers
Producers	0	1	1	1	0	3	3	3	3	3	3	3	2	2	3
Mountain lion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shrew	0	0	1	0	1	0	0	0	0	0	0	0	2	2	0
Shrike	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0
Hawks and falcons	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pronghorn	0	1	0	0	2	0	0	0	0	0	0	0	2	0	0
Mule deer	0	3	0	0	1	0	0	0	0	0	0	0	1	0	0
Pocket gopher	0	1	0	0	1	0	0	0	0	0	0	0	2	3	0
Insects	0	0	3	3	3	0	0	2	3	3	3	1	2	3	2
Kangaroo rats	0	1	1	2	3	0	0	0	0	0	0	0	2	2	0
Voles	0	1	3	2	3	0	0	0	0	0	1	0	2	2	0
Waterfowl	0	0	0	0	3	0	0	0	0	0	0	0	1	1	0
Coyote	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skunk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Warblers	0	0	0	1	2	0	0	0	0	0	0	0	0	1	0

0 - not used in diet
1 - makes up less than 10% of yearlong diet
2 - significant portion of the yearlong diet
3 - major importance in yearlong diet

Note: This matrix is presented as an example of a small portion of the food web of northwestern Colorado. Only 14 species have been considered here.

Therefore northwestern Colorado can produce more herbivore biomass than omnivore or carnivore biomass. As a result the combination of carnivore biomass can never approach that of the herbivores. This in part explains the relative low numbers of such carnivores as mountain lions within the subject region.

There are many other explanations for limited numbers of several faunal species in this area; Liebig's[1] "law" of the minimum can be used to illustrate some of the many factors that tend to limit animal numbers or species diversification. Liebig's "law" can be interpreted as saying whichever of an animal's needs reaches that animal's minimum requirement to continue existing, will serve as the limiting factor for that individual; this is also true for entire populations or biomes.

Many birds and some mammals, such as bats, migrate out of this region with the coming of winter because their tolerance to cold weather would be surpassed if they remained; this is an example of Liebig's "law".

Another example of this "law" is in the field of interspecific and intraspecific tolerances. Many species of wildlife in the subject area show a definite aversion to human activity, yearlong or seasonally; this would be an example of a low interspecific tolerance. Peregrine falcons will abandon their nests if disturbed during the nesting period. Other species such as some of the finches and doves will tolerate the close proximity of human activity; this would indicate high interspecific tolerance toward humans and thus would not limit these species in an urbanized area.

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[1]Liebig, Justin. A pioneer in the study of the effects of various factors on the growth of plants.

Intraspecific tolerance can also constitute a limiting factor. Many species establish territories that they may mark and defend against members of their own species. Some of these territories may be established to protect food sources; more commonly they are established for breeding purposes and defended only during breeding periods. It is believed that mountain lions establish and mark hunting territories. Sandhill cranes disperse during their nesting period and waterfowl will defend their breeding territory, as do many songbirds. Some species, such as many snakes, den together for the winter and then disperse during the spring and summer.

Many species appear to share the same niches, but indicate a high interspecific tolerance towards one another, such as several species of warblers, and the species of amphibians that occur in the study region. This can normally be explained by the fact that although two or more species occupy the same macrohabitat, their preferences are different. No two species can occupy the same niche, and the only time that competition exists is when niches overlap. Therefore competition does not exist between mule deer, mountain lions, river otter, or waterfowl. But competition will exist between mule deer, several species of grasshoppers, herbivorous rodents, and birds. The more species that share the same macrohabitat requirements the greater the chance of competition.

Species may increase or decrease but rarely remain static as a result of competition. Human poisoning of prairie dogs because of their competition with man's domestic livestock has resulted in a decline of not only the prairie dog, but also the black-footed ferret.

Competition may exist for food, water, cover, or living space. Any action will alter the ecological balance to favor one species at the detriment of another: disturbances of sagebrush stands may provide suitable sharptail grouse habitat at the expense of the sage grouse; disturbances of a pinyon-juniper stand may favor mule deer at the expense of pinyon jays and bushtits.

Aquatic Biology

Flora

Appendix D provides a list of the relative abundance of particular types of aquatic flora found at selected sites in the study region as of a specific sampling date. These data were collected during the coal mine drainage field survey conducted by the USGS (Wentz 1974) from April 19-July 19, 1972. Stream sites surveyed were selected from information regarding locations of coal deposits and mines (Landis 1959; Colorado Department of Natural Resources 1971).

The plants which are found in an aquatic community in the study region include various types of algae and rooted aquatics. Algae are found in natural waters in an impressive array of shapes, sizes, biochemical characteristics, and ecological roles (Reid 1961). Green algae, blue-green algae, and diatoms are the most common algal forms found in fresh water. Algae and plant-like protists constitute the major portions of the free-floating aquatic pastures in the natural waters of the earth's surface. Rooted aquatics include vascular plants and bryophytes (i.e., plants without the conducting tissues, xylem and phloem), which may be found in an aquatic community. Rooted aquatic plants may be defined as those whose seeds germinate in either the water phase or substrate of a body of water, and which must spend part of their life cycle in water. This ecological grouping includes plants which grow completely submerged as well as a variety of emergent types (Reid 1961).

According to the information shown in Appendix D the amount of aquatic flora in sampled streams is not overly abundant. Rooted aquatics and blue-green algae were seldom found, while green algae were present in over half of the sampled streams. It would appear that diatoms provide the bulk of photosynthetic activity in sampled streams as they are frequently listed as present-common. More data collection is needed before a detailed discussion of aquatic flora in the study region can be provided.

Fauna

The aquatic fauna or animal members of the aquatic communities in the study region will be discussed under four headings: fishes, endangered species, macroinvertebrates (insects), and microinvertebrates (zooplankton).

Fishes

The highest quality fisheries habitat in the study region consists of "blue-ribbon" trout fisheries. They are primarily concentrated on Routt and White River National Forest lands, north and east of Steamboat Springs and east of Meeker. Examples of these prime trout waters in the analysis area would be the North Fork of the White River, the Elk River, and the East Fork of the Williams Fork River. In addition there are numerous high mountain lakes on national forest land which provide unexcelled habitat for a diversity of trout species, including golden, rainbow, brown, cutthroat, lake, and brook trout. Kokanee salmon and grayling have also been introduced into some of these mountain lakes. The DOW supplements natural reproduction in some of these lakes by stocking.

In general major stream fisheries in the western segment of the study region are dominated by such warm-water species as catfish, carp, sunfish, bass, crappie, and pike. The White and Yampa Rivers characteristically change from warm water to cold water fisheries in an eastward direction. For instance, the fish population of the Yampa River changes from 30 percent chubs, 20 percent carp, 15 percent squawfish, ten percent channel catfish, ten percent suckers, ten percent rainbow trout, and five percent brown trout at its confluence with the Green River in Moffat County, to 80 percent rainbow trout, ten percent brown trout, five percent whitefish, and five percent suckers in Routt County south of Steamboat Springs.

The lake fisheries in the analysis area, excluding those on national forest land, generally contain a combination of warm and cold water species. For example, Ralph White Reservoir on Fortification Creek north of Craig contains green sunfish, bullhead catfish, channel catfish, rainbow trout, and northern pike.

An evaluation of the primary fisheries in the study region is presented in Table RIV-21 (stream fisheries) and Table RIV-22 (lake fisheries). The exact location of each of these fisheries is shown on Map Foldout 10 in Appendix B. A listing of the fish species with their scientific names and life history characteristics is presented in Appendix D.

Endangered species

Portions of White and Yampa Rivers, from Craig to Green River, provide the last remaining suitable habitat for four nationally endangered fish species: Colorado squawfish (Ptychoceilus lucius), bonytail chub (Gila elegans), humpback chub (Gila cyphia), and humpback sucker (Xyranuchers

TABLE RIV-21

Characteristics Pertinent to the Evaluation of Stream Fisheries in the Study Region

Stream Name	Drainage System Name	Value Rating*	Fish Species Present (Percent of Total Population)	Mean Stream Flow (cfs)	Mean Stream Width (Feet)	Populations Being Maintained By Stocking (Species)	Populations Being Maintained By Natural Reproduction (Species)	Overall Population Conditions
Routt County								
Bear C	Hot Springs-Elk	75	B(100)	2.0	3	No	Abundant (B)	Overpopulated (B)
Beaver C	SF Williams F	84	B(50), C(50)	1.5	4	Rarely	Some	Stable
Beaver C	Willow C	80	B(60), C(20), R(20)	10.0	5	Occasionally	Abundant (B)	Stable
Deep C	Elk R	55	B(10), C(10), R(70), W(10)	4.0	7	Rarely	Some	Stable
Egeria C	Rock C	72	B(1t), C(15), R(70)	E8.0	E4	Regularly	Some	Underpopulated
Elk R	Yampa R	73	B(5), Br(5), C(5), R(50) W(15), Rough(20)	500.0	50	Regularly	Some	Stable
Elkhead C	Yampa R	70	B(30), C(40), R(30)	NA	E11	Regularly	Some	Stable
Finger Rock C	Yampa R	73	B(50), Br(50)	E1.0	E2	No No	Some	Stable
Fish C	Trout C	67	B(50), C(50)	3.0	6	No	Some	Stable
Hunt C	Yampa R	57	R(90), S(10)	E2.0	E3	Rarely	Some (s)	Underpopulated
Middle C	Trout C	50	B(50), R(50)	E2.0	E3	Occasionally	Some	Stable
Morrison C	Yampa R	40	B(100)	E2.0	E3	Regularly	Abundant (B)	Overpopulated (B)
Oak C	Yampa R	40	R(100)	2.0	4	Regularly	No	Stable
Second C	EF Williams F	50	R(100)	0.5	2	No	Some	Stable
Slater C	Little Snake R	85	B(30), Br(5), C(5), R(60)	20.0	15	Regularly	Some (B, Br, C)	Stable
Little Snake R	Yampa R	88	B(5), Br(10), C(5), R(80)	150.0	70	Regularly	Some	Stable
MF Snake R	Yampa R	83	B(30), R(70)	20.0	20	Regularly	Some (B)	Stable
SF Snake R	Yampa R	77	B(30), R(70)	8.0	10	No	Some	Stable
Soda C	Yampa R	48	B(100)	2.0	3	Regularly	Abundant (B)	Overpopulated (B)
Spring C	Yampa R	52	B(70), R(30)	0.5	3	Regularly	Abundant (B)	Overpopulated (B)
Tow C	Yampa R	73	C(100)	7.0	10	Occasionally	Some	Stable
Walton C	Yampa R	47	B(99), R(T)	E4.0	E5	Regularly	Abundant (B)	Overpopulated (B)
Williams Fork R	Yampa R	93	Br(10, C(10, R(80)	30.0	30	Regularly	Some (Br)	Stable
SF Williams F R	Yampa R	80	C(40), R(60)	E5.0	E10	Occasionally	Some	Stable
Willow C	Elk R	83	B(20), C(10), R(60), W(10)	E20.0	10	Regularly	Some	Stable
Yampa R	Service C to Bear R	40	Br(5), R(80), S(10), W(5)	NA	E15	Regularly	Abundant (S)	Overpopulated (S)

SOURCE: Colorado Division of Wildlife, 1972.

Abbreviations Used - NA, (Data) Not available; E, Estimated
STREAM NAME - DRAINAGE SYSTEM: C, Creek; R, River; F, Fork; S, South; H, North; E, East
FISH SPECIES PRESENT: B, Brook Trout; C, Cutthroat Trout; R, Rainbow Trout; Br, Brown Trout; S, Suckers; W, Whitefish; Rough, Rough Fish; Cb, Chub; Ca, Carp; CC, Channel Catfish; Sq, Squawfish; Sc, Sculpin
*VALUE RATING SYSTEM: 60 and below, Poor; 61-74, Fair; 75-85, Good; 86 and above, Excellent

TABLE RIV-21 (cont.)

Characteristics Pertinent to the Evaluation of Stream Fisheries in the Study Region

Stream Name	Drainage System Name	Value Rating*	Fish Species Present (Percent of Total Population)	Mean Stream Flow (cfs)	Mean Stream Width (Feet)	Populations Being Maintained By Stocking (Species)	Populations Being Maintained By Natural Reproduction (Species)	Overall Population Conditions
Moffat County								
Little Bear C	Fortification C	100	B(30), C(40), R(30	1.5	2	Regularly	Some (c)	Underpopulated
Beaver C	Slater C	68	B(70), C(30)	1.5	3	Rarely	Abundant (B)	Overpopulated (B)
Deer C	Morapos C	88	B(30), C(70)	2.0	4	Occasionally	Some	Stable
Fortification C	Yampa River	95	B(40), C(40), R(20)	1.5	4	Occasionally	Some (B,C,R)	Overpopulated (B)
Green R	Colorado R	60	R(70), Br(5), Ca(10), Sq(T), S(10)					
Little Snake R 1	Yampa R			3,000	200	Regularly	Some	Stable
Little Snake	Wyoming to Powder Wash	85	B(2.5) Br(5), C(2.5), R(90)	150.0	70	Regularly	Some	Stable
Talamantes C	Vermillion C	38	Ca(80), Cc(120), Sq(T), S(T)	NA	E30	No	Abundant	Overpopulated
Yampa R	Lily Park to Maybelle	78	B(80), C(10), R(10)	1.0	2	Occasionally	Some	Stable
Yampa R	Green R to Maybelle	80	Cb(30), Cc(45), Br(5) R(5), Sq(15)	700.0	100	No	Some	Stable
Yampa R	Lily Park to Maybelle	63	W(10), Cc(5), (Br(5), R(10) Rough (70)	NA	E30	Regularly	Abundant (Rough)	Overpopulated (Rough)
Rio Blanco County								
Coal C	Little Beaver C	80	B(90), R(10)	8.0	6	No	Some	Underpopulated
Fish C	Yampa R	38	B(70), R(30)	0.5	5	Occasionally	Some	Stable
Morapos C	Williams F R	67	C(50), R(50)	3.0	6	Occasionally	Some	Stable
Pagoda C	S F Williams R	100	C(100)	3.0	6	No	Some	Stable
Trout C	Yampa R	43	B(80), C(10), R(10)	5.0	10	Regularly	Some	Stable
White R	Utah to Strawberry C	60	Br(10, Ca(10), Cc(30), Sc(10), Cb(10), S(10), R(10), W(10)	500.0	70	Rarely	Abundant (Cc, S,W)	Stable
N F White R	White R.	92	B(20), C(20), Br(15), R(25), W(15), S(5)	300.0	40	Regularly	Some	Stable
E F Williams F R	Yampa R	100	C(90), R(5), W(5)	14.0	20	Occasionally	Some	Stable

SOURCE: Colorado Division of Wildlife, 1972.

Abbreviations Used: NA, (Data) Not Available; E, Estimated

STREAM NAME - DRAINAGE SYSTEM: C, Creek; R, River; F, Fork; S, South; N, North; E, East

FISH SPECIES PRESENT: B, Brook Trout; C, Cutthroat Trout; R, Rainbow Trout; Br, Brown Trout; S, Suckers; W, Whitefish Rough, Rough fish; Cb, Chub; Ca, Carp; CC, Channel Catfish; Sq, Squawfish; Sc, Sculpin

*VALUE RATING SYSTEM: 60 and below, Poor; 61-74, Fair; 75-85, Good; 86 and above, excellent

TABLE RIV-22

Characteristics Pertinent to the Evaluation of Lake Fisheries in the Study Region

Lake Name	Drainage System Name	Township and Range	Section	Average Surface Acres	Maximum Maximum Depth	Fish Species Present (Percent of Total Population	Populations Being Maintained By Stocking (Species)	Populations Being Maintained by Natural Reproduction (Species)	Overall Population Conditions
Routt County									
Gill Re	E F Williams F	3N88W	11	7	E8	C(100)	Rarely	Rarely	Under
Hahns Peak L	Willow C	10N86W	12	40	45	B(T), R(75), S(25)	Regularly	Common	Stable
Pearl L	Lester C	10N85W	35	167	83	B(10), C(60), R(10),S(20)	Occasionally	Common	Under
Sage Creek Re	Sage C	5N88W	13	20	E30	R(100)	No	Rarely	Under
Steamboat L	Willow C	10N86W	35	1,083	85	B(10), Br(5), C(T), R(85)	Regularly	Common	Stable
Moffat County									
Butch Cassidy Re	Green R	10N104W	12	100	17	B(90), C(8), R(2)	Rarely	Some	Stable
Freeman Re	Cottonwood C	9N89W	6	14	E30	C(100)	Occasionally	Rarely	Under
Hog L	Green R	10N103W	9	51	15	B(100)	Rarely	Rarely	Under
Ralph White L	Fortification C	8N90W	26	40	E15	Su(49), Bh(30), Cc(10), Np(1), R(10)	Regularly	Abundant	Over (Bg, Bh)
Rio Blanco County									
Axial Basin Re	Milk C	4N93W	13	20	E10	Bh(10), Su(3), R(80), Yp(3), Cc(2), Cr(2)	Regularly	Common	Stable
Chapman Re	Oak C	3N86W	31	25	26	B(T), C(T), R(99)	Regularly	Rarely	Stable
Pagoda L	Snell C	2N89W	23	7	16	B(90), R(10)	Occasionally	Rarely	Under
Rio Blanco L	White R	1N96W	6	120	15	Cb(10), Cp(50), S(20)Cc(10), Np(5), Bh(3), R(2)			
Sheriffs Re	Trout C	2N87W	20	40	E30	R(100)	Regularly	Rarely	Stable
Vaughn L	Poose C	2N88W	22	36	26	R(99), C(T)	Regularly	Rarely	Stable

SOURCE: Colorado Disision of Wildlife, 1972

Abbreviations Used - LAKE NAME - DRAINAGE SYSTEM: C, Creek; L, Lake; Re, Reservoir; E, East; F, Fork
MAXIMUM DEPTH: E, Estimated
FISH SPECIES PRESENT: C, Cutthroat Trout; B, Brook Trout; R, Rainbow Trout; S, Sucker; Br, Brown Trout; Su, Sunfish; Bh, Bullhead Catfish; Cc,Channel Catfish; Np, Northern Pike; Yp, Yellow Perch; Cr, Crappie; Lmb, Largemouth Bass; K, Kokanee Salmon; Cb, Chub; Cp, Carp; (T), trace of species found in habitat.
OVERALL POPULATION CONDITION: Under, underpopulated; Over, overpopulated.

texanus). All four of these species were historically found in the main channels of Colorado and Green Rivers and their major tributaries from Mexico to Wyoming. It has been theorized that ongoing construction of dams on the Colorado River and its major tributaries (e.g., the Green River), has gradually reduced the range of these four species. Early references relate the great abundance of bonytail chub in large river channels in the ninteenth and early twentieth centuries before large dams were constructed. The history of their decline in the lower Colorado River Basin (below Grand Canyon) seems directly related to dams and their resultant flow regulation. For instance, after closure of Flaming Gorge Dam in 1962, the bonytail chub was relatively abundant in the Echo Park area of the Green River in 1964-66, but it was found to be very rare in this area by 1968-71 (Holden and Stalnaker 1973).

These endangered species are all classified as native "big river" fishes of the Colorado River Basin. Little is known of the life histories of any of these species, and due to their scarcity the possibility of future research concerning these species is remote. The morphology of all four indicates adaptations to swift, large river environments. However most collections have been made in pools and eddies away from strong currents, generally over silt or silt-boulder bottom types.

To reiterate, the Yampa River is the only major tributary in Colorado River drainage which still resembles its original condition. It is thus a most significant habitat for the preservation of these rapidly vanishing four endangered species. Any development on the Yampa River drainage which alters the present environment might eliminate one of the last refuge areas of these species. Man-made alterations in flow pattern, temperature, turbidity, and species composition through species introduction (e.g., rainbow trout, channel catfish) in the Colorado River Basin have had the most dramatic and devastating effect on these endangered species. The raising of the water temperature to 65°F is required to trigger spawning of these species during late June and early July. However, successful spawning had been eliminated in many portions of the Colorado River Basin due to the low temperatures (well below 65°F) of discharges from reservoirs into streams below dams. Also increases in stream sedimentation, particularly during the critical summer spawning period, would be disastrous to any populations of these species in the study region. The increased deposition of sediment in spawning areas would lead to the suffocation of the incubating eggs, and the abrasive suffocating effects of increased suspended material in streams would have detrimental effects on adult members of these species.

Macroinvertebrates

Aquatic macroinvertebrates may best be generally defined as organisms lacking a spinal column which inhabit the bottom of aquatic environments. Some of the most common macroinvertebreates are: (1) flatworms, (2) round-worms, (3) segmented worms, (4) insects, and (5) mollusks (e.g., snails). Benthic macroinvertebrates are large enough to be retained by a U.S. Standard No. 31 sieve (595 micron mesh) and spend at least part of their lives associated with the stream bottom (Weber 1973).

Macroinvertebrates which occupy an aquatic habitat are the best indicators of overall quality of that habitat. These organisms are extremely sensitive to changes within aquatic environment, but for the most part they are non-motile and must either be able to adjust to changes or perish.

Unpolluted healthy streams tend to have moderate-sized populations of a great many organisms, (i.e., thay have a relatively high diversity), whereas polluted streams will typically have low diversity. Depending on the degree of pollution, living conditions will be restricted in affected streams so that only a few different types of organisms will be able to survive, with these types often increasing tremendously in numbers due to lack of interspecific competition. If conditions in a polluted stream become severe enough, the environment becomes completely toxic and all living things may be eliminated (Reid 1961). Aquatic biota, in particular benthic macroinvertebrates, reflect stream quality over a long period of time. The most restrictive conditions during that period will dictate which organisms cannot survive and which are preferred; thus macroinvertebrates which are present at a particular time tell quite a bit about conditions in that stream during previous years.

Macroinvertebrates are an important fish food source, particularly in streams. For example, the number of North American insects known to spend part or all of their lives in fresh waters exceed 5,000 species (Reid 1961). A typical life history for a particular classification of these insects (e.g., stoneflies) indicates that the nymphal (immature) stages may persist for several years and are spent in association with stones or aquatic vegetation in swift, cool streams. During the immature portions of the life cycle, these insects provide abundant forage for local fish populations. Mass emergence of the adult insects generally occurs in late spring or early summer; adult stages usually persist only for a few days, during which time reproduction takes place.

A listing of the relative abundance of certain aquatic macroinvertebrates at selected stream sites in the study region is presented in Appendix D. This information was gathered by the USGS for its coal mining survey. According to this information presented in Appendix D, caddisflies were the most common benthic macroinvertebrates at the selected stream sites on the dates sampled. Mayflies, stoneflies, black flies, and midges were also common at a number of sites, while beetle larvae and snails were only found at a few stations. No leeches were taken at any of the sampling stations. Because these samples represent only specific dates (there was no long term sampling) and were not complete inventories, a detailed description of the aquatic macroinvertebrate populations currently existing in the study region is not feasible.

Microinvertebrates

Microinvertebrates which are of critical importance to the food chain in a fresh water habitat include the myriads of species which compose the floating masses of organisms collectively known as zooplankton. Some common types of zooplankters are three types of fresh water shrimp and over 130 species of water fleas (cladocerans). All carnivorous fishes pass through an early growth stage during which zooplankton is the major food source. Upon reaching larger size and becoming piscivorous (feeding on other fishes), these fishes are still indirectly dependent on zooplankters, since smaller fishes which they take as food usually feed regularly on microscopic forms. Due to limited information any further discussion of microinvertebrates present in the study region is not practical.

Cultural Components

Archeological Resources

As generally used, archeology refers to that brand of science dealing with the study of prehistoric man, especially as revealed in physical on-the-ground evidence. This study has both a scientific and a human-interest aspect; the first deals with learning more about the hows, whens, wheres, and whys of prehistoric occupations, and the second deals with the layman's perception of these cultures in relation to modern life (see Recreation). The scientific aspect deals more broadly with the obvious as well as the rather subtle evidences of previous human habitation, in terms of environmental and social conditions, limiting factors, etc. that have ultimately determined cultural settlement patterns.

Cultural description

Archeological resources of the region are believed to include representatives from the earliest known culture, Clovis, to modern man. This array of cultures spans at least 13,000 years, and includes the Clovis, Folsom, Plano, Desert Archaic, Fremont, and more recent ethno historic cultures such as the Ute Indian. The relative abundance of sites representing each culture is inversely proportional to their age.

The earliest known culture widespread on the North American Continent was the Llano (Clovis). To date no Clovis points (the first of which was found on the Great Plains) have been reported in published reports for the study region; however, local collectors reportedly have found several. Clovis points (10,000 to 9,000 BC) are often found in association with the mammoth. Sixty-five miles north of Craig lies the Union Pacific mammoth site in southwestern Wyoming, although only two flint tools were found at that site.

Chronologically following the Clovis culture was the Folsom (9,000 to 8,000 BC). Again, no recorded Folsom site occurs in the study region, though others have been found in western Colorado. A few local collectors claim to have found Folsom points at undisclosed locations in the region (BLM, Williams Fork URA, 1974).

Evidence of the Plano culture of the western plains was found in Dinosaur National Monument (Breternitz 1963). This culture extended from 8,000 to 5,000 BC.

Developing out of the Great Basin was the Desert Archaic Culture beginning approximately 7,000 BC. Desert Culture sites have been reported in Dinosaur National Monument and on the Uncompaghre Plateau, though none have been specifically recorded in other areas of the study region.

Following the Desert Culture, and an outgrowth of it, was the Fremont Culture, which extended from AD 800 to 1150. Noted for its agricultural lifestyle, the Desert Culture also had a larger than usual dependence on hunting and gathering for an agrarian culture. Several Fremont sites occur in western Moffat and Rio Blanco Counties. Rock shelters, masonry granaries, and distinctive rock art are characteristic of this culture.

The last period of prehistoric occupation was concerned chiefly with the Ute Indians, and to a lesser extent, in the northern portion of the study area, with the Arapahoe, Cheyenne, and Sioux. The Utes were dependent upon hunting and gathering natural products that could be collected in this somewhat arid and harsh environment. Since they did not have a well-developed agricultural system, staple foods, nor domesticated animals, the Utes could not support large tribes. Artifactual evidence is most often seen in the form of chipping areas, campsites, tipi rings, and rock art.

History of archeology in the region

The first record of archeological sites in northwest Colorado was made by Father Escalante in 1776. Escalante named the Douglas Creek pictograph area south of Rangely, "Canon Pintado". Very little interest was shown in northwest Colorado's archeological resources until 1927, when Jean Jeneon from the Colorado State Historical Society investigated evidence of the Fremont culture in the Skull Creek Basin. In 1950, Gilbert Wenger from the University of Denver did a research project near Rangely for his Master's thesis. In 1963, archeological research was begun in Dinosaur National Monument by Dr. David Breternitz of the University of Colorado.

Since 1973, there have been a number of inventories completed in localized areas for impact assessment related to energy development by: Dr. William Buckles of Southern Colorado State College, Dr. David Breternitz of the University of Colorado, Dr. James Hester of the University of

Colorado, Dr. Calvin Jennings of Colorado State University, Dr. Joe Lischka of the University of Colorado, and Dr. Alan Olson of Denver University.

Several hundred archeological sites have been recorded in the three-county region. Work has concentrated in Dinosaur National Monument and in areas of existing and proposed coal development, prompted by the provisions of current antiquities legislation. Map Foldout 14 in Appendix B indicates known densities of recorded sites. Current records should not be viewed as a complete and final list of all the archeological resources of the study region; they are only an indication of the extent and type of prehistoric cultural resources; less than one percent of the region has been adequately surveyed to identify significant sites.

<u>National Register of Historic Places</u>

Under Title I of the Historic Preservation Act (S. 3035, October 15, 1966), Section 101(a) authorizes the Secretary of the Interior "to expand and maintain a national register of objects significant in American history, architecture, archeology, and culture, hereinafter referred to as the National Register, ..." The Federal Register of February 4, 1974 was reviewed, as were all monthly revisions. In addition, the State Historic Preservation Officer for Colorado was contacted for the most current listing of National Register properties. The State Historical Society's Buildings and Sites office was also consulted (Colorado State Historical Society 1975). No archeological sites nor areas are currently on the register in the study region. However, one area, the Miller Creek Archeological District, has been nominated to the National Register and recommended by the Colorado State Historic Preservation Officer (1974).

Historical Resources

Historic places and trails

The western portion of the study region historically provided hunting grounds for Ute Indians who traded with other Ute bands in Utah and south-central Colorado. Enroute to California, Fathers Escalante and Dominguez entered the southwest corner of the study region from Douglas Creek and crossed the White River near Rangely; they were the first to record evidence of aboriginal Indian cultures.

The advent of the fur trade initiated more intensive exploration of the region, notably by members of the Rocky Mountain Fur Company; William Ashley first brought trappers to Browns Hole in 1825. This is the site of Fort Davy Crockett, the trappers' winter headquarters, built in 1837, also called Fort Misery. A few years later, a party of trappers on the Little Snake River were attacked by approximately 500 Arapahoe and Cheyenne Indians; several trappers and their leader, Henry Fraeb, were killed in the battle.

Captain John C. Fremont traveled down the White River, and through Browns Park along the Green River, enroute to North Park in 1844 on his second expedition to the west. A few years later, in 1861, Captain E. L. Berthoud set out to find a more direct route from Salt Lake City to Denver and travelled through both the Yampa and White River Valleys.

Placer gold mining first began on an intensive scale in 1862 when Joseph Hahn and his companions found gold at Hahns Peak; by 1866 a mining district had been formed. Hahns Peak became the first county seat for Routt County a few years later (1877). Other placer gold mining operations were observed north of Craig at Blue Gravel Gulch as early as 1869.

As a result of the 1868 treaty with the Ute Indians, the White River Indian Agency was established a short distance above the present Meeker town-site, as one of three supply headquarters for the reservation. This date coincides with the arrival of the railroad in Rawlins, Wyoming; establishment of the Agency Supply Trail naturally followed. This was the first major supply route into the study region.

One year later the famed river explorer John Wesley Powell led the first expedition through Ladore Canyon on the Green River.

The Town of Steamboat Springs was established in 1875 by James H. Crawford, and the year after a combination Indian-fur trading post was established in Hayden.

Trouble precipitated at the White River Indian Agency as a result of poor relations with the Utes. This resulted in two significant battles: the Thornburg Battle and the Meeker Massacre. In the latter, Indian Agent Nathan C. Meeker was killed. Both battles occurred in the period from September 27 to October 2, 1879.

In 1880 William Teagarden and W. H. Tucker established the Town of Craig. Williams S. Taylor engaged in ranching at Spring Gulch and founded the Axial Post Office in 1882. The first trading post in Rangely was also built in 1882; this was Rangely's first building. By 1885 the Rangely area was a prominent cattle raising and grazing area.

The last Indian conflict in Colorado occurred on August 25, 1887, nine miles west of Rangely; the alleged theft of horses by two Utes resulted in a minor skirmish with six cavalry troups.

Several stage routes later provided transportation through the area, though no stage stations remain as historical sites. In 1908 the Moffat railroad reached Steamboat Springs. One year earlier, in 1907, 2,000 tons of coal were mined in Oak Creek in anticipation of the train's arrival. Several of these historic sites and trails are shown on Map Foldout 14 in Appendix B.

National Register of Historic Places

Under Title I of the Historic Preservation Act (S. 3035, October 15, 1966) Section 101 (a) authorizes the Secretary of the Interior "to expand and maintain a national register of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, and culture, hereinafter referred to as the National Register....." The Federal Register of February 4, 1974 was reviewed for this Environmental Impact Statement, as well as all monthly revisions. In addition, the State Historic Preservation Officer and the State Historical Society's Buildings and Sites Office were consulted.

Currently the following historic properties have been entered on the National Register of Historic Places on the date shown:

Hahns Peak Schoolhouse (Routt County) - February 15, 1974,

Old Lodore School (Moffat County) - February 24, 1975,

David H. Moffat private car, "Marcia" (Moffat County) - June 20, 1975, and

Thornburg Monument or Milk River Battle Site (Rio Blanco County - August 22, 1975.

No additional historical sites have been nominated to the National Register of Historic Places.

Land Use

Use patterns

Factors that have had a major influence in developing existing land use patterns are a combination of land ownership, legal constraints, and physical characteristics. Historically lands along river bottoms, drainages, and fertile rolling hills suitable for crop production, were patented in the late 1800s and early 1900s under the agricultural homestead laws. Other lands rich in mineral resources were developed and later patented under the General Mining Law of 1872. Most rangeland in private ownership today was acquired through the Stockraising Homestead Act.

During the early period of public land disposal, the Federal Government recognized the need for preserving certain resource values for future generations of Americans. Lands determined to be needed for a variety of federal programs began to be withdrawn from entry, and reserved for such things as powersites, reservoirs, reclamation projects, public water sources, recreation, and National Forest. Major withdrawals in the region still in effect include Routt National Forest bordering on the east, White River National Forest in the southeast, and Dinosaur National Monument and Browns Park National Wildlife Refuge near the Colorado-Utah border. Smaller withdrawals for powersites and reservoirs are scattered along major water courses of Little Snake, Yampa, and White Rivers.

The State of Colorado was authorized to accept "State School Sections 16 and 36" of each township in Routt and Moffat Counties when it was admitted to the Union in 1876. However, because some of these sections were previously patented, and many that were acquired by the State have been sold or traded through the years, the State now owns relatively few Sections 16 and 36. Colorado has more land acquired through exchange and School Indemnity Selection (Act of February 28, 1891). Since land comprising Rio Blanco County was the White River Ute Indian Reservation in 1876, the State could not acquire Sections 16 and 36 in that County. The Colorado State Land Board controls the use of state-owned lands and has authority to sell, trade, or lease them for agricultural and mineral development purposes.

The DOW also owns land in the region; its land is managed primarily for recreation use and wildlife habitat.

The following is a summary table for the tri-county region.

TABLE RIV-23

Land Ownership in the Study Region

Ownership	Moffat County	Routt County	Rio Blanco County
Private	1,498,126	949,424	561,048
Federal	1,600,967	671,428	1,583,817
State	203,177	67,761	58,531
County and Municipal	7,521	2,841	1,365
Totals	3,309,791	1,691,454	2,204,761

The major land uses in the tri-county region include livestock grazing, minerals production, farming, residential, and recreation or other public purposes. Although in many cases there are overlapping land uses, such as minerals exploration or recreation on grazing land, there is usually a principal use on each particular tract of land. These principal uses in the region are depicted on the land use maps in Appendix A. The following table is a summary of land uses by their acreages.

TABLE RIV-24

State and Private Land Uses in Study Region

Type	Moffat County	Routt County	Rio Blanco County
Rangeland	1,142,678	449,234	408,500
Non-Irrigated Cropland	68,670	74,854	20,500
Irrigated Pasture and Cropland	30,000	60,600	16,000
Non-Irrigated Pasture	28,087	4,900	7,000
Privately Owned Woodland	14,000	152,420	22,800
Commercial and Industrial	10,857	8,000	*
Residential and Subdivision	NA	15,100	4,418
Total	1,294,292	765,108	479,218

* No land specifically labeled as such
NA-Not available

Livestock grazing

As shown in Table RIV-24, the most extensive use is rangeland for livestock grazing. Statistics show in 1973 there were over 200,000 sheep and 112,500 cattle and calves on rangeland in the region. Most of the livstock operators have either BLM, U.S. Forest Service or Colorado State leases or permits to graze their livestock on public lands in conjunction with their own land. Because of the severe winters, cattle and sheep generally use summer ranges on the higher and more remote federally owned land, and use winter ranges on lower and more accessible private land.

In recent years there has been a transition in land use from grazing to minerals production or residential use, especially in Routt County. In the Steamboat Springs area, the "ski-boom" and other recreational development have stimulated interest by investors and land developers to subdivide former mountain forest and rangeland into recreational homesites. In addition, new and expanding coal strip mines have at least temporarily taken grazing land away from the livestock industry. In some cases grazing leases have been cancelled or modified to reduce useable forage land, and in others the mining company simply purchased the land from livestock operators. However considering the vast areas of grazing land, those lands that have undergone a transition in use constitute a very small part of the total resource available.

Farming

Because of limited precipitation and short growing seasons, less than 10 percent of the tri-county area is in crop production. The principal crops are hay and wheat. Most hay is irrigated along river bottoms and drainages, and most wheat is dryland, farmed in the vicinity of Craig and Hayden. Nearly all hay grown in the region is used locally for livestock winter feed. Table RIV-25 shows the extent of the major farm crops in the region.

TABLE RIV-25

1970 Winter Wheat Production in the Study Region

	Acres Irrigated	Yield bu/ac	Acres Non-Irrigated	Yield bu/ac	Total
Moffat	1,500	38.3	23,500	26.3	25,000
Rio Blanco	220	40.0	4,080	27.0	4,300
Routt	1,500	41.0	16,400	28.0	17,900
Total	3,220		43,980		47,200

TABLE RIV-26

1970 Hay Production in the Study Region

	Hay Alfalfa	Yield tons/ac	All Other Hay	Yield tons/ac	Total
Moffat	13,000	1.7	8,200	1.6	21,200
Rio Blanco	10,500	1.8	17,000	1.8	27,500
Routt	13,500	1.5	32,500	2.0	46,000
Total	37,000		57,700		94,700

Farmlands are either in private ownership or leased from the State of Colorado. It is common to find situations where mineral estates are separate from surface estates, and mineral rights beneath farmland may be either federally or State owned and subject to leasing. Where this situation exists with oil and gas deposits, compromises can be made to enable both mineral and surface uses to continue in a given area. However, if there are coal deposits at a level that can be strip-mined, obviously both uses cannot continue at the same time, and it is usually the farmer that must sacrifice a portion of his operation, at least temporarily.

Minerals production.

Because of the extensive occurrence of mineral resources throughout the region, exploration and development of minerals has been underway since the early 1900s. Old scars from geophysical work, test pits, old mine shafts, piles of overburden, and abandoned drill pads are commonly found in the study region. The most important minerals in the area are coal and oil and gas. Lands devoted to coal production are primarily located southwest of Steamboat Springs and include five large strip mines--Edna, Energy 1, Energy 2, Energy 3, and Seneca 2. Another large strip mine immediately south of Craig is being started by Utah International.

The largest oil and gas development area is the Rangely Oil Field. The area comprises several hundred acres, and the land is presently committed almost entirely to purposes related to extraction of oil and gas. It is intensively developed with powerlines, roads, pipelines, storage tanks, pumps, separators, and other production facilities. Other major oil and gas fields include Wilson Creek, Iles Dome, Magnolia Field, West Douglas, Dragon Trail, White River Dome, Hiawatha, Powder Wash, and Tow Creek.

Residential

The total 1975 population of the tri-county region was approximately 25,900. Most of the population is centered in and around Craig, Steamboat Springs, Hayden, Oak Creek, Yampa, Meeker, Rangely, Maybell, and Dinosaur. Most of the 8,877 square mile area consists of vast expanses of open space and undeveloped lands, especially in the western portion. Recently residential subdivision activity has increased in Steamboat Springs; although some construction of recreational homesites and condominiums has occurred, most of the subdivisions are not yet totally developed. Quite commonly lots are purchased for speculation with no serious intention of ever constructing a recreational home or other residence. There has also been an increase in sales of 40 acre tracts for "ranch-houses".

Besides recreation oriented subdivisions, lands adjacent to Steamboat Springs, Craig, Meeker, and Rangely are being studied and planned for residential use to accommodate anticipated growth from increased minerals development.

Commercial and industrial

Except for the towns and minerals producing areas in the region, little land is being used for commercial and/or industrial purposes. The only other major industrialized area is the Hayden Electric Generating Plant and the adjacent Yampa Valley Airport just east of Hayden. This fossil fuel burning plant is operated by Colorado Ute Electric Association and has a present capacity of 170 megawatts. However it is in the process of being upgraded to a 500- megawatt facility. In addition, a 760- megawatt plant is being built south of Craig.

Land use controls and constraints

Various controls and constraints on land and resource uses are exercised by several Federal, State, county and city governmental agencies. Development, management, use and/or control of use of Federal lands has been delegated to such agencies as the Bureau of Land Management, U.S. Forest Service, Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, and the National Park Service. With certain exceptions, uses and controls come under the discretionary authority of the agency head. Controls are effected through issuance or non-issuance of a variety of leases, permits, licenses, etc. Each authorization to use Federal lands contains provisions to control that use; agencies have monitoring, compliance and enforcement authority. Controls exercised by the Federal government for the subsurface estate are governed by the statutes authorizing the disposition and use of that estate. Foremost among these statutes is the authority for leasing coal deposits and authority to require, as a condition of such leases, an operation-management plan and a reclamation-restoration plan. Management policy has been extended in greater detail by the National Environmental Policy Act of 1969. In certain situations there is a joint or multi-agency sharing of particular management and control functions and responsibilities. For example, on national resource lands BLM has authority to issue coal leases, and the USGS has various responsibilities for use of the land after the lease is issued.

A number of State agencies have development and administrative authority over lands owned by the State of Colorado. The principal ones are the State Land Board, Division of Parks and Recreation, Department of Health, Division of Wildlife, and Department of Natural Resources. Furthermore, state statutes provide authority to local governments to perform and administer certain surface land use, planning, and development activities on State, county, municipal, and patented lands; control does not apply to Federal properties except as provided by law. Among important State legislation are: Colorado Land Use Act of 1971, which related to the need for land use planning; Article 2, Chapter 106 CRS 1963, which authorized county planning and zoning; Senate Bill 35, which directed county commissioners to adopt subdivision regulations, and required parcels of less than 35 acres to meet those regulations before being sold (with certain exemptions); the Planned Unit Development Act of 1972, which granted powers to counties and municipalities in an effort to promote the Planned Unit Development (PUD) concept of developing an area of land for multiple uses under a unified plan of development; the Colorado Open Mining Land Reclamation Act of 1973, which made it unlawful for any operator to engage in new open mining without first obtaining a permit from the Reclamation Board, Colorado Department of Natural Resources; Chapter 66, Article 28 CRS 1963, which established water pollution control; and the Air Pollution Control Act of 1970, which established air pollution control.

Colorado House Bill No. 1041 concerns land use and provides for identification, designation, and administration of areas and activities of State interest, assigns additional duties to the Colorado Land Use Commission and the Department of Local Affairs, and makes appropriations therefore. The areas and activities of concern in the bill include such things as: mineral resource areas, natural hazard areas, areas containing, or having a significant impact upon, historical, natural, or archeological resources of statewide importance, and areas around key facilities where development may leave a material effect upon the facility or the surrounding community.

House Bill No. 1034, which is called the Local Government Land Use Control Act of 1974, identifies the manner by which local governments may plan for and regulate the use of land.

All three counties, Routt, Moffat, and Rio Blanco, have subdivision regulations in effect. They also have zoning resolutions, building codes, and a variety of county ordinances. In Routt and Rio Blanco Counties, technically lands have to be zoned for mining before minerals extraction can occur. In Moffat County, zoning is not changed to allow mineral production, but special use permits from that county must be acquired first. Routt County has a recently prepared Comprehensive Land Use Plan for the county and Steamboat Springs. A similar plan covering Rio Blanco County, Meeker, and Rangely is in the formulative stages and should be completed within the year. Moffat has a land use plan that was prepared in 1969 and a revision of it should be completed by the end of 1975. Although the job of comprehensive land use planning has been contracted to individual consulting firms, all three counties have planning programs with county planners and staffs.

The incorporated towns have city ordinances, but other controls and constraints are limited and are exercised by only the larger communities. Master planning and zoning are generally accomplished jointly with the county governments.

Aesthetics

Aesthetics is a term that invokes a variety of subjective feelings about one's environs. Webster defines aesthetics as "the study of the qualities perceived in works of art, with a view to the abstraction of principles." The chief concern in dealing with aesthetics is visual resources, as 87 percent of man's perception is based on sight. The remaining perception of our environment accrues to the other senses as follows: hearing - 7 percent; smell - 3 1/2 percent; touch - 1 1/2 percent; and taste - 1 percent (USFS 1973). A developing visual management system has been formulated to analyze visual resources objectively (Litton 1968, U.S. Forest Service 1973, and U.S. Forest Service 1974). Three basic concepts are essential to this process: characteristic landscape, variety, and deviation.

Characteristic landscape is the result of an overall combination of landform, vegetation, water and man-made features that can be described in terms of four dominance elements: form, line, color, and texture. These basic building-blocks can be analyzed in terms of their arrangement, as well as in terms of outside influences that affect our perception of them.

The overall combination of features can also be analyzed with respect to the amount of variety of dominance elements present. This concept addresses the fact that most people prefer an intermediate amount of landscape variety, irrespective of subjective value judgments available to the individual.

A third concept, deviations, deals with relative harmony or disharmony inherent in existing or proposed alterations of the landscape. Man-made features or alterations which borrow similar form, line, color, and texture from the characteristic landscape are called "plus" deviations while those which do not are called "minus" deviations. It should also be noted that landscapes of greater variety offer a wider assortment of one or all of the four basic elements from which proposed actions may borrow. The degree to which a proposed action blends with adjacent environs is directly proportional to its ability to borrow (i.e., match) dominance elements from it.

Upper Yampa Valley

Two high mountain valleys dominate this area: the Elk River Valley extends north and Upper Yampa Valley extends south. Both landscapes are somewhat enclosed, as rolling and rugged woodland landscapes contain them on either side. West of Steamboat Springs, the focal point of the valley, the landscape opens into a more panoramic agricultural and rangeland landscape.

A pastoral landscape occupies the Yampa and Elk River floodplains which contain almost exclusively irrigated meadowlands. Characteristic riparian vegetation consisting of cottonwoods and willows lines the meandering rivers which are both form and line-dominant. Form and line also dominate the meadows whose angular pattern is dissected by fences, irrigation ditches, roads, and utility lines.

The adjacent native landscape varies greatly in its basic texture, consisting largely of scrub oak and sagebrush. Aspen and conifers are interspersed, especially on the northern slopes, adding to the landscape variety. Viewing angle is often high due to topographic exposure of the adjacent landscape, most of which lies in the foreground or middleground. Timbered mountainsides at higher elevations can be viewed in the distance.

Rock formations are isolated deviations distributed intermittently in the form of rock outcrops or volcanic remnants (e.g., Elk Mountain and Finger Rock). Higher peaks are visible in the middle and back-ground as rock escarpments and talus slopes (e.g., Hahns Peak and the Flattops).

Smaller streams in this area are line-dominant and are part of the basic landscape character. These and smaller lakes and ponds are very much a part of the characteristic landscape, especially during the spring. Steamboat and Pearl Lakes are noteworthy examples of larger water bodies.

Steamboat Springs lies between Emerald Mountain on the south, Woodchuck Mountain on the north, and National Forest lands on the east. A considerable amount of housing, ski area, and associated recreation facility development in this area, especially east of town, has resulted in several minus deviations from the existing landscape. Other minus deviations have resulted from similar activity near Hahns Peak and east of Oak Creek.

South of Steamboat Springs a spreading pastoral landscape is ultimately enclosed by Thorpe and Blacktail Mountains. The major through road, Colorado 131, enters a very restricted landscape at Oak Creek Canyon. Historic as well as present-day coal mining operations have produced a variety of minus deviations from the characteristic landscape. Largely out of sight from Colorado 131 and immediately northwest of Oak Creek lies the Edna coal strip mine.

South of Oak Creek the valley-bottom is more restricted than it is adjacent to Steamboat. Irrigated meadows form a pastoral landscape on a smaller scale in a more arid environment. Rolling sagebrush landscapes occupy the transition from floodplain to woodland-forest.

Twentymile Park is another separate geographic entity; a rolling landscape of range and cropland is surrounded on nearly all sides by sedimentary uplifts. Scattered irrigated fields occur along Fish and Trout Creeks. Spoil banks from the old MacGregor mine near Milner can be seen from U.S. Highway 40. Energy Fuels Corporation's three existing coal stripping operations occur in the area: two lying on the park's southern periphery and one lying centrally. A series of southwesterly-trending ridges rise on the park's southern edge. Linking the park with Flattop Mountains, these ridges take on an angular form as several rimrock outcrops line their summits.

Other man-made deviations in this area are present in the form of roads, railroads, and electric transmission lines. A county road system provides public access throughout the area. The Denver and Rio Grande Western (D&RGW) Railroad nearly parallels Yampa River, and a spur rail follows Trout Creek to Energy Fuels' mine tipple.

Mt. Harris Area

Rolling to rugged mountainous topography dominates this portion of the county, extending from Elkhead Mountains to the north and Dunckley Flattops to the south. The Yampa River bisects this topography adjacent to Mt. Harris.

The pastoral landscape of the Yampa River enters a very enclosed landscape near the old town of Mt. Harris. A rugged form and line-dominant landscape of rimrock ledges rises above the river's riparian and pastoral features. A high viewing angle is offered from Highway 40 towards the floodplain and adjacent steeply sloping hillsides. Scrub oak, aspen and coniferous trees occupy north-facing slopes south of the river while scrub oak almost exclusively occupies more-rugged south-facing slopes north of the river.

A similar landscape rises above the riparian landscape at Mt. Harris. Largely uniform in texture, a series of ridges support scrub-oak woodlands. At higher elevations and on steeper, north-facing slopes, vegetative variety increases, due to interspersed groves of conifers and aspen. Rock formations occur largely in the form of tilted sediments that are line-dominant.

Except for the Yampa River, water bodies in this area occur as isolated deviations. Small perennial streams are strongly line-dominant. Isolated peaks offer panoramic views into adjacent terrain; views occur both into eastern and western portions of Routt County. Hayden and the Hayden power plant are visible to the west, while views eastward extend into Twentymile Park and Energy Fuels' mines.

Peabody Coal's Seneca Mine lies on the western edge of this area, a short distance south of Highway 40, though not visible from it.
The topographic layout nearly precludes viewing it from Routt County Road 27.

Western Routt County and Eastern Moffat County

The landscape character east of Craig is a more arid combination of open range lands and scattered dryland farming. While the landscape along the lower Yampa River is similar to that of the upper river, the adjacent landscape is more gently rolling. Immediately below Craig the Yampa leaves this landscape.

Vegetative composition is largely sagebrush with scattered dry-land farming. Rock formations are generally absent, and streams occur more infrequently.

Craig is the focal point in this open landscape. Four major transportation arteries emanate from Craig in the four cardinal directions. The D&RGW Railroad also terminates here.

This area exhibits little topographic variation east of Little Snake River. Scattered pinyon-juniper groves and isolated agricultural landscapes are characteristic. Roads and utility corridors tend to dominate views due to their inability to borrow line from the characteristically form-dominant landscape.

Significant exceptions to this rolling landscape are Cedar Mountain lying immediately northwest of Craig, and Godiva Rim-Bald Mountain lying northwest of Maybell. Both offer significant views into the adjacent landscape and are isolated deviations. Exposed rock outcroppings render their form more angular and increase line dominance. A high viewing angle is offered from Highway 40 to these areas.

The Slater Creek area is an isolated geographic entity that occupies the extreme northwest corner of Routt County; the landscape consists of rolling sage-grass hills and several sharply angular prominent peaks. Bounded on the north by the irrigated meadow floodplain of Little Snake River and on the south by timbered National Forest lands, this area exhibits a great deal of vegetative variety. Conifers, aspen woodland types, and a variety of rock formations flank most of the peaks. Water, however, is an isolated feature in the overall landscape, except for the Little Snake River and Fourmile and Slater Creeks.

Williams Fork Mountains

South of Craig lies an elevated mountainside of scrub oak and other woodland types; its form appears as an undulating ridge. These mountains extend east to the base of Dunckley Flattops and west across Williams Fork River, north of Little Yampa Canyon. South of the mountains' crest topographic variety increases. Rimrock outcrops, strongly angular and line-dominant, dominate the characteristic landscape.

This rugged southerly-exposed landscape intersects the meandering Yampa River floodplain southwest of Craig. Sagebrush benches and typical riparian vegetation are characteristic of the floodplain.

South of Craig, the Williams Fork River turns eastward and forms the dominant feature at the southern base of the remainder of Williams Fork Range. This setting is a line-dominant landscape of irrigated meadowlands and riparian vegetation.

Landscape similar to that of Williams Fork Mountains rises south of the river to White River National Forest lands. Man-made deviations in this area are largely roads and utility lines. South of Craig and visible from town lie several coal exploration trails, roads, and fences that are strongly line-dominant in an otherwise texture-dominant landscape.

Axial Basin

South of Little Yampa Canyon the landscape rises to Iles and Duffy Mountains. Consisting of strong form and line-dominant rimrock and talus slopes, they form Axial Basin's northern boundary. On the west rises the rounded juniper-covered form of Juniper Mountain, and to the south rise Danforth Hills. The basin's southern enclosure has a very similar appearance to that of the north slope of Williams Fork Mountains, though it contains few minus deviations. The eastern end rises towards the angular form of Monument Butte and Thornburg Mountain and ultimately into White River National Forest lands.

The Basin itself exhibits a gently undulating landscape of sagegrass types and scattered dryland agriculture in a large-scale enclosed landscape. Waterforms generally constitute isolated deviations in a rather arid landscape. Visible in the distance, rock features are common, though none are present in the basin's interior.

Man-made deviations exist largely in the form of roads and electric transmission lines; the degree to which they borrow the basic dominance elements from the characteristic landscape varies considerably and is beyond the scope of this analysis.

Meeker Area

Yellowjacket Pass, Ninemile Gap, and the Wilson Creek Oil Field are place-names marking the Danforth Hills divide that separates the Yampa and White River drainages. Like the Williams Fork range, the southern slope of these mountains is characterized by a rugged landscape. The vegetative composition is rather uniform; rock outcrops that are very strongly line and form-dominant are the greatest contributor to landscape variety. This landform is rolling to angular, while the line component of the characteristic landscape is strongly horizontal.

At the base of the escarpments a rolling sagebrush landscape fades ultimately to irrigated agricultural lands. Here water is an inherent part of the characteristic landscape and rock formations are entirely absent. East of Meeker White River's meandering pastoral landscape joins agricultural lands. Near the southeastern corner of this area, greater landscape variety is encountered. Greater topographic definition and vegetative variety result in a pastoral landscape typical of high mountain valleys.

The upper White River's combination of roads, utility lines, and irrigated cropland render these areas more line-dominant than adjacent woodland and forest types.

West of Meeker a similar agricultural landscape occupies Strawberry Creek drainage. Having a characteristic landscape similar to that of Danforth Hills, the Gray Hills and Colorow Mountain rise west of Strawberry Creek. Views extend into both areas from Strawberry Creek as well as northward into the Danforth Hills and the Wilson Creek Oil Field.

Before this landscape joins White River it encounters a rolling but highly eroded series of dry washes and hills; on a small scale, sparse vegetation and an absence of water characterize this landscape.

Man-made minus deviations in this area are not as common as they are east of Meeker; most are a result of unimproved roads, trails, and oil and gas exploration activity.

Rangely area

Containing the town of Rangely and the Rangely Oil Field, the Rangely Anticline is the focal point of this area. Sharply angular exposures of tilted sediments display strong line-dominance and are arranged in an arc enclosing the oil field. Vegetative cover within this geologic structure is very sparse. The dominant feature is the oil field itself with an array of intensely line-dominant roads, pipelines, and transmission lines; minus deviations from the characteristic landscape dominate this setting.

Beyond the anticlinal escarpment a rugged and arid landscape extends outward for several miles. Topographic variety diminishes as distance from the rim increases. A significant exception are the large-scale angular cliffs that flank the lower White River; these exposed and bleached horizontal sediments are strongly line-dominant; lying above a meandering riparian river landscape, they contribute to increased landscape variety.

The remainder of the river exhibits a typical riparian landscape with a variety of tilted small-scale sediments lying adjacent to it. Though it is less intensely agricultural, the floodplain contains intermittent irrigated fields. East of Rangely, the roughly angular landscape softens into a rolling but dissected rangeland of short sage types. Here line ceases to be a significant element, except as it appears on the horizon. Both Coal Oil Rim and Pinyon Ridge exhibit strong horizontal lines in rocky outcrops along their summits.

Water bodies in this area occur as isolated deviations largely in the form of livestock water retention dams. Pipeline rights-of-way, roads, and transmission lines constitute most minus deviations outside the oil field, though they are generally not dominant in this area.

Blue Mountain-Skull Creek

Lying east-west through Dinosaur and Massadona, Highway 40 marks the southern boundary of an extremely rugged landscape that extends into the Yampa Canyon section of Dinosaur National Monument.

A series of steeply-dipping hogbacks parallel Highway 40 and mark the southern boundary of a sharply-angular to gently-rolling landscape. Form, line, and color are all strongly displayed in the large-scale outcropping sediments that surround Skull Creek Basin. A variety of patterns are created largely by pinyon-juniper, sagebrush, and park-like landscapes.

Visual access to this area is largely blocked from the south by the hogbacks, but views do extend into the area from a superior position to the north, on the edge of Wolf Creek Basin.

The Wolf Creek drainage contains an open and panoramic sagebrush landscape that lies immediately north of Blue Mountain and Skull Creek. This elevated rangeland ultimately descends through rugged and sharply angular Wolf Creek Canyon toward the White River.

Much of this area is presently untrammeled, but minus deviations are present largely in the form of seismic exploration trails, roads, and dozed fire breaks.

Western Moffat County north of Yampa River

A rather arid landscape of largely rolling sage-grass types extends throughout western Moffat County. However it differs from eastern Moffat County in that it exhibits more topographic variety. An attendant increase in variety of vegetation and rock formations also results.

Green River enters this area on the west through Browns Park, an extensive rolling sagebrush park. The riparian landscape of the river is a dominant feature, though rather steeply rising rugged mountainsides flank the park on both north and south sides. A uniform textured pinyon-juniper woodland rises to a rolling mountain crest on either side.

The northern breaks end at Cold Springs Mountain. Here other high peaks assume a more angular form, and vegetative variety increases due to interspersed sagebrush parks and aspen groves.

Rock formations in this area occur intermittently as large-scale sedimentary outcrops such as Vermillion and Lodore Canyons; they emphasize dominance elements distinct from the adjacent landscapes.

Immediately south of Browns Park lies Dinosaur National Monument containing rugged canyon sections of Green and Yampa Rivers. A rolling pine-clad landscape, Douglas Mountain, rises north of Yampa Canyon. East of the canyon lies the rounded massive form of Cross Mountain which is sharply dissected on its southern flank by Yampa River to form Cross Mountain Canyon.

Below and north of the even-textured form of Cross Mountain stretches Sand Wash Basin. The basin consists of a highly dissected and gently sloping landscape that rises to the north; the sparsely vegetated area rises on three sides to form a broad open landscape.

The basin exhibits gently rolling hills with intermittent washes occupying the lowlands; water bodies and rock formations are deviations from this characteristically subdued landscape.

The basin's northern crest marks Vermillion Rim. Lying beyond Vermillion Rim is the very highly dissected badlands landscape of Vermillion Creek complex. Form is sharply angular, and lines are characteristic of small canyon walls and arroyos. Vegetative cover is generally sparse, and a variety of exposed rocks and sediments dominate the landscape.

Man-made deviations in the form of seismic exploration trails are abundant in this area. These are strong minus deviations, as their combination of line and color fail to borrow from the rolling sagebrush-covered characteristic landscape.

Recreation

Recreation involves more than the traditional active pursuits such as hunting, fishing, skiing, rockhounding, or off-road-vehicle (ORV) use; it also includes a recognition of values that challenge the mind (human-interest values).

The multiple use concept of forestry, watershed, range, wildlife, and minerals management involves human-interest values; for example consider the recreational value of viewing sage grouse strutting grounds. Other less easily understood sciences such as archeology, paleontology, or ecology also exhibit human-interest values; Indian ruins, for example, have considerable recreation value when viewed or studied.

Recreation therefore can be described as looking at all resources through visitor's eyes. Awareness of human-interest values can be gained through education or interpretation; proper management of this aspect of recreation resources can promote their appreciation and protection. Recreation can best be described in terms of (1) the actual physical resources, (2) existing recreation developments-operations, (3) use of the various resources, and (4) an analysis of supply and demand.

Resources

Wildlife viewing

Viewing of wildlife resources has significant value in the study area. See the wildlife section for description and location of significant sage grouse strutting grounds, sandhill crane and sharptail dancing areas, waterfowl concentration areas, heron rookeries, and prairie dog towns.

Wildlife hunting

Refer to the wildlife section for a description of the resource; visitor-use data will be discussed later.

Fishing

Again refer to the Fisheries section for a description of the resource; visitor-use data will follow.

Geologic-interpretive

Several geologic features of significant human-interest value are worth noting in the Regional Analysis. These resources are located on Map Foldout 13 in Appendix B and are summarized in Table RIV-27 (BLM 1972, 1974 and 1975; VTN 1975).

Rockhounding

Rock collecting is generally of greater quality and abundance in adjacent portions of Utah and Wyoming; however a variety of agate, petrified wood, and placer gold areas do occur in the study region (see Map Foldout 13 in Appendix B, BLM 1974).

Recreation water resources

Several impoundments are scattered through the study area especially in Routt and eastern Rio Blanco Counties (see Map Foldout 13 in Appendix B). Most recent information on use of these resources is included in the visitor-use section. Boating and water-skiing capabilities occur on Steamboat Lake, Pearl Lake, Elkhead Reservoir, Ralph White Lake, Lake Avery and Rio Blanco Lake; these support a variety of fisheries as well. Several lesser lakes offer only fishing or waterfowl viewing opportunities. Capabilities of those reservoirs to attract and sustain recreational use (irrespective of surface ownership) ranges from high at Steamboat Lake to moderately low at several lesser reservoirs (refer to the fisheries section for the fisheries capabilities of both lakes and streams).

The Yampa, Elk, and White Rivers offer opportunities for river floating. White-water rafting occurs in the Dinosaur National Monument sections of Yampa and Lodore Canyons. Other significant potential has been identified in Little Yampa Canyon (immediately southwest of Craig) and along lower White River, especially below Rangely (BLM 1974 and 1975).

Capabilities of these streams to sustain recreational use is determined in part by water quality. Water quality standards for Colorado, adopted

TABLE RIV-27

Geologic Interpretive Areas in the Study Region

No.	Name	Description
G-1	Chimney Creek Dome	A unique geologic dome that contains igneous dikes around its perimeter in concentric configuration.
G-2	Tow Creek Anticline	U.S. Highway 40 passes through four formations (Mancos, Mesaverde, Trout Creek and Twentymile) that readily expose a scenic anticlinal structure. The much larger southern end of this area displays, in almost text-book fashion, the plunging southern end of the anticline.
G-3	Fish Creek and Sage Creek Anticlines	Scenic combinations of exposed rock, vegetation, and topographic variety lie adjacent to Routt County road 37. Four exposed formations (Twentymile, Trout Creek, Tow Creek, and Mancos) visible in rocky escarpments reveal anticlinal structures.
G-4	Blacktail Mountain	Contains an excellent example of columnar jointing in an igneous sill.
G-5	Finger Rock	A classic example of a volcanic plug lying adjacent to Colorado Highway 131.
G-6	Bibleback Mountain	Area contains a series of peaks displaying rugged scenic examples of volcanic activity.
G-7	Slater Creek	A classic example of large-scale columnar jointing lies just south of Slater Creek's confluence with the Little Snake River.
G-8	Fortification Rocks	A classic example of an igneous dike. This is the best example of several lesser dikes that radiate from the Black Mountain area.
G-9	Cedar Mountain	This is an isolated remnant of a larger igneous flow that originated near Black Mountain.

TABLE RIV-27

Geologic Interpretive Areas

No.	Name	Description
G-10	Little Yampa Canyon	The canyon exposes five formations (Williams Fork, Lewis, Lance, Browns Park, and Trout Creek) that display portions of the Williams Fork and Axial Basin anticlines and the Round Bottom syncline.
G-11	Aldrich Lakes Land-slide	A massive landslide lies immediately north of Yellow Jacket Pass.
G-12	Oak Ridge	Though densely vegetated with scrub oak, eight formations (Mancos, Dakota Morrison, Navajo-Entrada, Chinle, State Bridge, Weber, and Marroon) out-crop on the south side of Oak Ridge.
G-13	Mt. Lobo	An outstanding viewpoint reveals several area geologic structures. Grand Hogback, Oak Ridge, Grey Hills, and Meeker Dome are notable features that can be viewed from this point.
G-14	Scenery Gulch	A highly eroded area of the Wasatch Formation contains small-scale vertical columns, spires, and balanced rocks.
G-15	Crooked Wash	Contains entrenched meanders in the Mesaverde Formation.
G-16	Skull Creek Basin	This anticlinal structure reveals several formations in a vari-colored escarpment that essentially surrounds the basin. A series of scenic and steeply dipping hogbacks expose six formations (Mancos, Frontier, Mowry, Dakota, and Curtis).
G-17	Raven Ridge - White River	The Rangely anticline's western edge exposes four differentially eroded formations (Mancos, Mesaverde, Green River, and Uinta). Spectacularly eroded Green River sediments flank the lower White River.

TABLE RIV-27

Geologic Interpretive Areas

No.	Name	Description
G-18	Cross Mountain Canyon	This extremely rugged canyon has been eroded through the flank of Cross Mountian by the Yampa River.
G-19	Irish-Vermilion Canyon	Nine steeply dipping formations (Uinta, Mississippian Undivided, Older Pennsylvanian, Weber, Park City, Triassic, Nugget, Morrison, and Mancos) are exposed in a sparsely vegetated landscape.
G-20	Vermilion Bluffs	A rugged and highly dissected scenic landscape of varicolored bluffs extends from the top of Lookout Mountain to Red Wash.
G-21	Sand Dunes	An extensive area of relic barcheon and parabolic sand dunes that appear as blowouts (VTN 1975).

SOURCE: BLM, Craig District Office, URA-MFP data; 1972, 1974, and 1975.

January 15, 1974 (effective June 19, 1974) (Colorado State Health Department 1974), establish standards for A or A_2 waters, and for B_1 or B_2 waters. Class A waters are defined to include all waters "suitable for all purposes for which raw water is customarily used, including primary contact recreation such as swimming and water-skiing". Class B waters differ in that they include waters "suitable for all purposes for which raw water is customarily used, except primary contact recreation, such as swimming and water-skiing." Based on the standards in Table RIV-9, neither Green, Yampa, Little Snake nor White Rivers have been classified to allow for body-contact water sports.

However, mean values obtained in recent coliform sampling (EPA STORET, 1975; Table X-1, Appendix D) indicate that the lower Yampa indeed does meet Class A criteria established for body-contact water sports; though all remaining river segments sampled are not suitable.

Public Law 93-621, January 3, 1975, amends the Wild and Scenic Rivers Act (P.L. 90-542, 82 Stat. 906) to designate segments of certain rivers for possible inclusion in the National Wild and Scenic Rivers System. The river segments included are to be studied and reported on by October 2, 1979. Three river segments lying within or adjacent to the study region boundaries are included in this Act. These are: that portion of the Elk from its source to Clark, the entire segment of the Green that lies within the State of Colorado, and that portion of the Yampa within the boundaries of Dinosaur National Monument (Public Law 93-621, 1975).

The Little Yampa Canyon section of the Yampa River appears to meet the criteria established by P.L. 90-542 (1968) for inclusion in the National

Wild and Scenic Rivers System as a scenic river. This observation is based solely on observed resource values; this segment has not been officially nominated nor evaluated by the Bureau of Outdoor Recreation for its Wild and Scenic River potential.

Winter sports

The study region has especially significant caabilities to attract and sustain downhill and cross-country skiing as well as snowmobile use. Developed downhill skiing is addressed in the Existing Recreation Developments Section. Virtually all of the study area can support snowmobile and cross-country skiing use; however the capability is much greater in Routt and eastern Rio Blanco Counties due to longer lasting snow cover.

Ecological features.

The study area contains one known pinyon-juniper relic area that lies about ten miles west of Meeker; it is thought to contain trees about 500 years old. A species of manzanita (Arctostaphylos coloradensis) has been reported in the Yellow Jacket Pass Area, reportedly unique to this area (BLM 1975).

Significant unique plant communities are known to occur in Strawberry Park immediately north of Steamboat Springs. These resources are included in the recreation section due to their inherent human-interest value as an interpretive or educational recreation resource. Rare flowering plant communities also occur east of Clark on the road to Slavonia on National Forest lands (BLM 1974).

Primitive-natural values

The study area contains portions of two primitive or wilderness areas that lie wholly on National Forest lands. In 1931 the 43,120 acre Mt. Zirkel-Dome Peak Wild Area was established; the area straddles Park Range north of Steamboat Springs. In 1964 the area was enlarged to 72,472 acres and re-designated as the Mt. Zirkel Wilderness Area. The Flattops Primitive Area lies adjacent to the southeast corner of the study area. Atop the White River Plateau, this area of 52,775 acres was designated in 1932 (U.S. Forest Service 1974); the area presently has been enlarged to 102,124 acres.

No other designated primitive or natural areas now occur outside the National Forest boundary. However several areas adjoining the Flattops have been identified either for further study or for designation as wilderness. Additional areas proposed for wilderness inclusion total approximately 142,000 acres.

The National Park Service has completed an environmental statement (1974) for designation of 165,431 acres of Dinosaur National Monument as wilderness; this proposal includes the canyons of Green and Yampa Rivers. An additional 10,274 acres, including the undeveloped balance of the Monument, is proposed for potential wilderness addition, to be added at such times as they qualify (National Park Service 1974). The proposal is presently awaiting Congressional action. There are at least three bills in Congress now: Senator Haskell has introduced Senate Bill S1102 (1975) which calls for 165,341 acres of wilderness and 10,274 acres of potential wilderness addition; House Bill 5823 proposes that 197,000 acres of wilderness be designated; House Bill 7180 (a third wilderness proposal) suggests designation of an unknown number of acres as wilderness.

Through its planning system, the BLM has identified ten areas as potential for either natural or primitive area designation; see Map Foldout 13 in Appendix B. Further decisions are pending the result of current as well as scheduled land-use planning efforts. These areas are summarized in Table RIV-28 (BLM 1972, 1973,and 1974).

TABLE RIV-28

Potential Primitive and Natural Areas in the Study Region

Name	Acres	Features
Cold Springs	39,660	Largely a south-facing pinyon-juniper breaks that rises north of Browns Park. Beaver Creek Cayon and portions of Irish Canyon lie within the area.
Diamond Mountain Breaks	14,480	A north-facing pinyon-juniper breaks that rises south of Browns Park.
Vermilion Bluffs	26,480	Highly-dissected badlands topography extends from top of Lookout Mountain down into Red Wash.
Bears Ears	24,940	Contains a mixture of sagebrush and woodland types in a rolling to rugged and essentially roadless topography. Dry Mountain, Bears Ears, and Vermilion Canyon are the dominate topographic features.
Douglas Mountain	11,480	Rugged to rolling topography dominates this arid and essentially roadless landscape.
Cross Mountain	15,680	The rounding form of this mountain rises above a rolling sagebrush landscape. It is sharply dissected by Yampa River at Cross Mountain Canyon.
Buckwater Draw	21,120	An elevated pinyon-juniper mesa is dissected by several sagebrush meadows, and small-scale but extremely rugged cliffs, canyons, and arroyos.
Skull Creek Basin	52,480	Vari-colored rimrock escarpments encircle an elevated pinyon-juniper landscape. A series of steeply dipping hogbacks mark the southern boundary.
Pinon Ridge	26,880	A rugged elevated pinyon-juniper mesa outcrops in rimrock escarpments on the west. Crooked wash lies near the eastern boundary.
Black Mountain	12,160	A scattered pinyon-juniper mesa descends in a rolling landscape to White River.

SOURCE: Bureau of Land Management, Craig District; URA-MFP data 1972, 1974, and 1975.

Existing recreation developments

See Map Foldout 12 in Appendix B for the existing recreation development locations.

U.S. Forest Service

Both Routt and White River National Forests flank the study region on the east and southeast respectively. Several campgrounds and picnic grounds lie on these peripheral areas. Facilities and their respective capabilities are tabularized in Appendix D. There are 25 National Forest campgrounds in the study area that have a total of 373 camping units; seven picnic grounds have a total of 43 picnic units (U.S. Forest Service, 1973).

Dinosaur National Monument

Named after a remarkable assemblage of dinosaur fossils in the southwestern corner of the Monument, this natural area is equally well-known for its spectacular canyons of Green and Yampa Rivers. This area contains 206,663 acres and straddles the Utah-Colorado State-line. Scenic drives lead to overlooks, picnic areas, and campgrounds.

The Monument contains 135 trailer campsites, 39 tent campsites, 60 picnicking sites, and five boat launching ramps (three ramps in Colorado). Those facilities within the study region are tabularized in Appendix D. There are three regular campgrounds containing 45 units plus nine primitive river camps in the study area portion of the Monument; in addition a total of 23 units are contained in three picnic grounds (Dinosaur National Monument, 1973 and 1975).

Browns Park National Wildlife Refuge

Lying adjacent to Green River and stretching from the Utah State-line to Dinosaur National Monument are 4,416 acres of wildlife refuge. Though its primary concern is waterfowl production, the refuge offers open space camping, picnicking, and horseback riding. Approximately ten and 15 trailer camping sites are available at the swinging bridge and refuge headquarters, respectively.

River floating, fishing, and bird-watching are other notable recreation resources. Outstanding concentrations of waterfowl render this area highly capable of attracting and supporting wildlife viewing (Colorado Division of Parks 1974 and Creasy 1975).

Colorado Division of Parks (DOP)

The DOP maintains Steamboat Lake State Park north of Clark which includes both Steamboat and Pearl Lakes.

Steamboat Lake area contains 2,679 acres that offer boating, water-skiing, and fishing opportunities. Three boat launching ramps, 44 trailer and 60 tent campsites, and 70 picnicking sites have been constructed.

One launching ramp and 50 tent campsites accommodate Pearl Lake. Boating and fishing are its primary attractions (BLM 1974).

Colorado Division of Wildlife (DOW)

The DOW maintains a variety of recreational facilities in the study region. These include Service Creek, Indian Run, and Bel Air campgrounds as well as Cristina picnic ground. In cooperation with BLM six primitive hunter camps are maintained on Cold Springs Mountain. Three water-based recreation areas include Ralph White Reservoir, Lake Avery, and Rio Blanco Recreation Areas. The DOW also maintains four fishing leases on White River near Meeker and one on Elk River north of Steamboat Springs. Appendix D presents the DOW recreation facilities in the study region (Colorado Division of Parks 1974).

Colorado Division of Highways (DOH)

The DOH maintains one roadside reststop in the study region. Lying west of Hayden on U.S. 40 is a traffic pull-off with four acres containing 16 picnic sites (DOP 1974).

Municipal-County

City parks are in Steamboat Springs, Craig, Maybell, Rangely, and Meeker. Quasi-public nine hole golf courses are maintained at Steamboat Springs, Craig, Meeker, and Rangely. A variety of apparatus and game fields lie throughout the study region and are associated with the various schools. Both Routt and Rio Blanco Counties have county-owned recreation sites. There are 30 municipal or county recreation areas in the study region. See Appendix D for a listing of these facilities.

Private recreation

One hundred and twenty-one private recreation areas lie in the study area: 34 are in Moffat County, 40 in Routt County, and 47 are in that portion of Rio Blanco County encompassed by the study region. Most are hunting and fishing areas, campgrounds, picnic grounds, dude ranches, or recreation resorts. This also includes three ski areas, two of which were out of operation for the 1974 and 1975 ski season. This information is summarized in Appendix D. (See Map Foldout 12 in Appendix B for locations).

Both the American Sportsman's Club (ASC) and the International Sportsman's Club (ISC) have leases in the study area (see map Foldout 12 in Appendix B). These nine private lease areas are for exclusive use of ASC and ISC members; hunting and fishing are the most significant recreation opportunities at these areas (see Appendix D).

Visitor-use data

In addition to the information contained in the supply-demand analysis (which follows this section), a variety of visitor information has also been compiled by several organizations, indicating current use for their respective areas of responsibility.

U. S. Forest Service

Routt National Forest use for 1974 and 1969 is summarized by kinds of site in Appendix D. Average annual percentage changes compounded annually for the various sites are also compiled for the five-year period.

Visitation for Mt. Zirkel Wilderness area was 8,000 visitor days for 1967 and 29,000 for 1974. This constitutes 2.56 percent and 4.4 percent of the respective total forest visitor volumes; it is a 20.20 percent average annual increase in wilderness use over the seven-year period.

The greatest average annual increase in use over the 1969-74 period occurred in roads recreation. Winter sports sites use and recreation at boating sites account for the second and third greatest average annual increases respectively.

However, in both 1969 and 1974 use at undeveloped sites constituted the greatest portion (nearly one-third) of total forest recreation use. Roads recreation, winter sports sites, and campground recreation use also constituted significant portions of total forest use during these two years.

Visitor-use for both 1974 and 1969 on the Blanco Ranger District of White River National Forest is also summarized by kinds of sites in Appendix D. Only the Blanco Ranger District of White River National Forest lies adjacent to the study area, and therefore it was used as a data source in lieu of forest-wide visitor-use data.

Visitor use in the Flat Tops Primitive Area in 1974 was 36,600 visitor days or 0.94 percent of the total for the forest and 15 percent of the total for the district.

White River National Forest visitor use totals for 1969 and 1974 were 1,588,700 and 3,911,700 visitor-days respectively. Of this total, the Blanco District constituted 14.38 percent and 6.29 percent of the respective totals; the Blanco Ranger District average annual increase in visitation of 1.50 percent is much smaller than the 1975 percent average annual increase for the entire forest.

The White River Forest visitor-use data in Appendix D indicate the greatest average annual increase in site use was experienced at campgrounds; the second greatest increase occurred in trails recreation.

For both years, use at general undeveloped sites constituted the greatest portion of total visitor use. Roads, campgrounds, and lakes recreation also constituted large portions of total recreation visitation.

Dinosaur National Monument

Visitor-use statistics for Dinosaur National Monument are summarized in Appendix D for 1969 and for 1973.

This table indicates an average annual increase in visitation during the four-year period from 1969 to 1973 of 5.14 percent. However an analysis of yearly totals for the same period indicates the following annual changes: 1970: +9.94 percent; 1971: +10.86 percent; 1972: +20.74 percent; and 1973: -16.97 percent. Total visitation in 1974 (332,648) indicates a 19.40 percent decrease in total visitation during the last season.

Boating (river floating) has remained relatively constant since 1972 when a base ceiling was established. Notwithstanding, concession boating has experienced the greatest average annual increase during the four-year period from 1969 to 1973. Visitation at Deerlodge Park and at Lodore Ranger Station also experienced significant average annual increases, and analysis of yearly totals indicates that they experienced increases for all but the 1973 season.

Small game - waterfowl hunting

Sage grouse hunting attracted the greatest number of hunters in 1973 for all three counties combined, followed in order by cottontail rabbit and blue grouse hunting. However the greatest number of activity days (participation in any recreational activity for all or part of one day) for the three counties combined was spent on coyote hunting; cottontail rabbit hunting, the second most heavily hunted species, constituted less than one-third as many activity days.

In Routt County the most popular species in terms of numbers of hunters as well as activity days was blue grouse. Moffat County's most popular species hunted, both in terms of hunter numbers and activity days, was sage grouse. Sage grouse also attracted the greatest number of hunters in Rio Blanco County, but coyote hunters spent more than two and one-half times as many activity days than all other small game waterfowl hunting combined.

Appendix D contains a tabulation of hunter numbers and days hunted by species for each of the study area's three counties.

Big game hunting

Information on big game hunting pressure is assembled in Appendix D. Data are presented for deer and elk (firearms as well as archery use), bear and antelope hunting. Lion hunting occurred in big game units 2 and 11, but no data on hunting pressure are available.

Maximum hunter-days for each species hunted occurred in the following Game Management Units (GMU): deer (regular), GMU 11 - 17,474; deer (archery), GMU 23 - 1,405; elk (regular), GMU 14 - 9,748; elk (archery), GMU 4 -1,008 (also GMU 23 - 1,000); bear, GMU 12 - 207; and antelope, GMU 3 - 962. See

Figures RIV-30 and RIV-31 for a delineation of the game management unit reporting areas; note that antelope management units are different than those for other big game species.

Appendix D contains tabulations of both resident and non-resident deer and elk hunter origin information. User origin for resident hunters is delineated by the 13 Colorado planning regions; nonresident user origin data indicate residence by State.

The greatest resident hunting pressure in the study area comes from the Denver metropolitan area (Region three) for deer and elk alike; the greatest number of out-of-state hunters were residents of California and Texas, for deer and elk alike.

Fishing

The DOW 1972 fisheries inventory printout contains visitor-use estimates for the study area. These are summarized in Appendix D.

This survey indicates a total of 109,557 fisherman days (fishing for all or part of a day) occurred in the study area. Lake and reservoir fishing constituted 59.2 percent of this total; the remaining 40.8 percent occurred as stream fishing.

In descending order, the greatest amount of fishing occurred in Routt, Rio Blanco, and Moffat Counties, for both lake and stream fishing. Most fishing actibity occurred on National Forest lands.

A 1974 fisheries questionnaire by DOW produced some user origin information by State planning regions. Information was compiled both for stream and lake fishing; Appendix D summarizes these results. This provides a base from which to project future fishing pressure assuming uniform participation rates/population in each planning region.

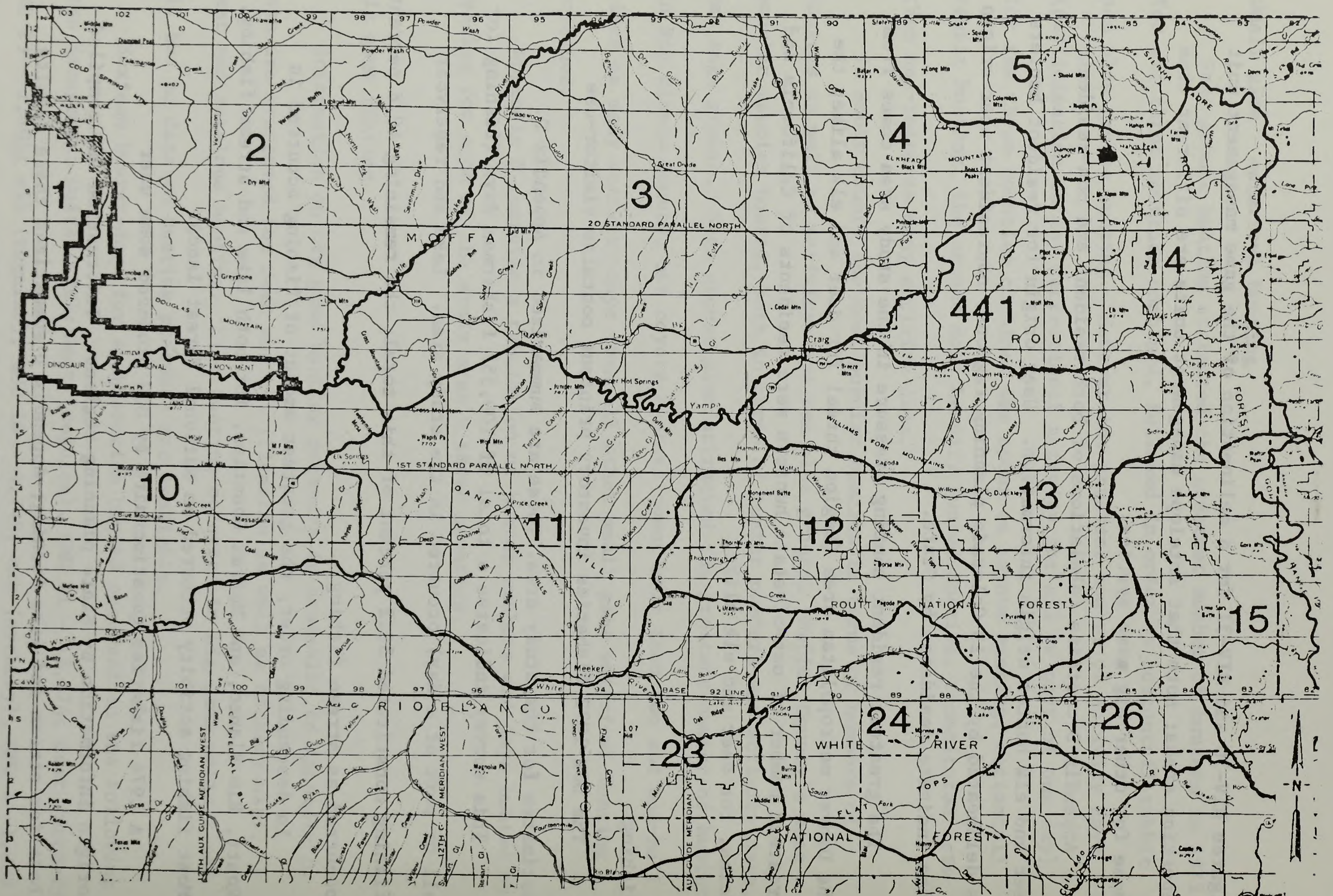

FIGURE RIV-30

Big Game Management Units.

SOURCE: Colorado Division of Wildlife

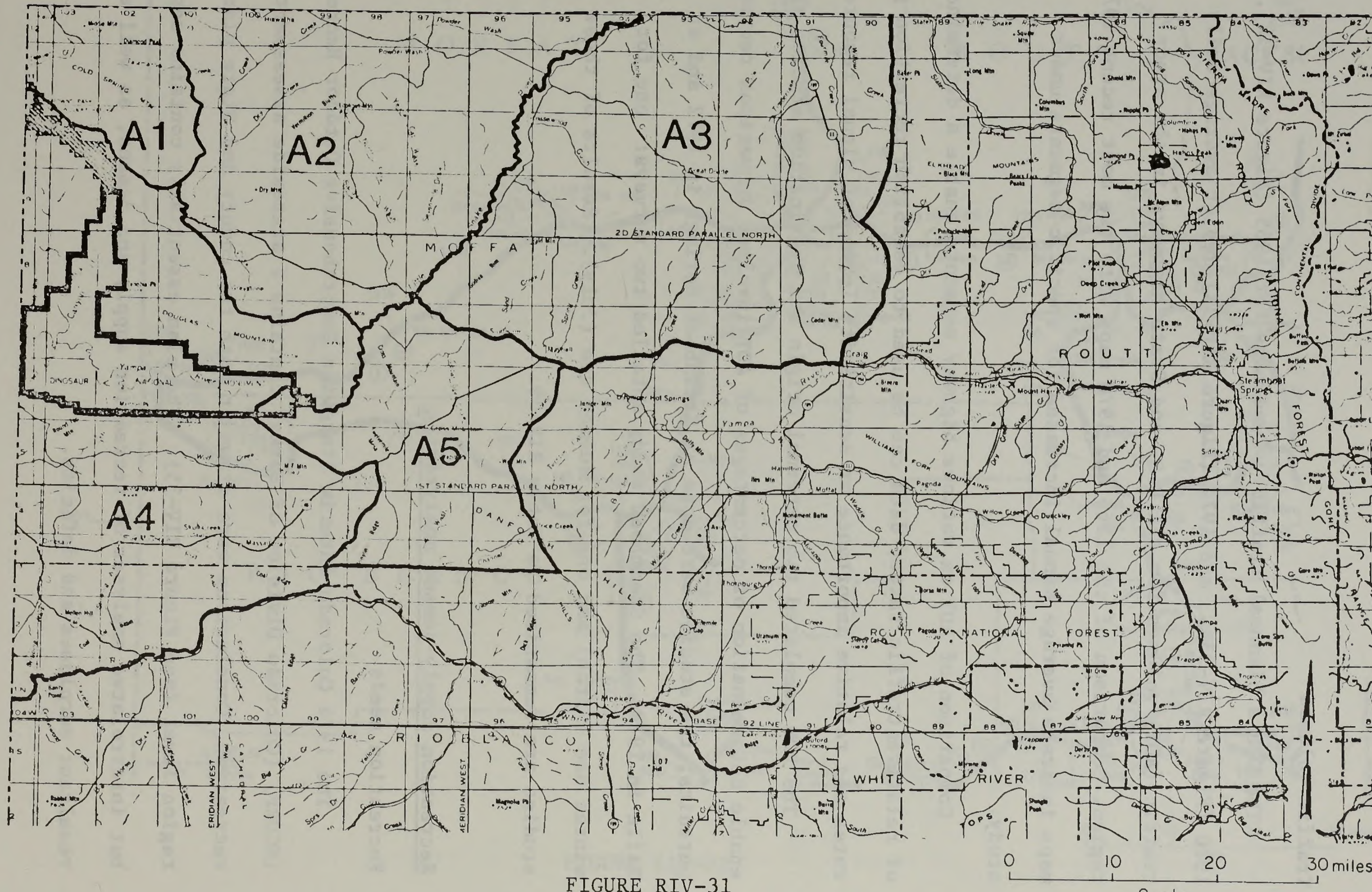

FIGURE RIV-31

Antelope Game Management Units.

SOURCE: Colorado Division of Wildlife, 1973

Traffic volumes

The DOH's biannual traffic volume maps for 1965 (Figure RIV-32), 1970 (Figure RIV-33), and 1974 (Figure RIV-34) depict average daily traffic (ADT) volumes for all U.S. and State highways in the study region. Comparison of the 1965 and 1970 maps with the most recent 1974 maps indicate average annual increases for specific segments under study.

Comparison of ADT on various highway segments enable a determination of relative traffic rates; data can be used to establish recreation participation rates and relative importance or sensitivity levels of visual resources.

The DOH completed two external origin and destination studies that enable determination of percentages of ADT involved in various recreational pursuits; the studies were done at Steamboat Springs in 1972 and at Rifle in 1973. The Steamboat study entailed two surveys: one for winter use (March) and one for summer use (July). Results of these studies are summarized in Table RIV-29.

Recreation supply-demand analysis

Recreation needs

The 1974 Colorado Interim Statewide Comprehensive Outdoor Recreation Plan (SCORP) (Colorado Division of Parks) contains a statewide assessment of outdoor recreation. Conclusions were drawn at both the county and State planning region level (see Figure RIV-35). The plan essentially contains separate but interrelated analyses of recreation supply and demand, as well as resultant surpluses and deficits.

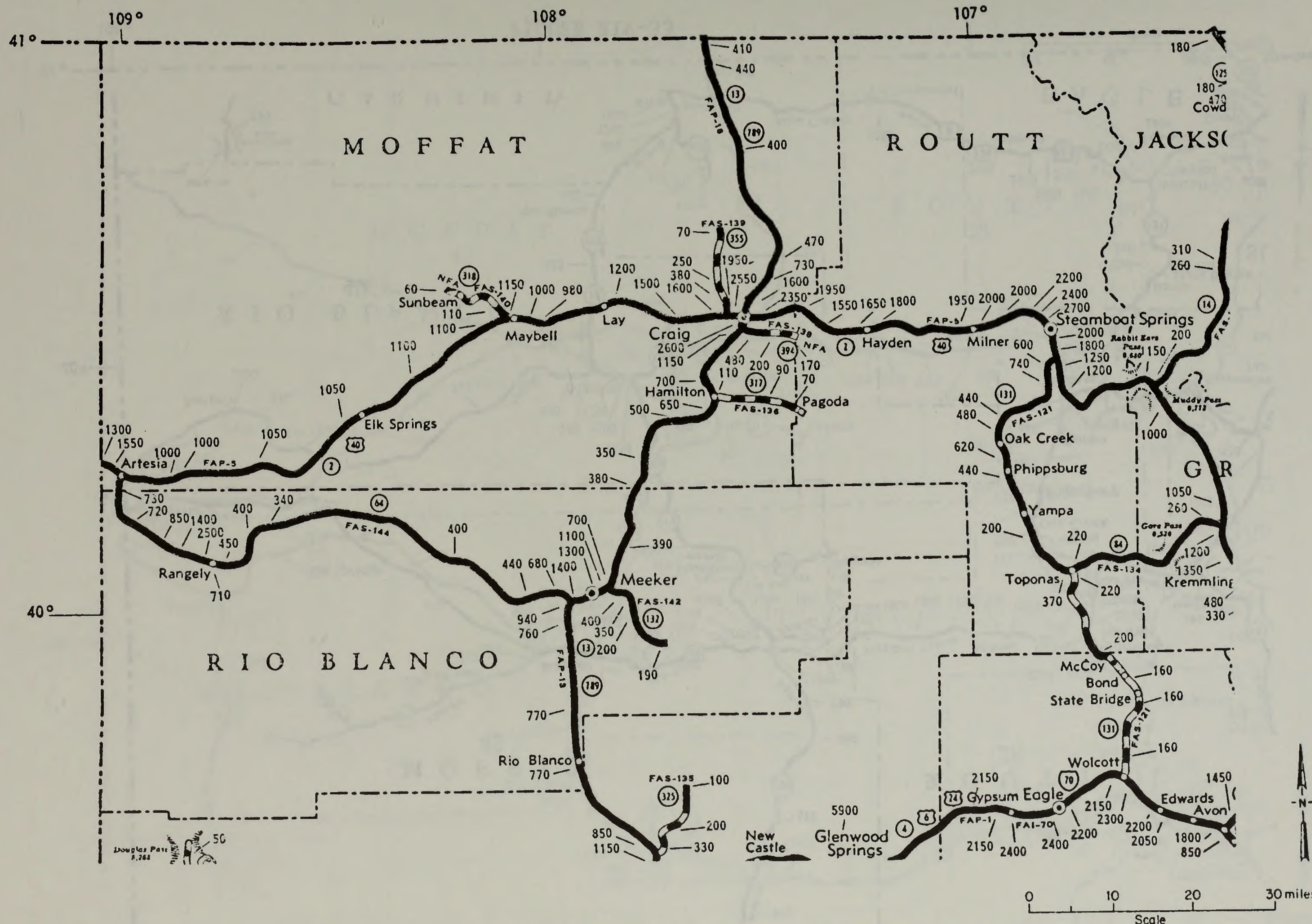

FIGURE RIV-32

Average daily traffic (ADT) volumes - 1965.

SOURCE: Colorado Division of Highways

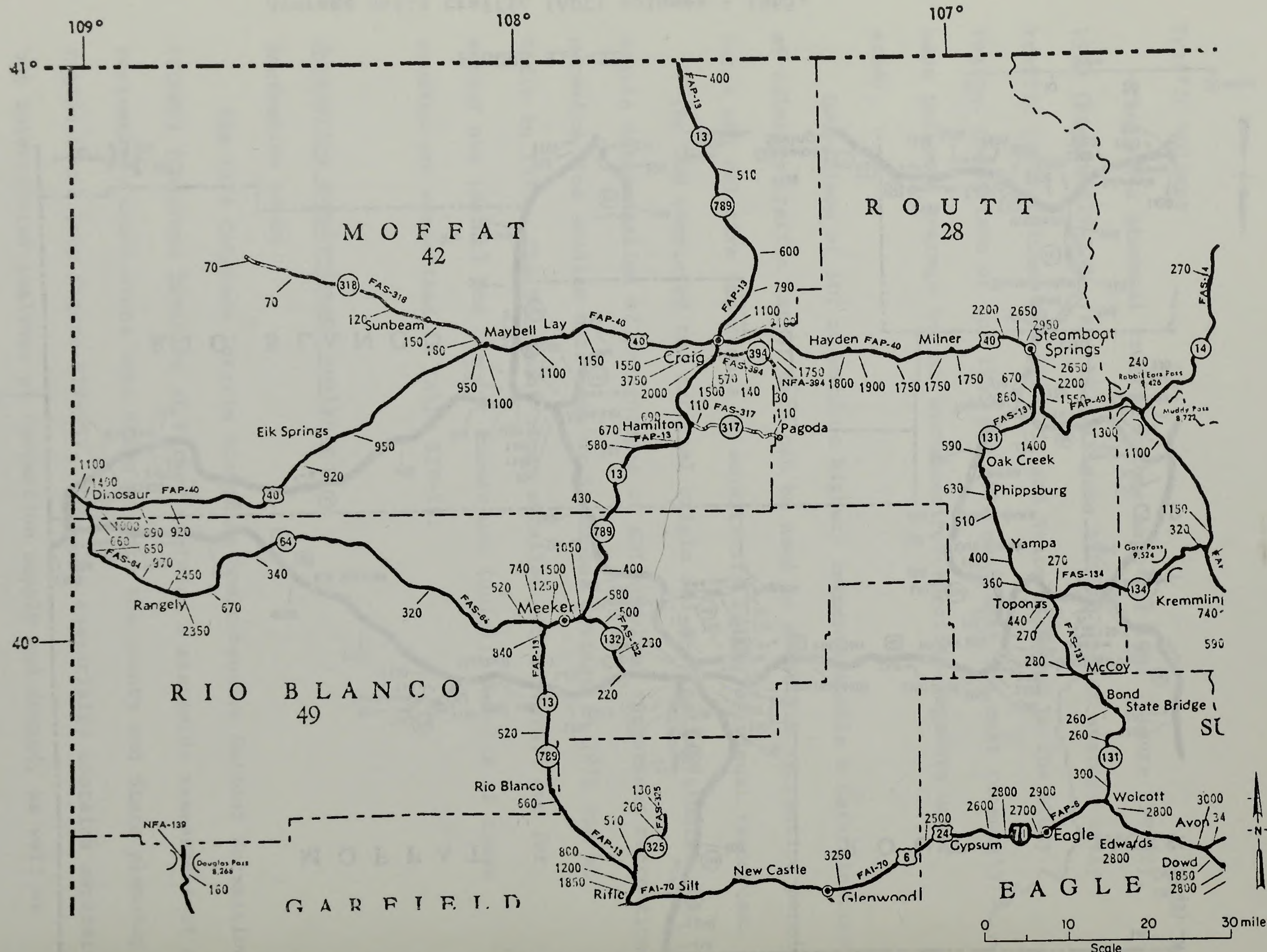

FIGURE RIV-33

Average daily Traffic (ADT) volumes - 1970.

SOURCE: Colorado Division of Highways

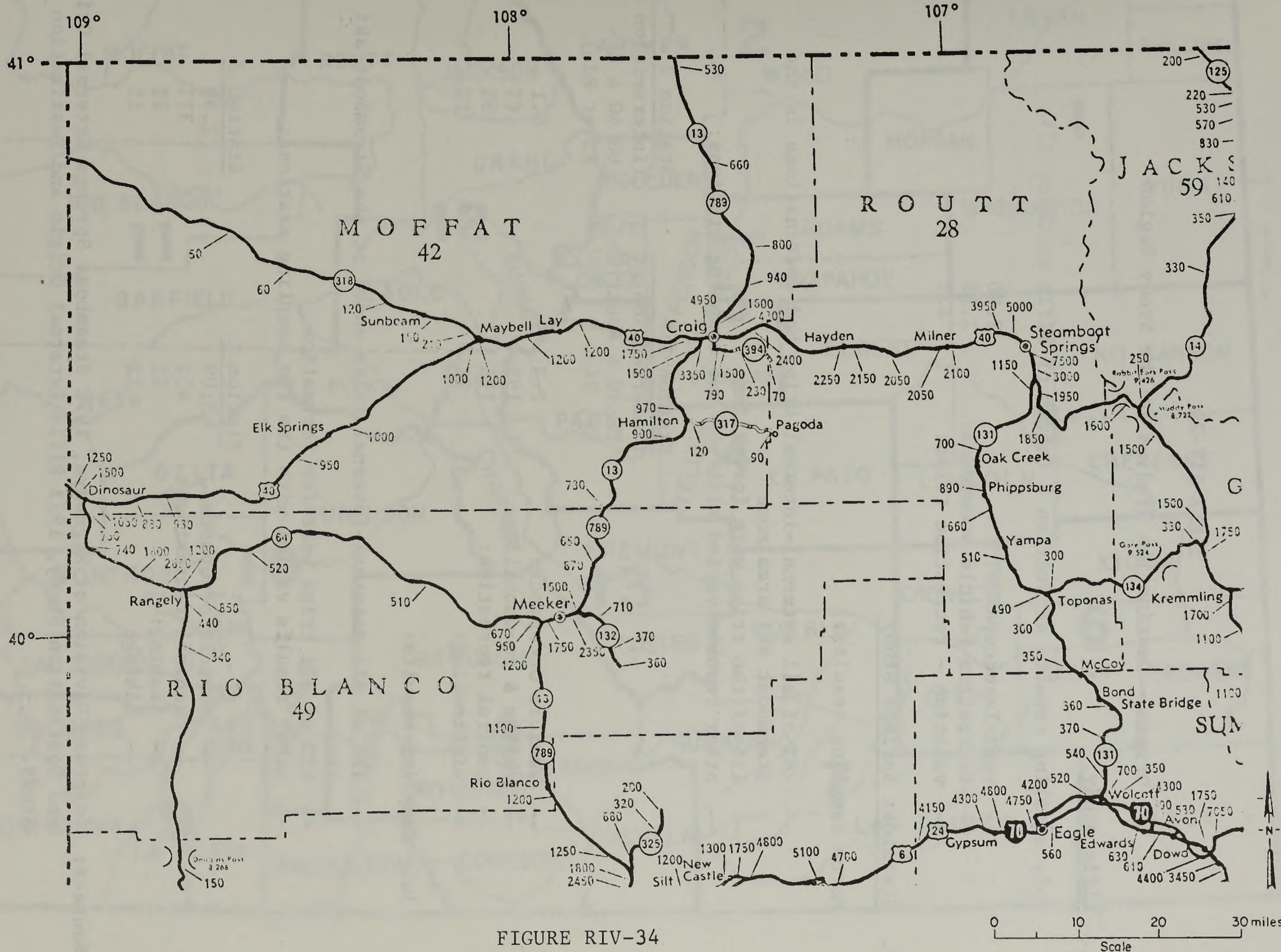

FIGURE RIV-34

Average Daily traffic (ADT) volumes - 1974.

SOURCE: Colorado Division of Highways

TABLE RIV-29

Origin - Destination Studies in the Study Region

1. Rifle study

July sampling results at Station 2 (north of Rifle on Colo. 13):

-- vehicle occupance:	2.20
-- recreation vehicle occupance:	2.95
-- vacation - recreation trips:	42%

2. Steamboat Springs study

March sampling results:

- -- 28% of all external-internal trips had destinations in the Steamboat ski area zone
- -- 13% of the trips were for skiing
- -- other results varied with the two sampling stations:

	Station 1 (Intersection of US 40 & Routt Cy. 24)	Station 2 (Intersection of US 40 & Elk River Rd.)
-- vehicle occupance:	2.3	4.1
-- skiing & snowmobiling:	19%	6%
-- general recreation:	19%	15%
-- sightseeing:	2%	1%

July sampling results:

- -- 18% of all external-internal trips ended at the Steamboat ski area
- -- 49% of all trips were for recreation
- -- other results varied with the two sampling stations:

	Station 1	Station 2
-- vehicle occupance:	3.09	2.90
-- general recreation:	45%	37%
-- fishing:	2%	2%
-- hiking:	1%	1%

Sources: Colorado Division of Highways, 1972 Steamboat Springs External Origin and Destination Study, 1973 Rifle External Origin and Destination Study.

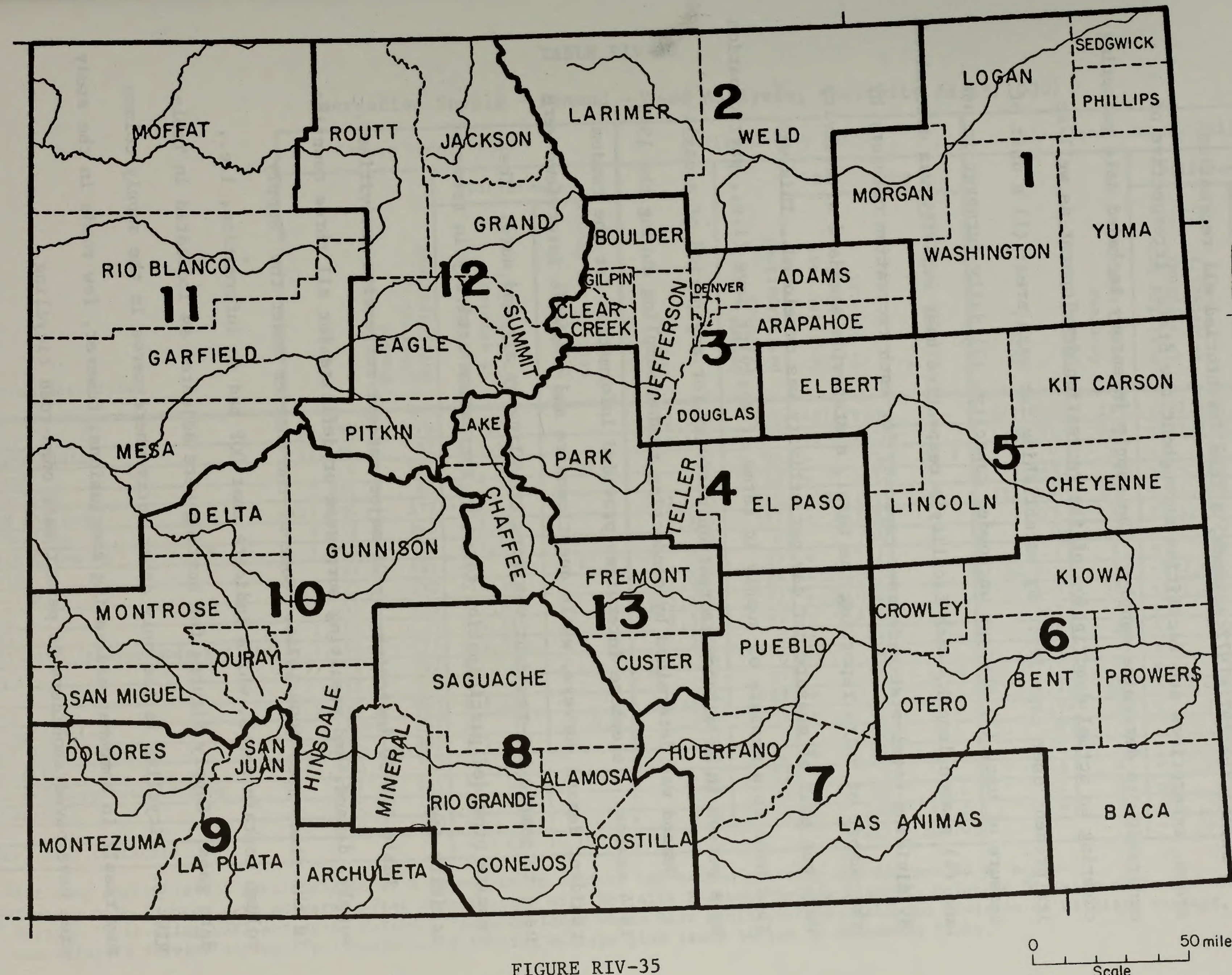

FIGURE RIV-35

13 State Planning and Management Regions.

During the 1971-1972 seasons, a team inventoried all recreation areas, enterprises and facilities throughout the State, irrespective of ownership, to determine supply. The supply inventory included data gathering covering an actual description of the recreation development as well as its present user capacity. By establishing for each area: (1) a unit of measure of use, (2) average uncrowded capacity, (3) daily turnover in use, and (4) season length, each facility's respective user capacity was determined. By dividing total statewide user capacity for each recreation category by the number of units reporting the total, a statewide standard of activity days per unit of measure per day per activity was developed. This was then used as a measure of supply in terms of activity days (i.e., participation by a person in an outdoor recreation activity for any period of a day).

Demand was determined by conducting random sampling during the 1973-1974 season. Telephone interviews provided information for the random resident demand surveys, while questionnaire and roadside interviews were used to sample non-resident visitors traveling by air and auto. The results provided participation rates by recreation activity in terms of activity days.

Table RIV-30 indicates, by 21 major outdoor recreation activities, supply, demand, and resulting surpluses or deficits for all three counties in the study area (DOP 1974). Some of the entries under the "Supply" column contain zeros, which indicate that DOP had no information, i.e., data gaps. Supply figures for hunting were adjusted as indicated in Table RIV-30. Bicycling is the only other entry where zeros in the supply column may result in somewhat misleading conclusions; however, few roads in the study area have paved shoulders to permit safe open-road bicycling.

TABLE RIV-30

Recreation Supply - Demand - Need Analysis, (Activity days*/1000)

Recreation Activities	Routt County (54)				Moffat County (41)				Rio Blanco County (52)			
			Difference				Difference				Difference	
	Supply	Demand (current participation)	Activity Days (+ surplus) (- deficit)	% of total deficit for County	Supply	Demand (current participation)	Activity Days (+ surplus) (- deficit	% of total deficit for County	Supply	Demand (current participation)	Activity Days (+ surplus) (- deficit)	% of total deficit for County
Hiking	25,290	778	+24,776		272,126	136	+271,990		227,862	178	+227,684	
Horseback Riding	13,464	32	+13,431		159,105	0	+159,105		135,096	345	+135,250	
Bicycling	0	557	- 557	68.0	0	93	- 93	35.4	0	65	- 65	54.2
Motorcycling	2,861	65	+ 2,796		443	86	+ 357		3,765	0	+ 3,765	
Driving for fun	111,990	577	+111,414		237,690	512	+237,178		111,602	297	+ 11,305	
Four wheeling	1,533	240	+ 1,293		3,355	127	+ 3,228		1,579	13	+ 1,566	
Mountain Climbing	1,883	0	+ 1,883		0	0	0		0	0	0	
Swimming	399	491	- 92	11.2	144	17	+ 127		411	15	+ 396	
Picnicking	12,822	230	+12,591		147,088	86	+147,002		122,013	13	+122,000	
Camping	22,605	753	+21,852		105,379	374	+105,006		101,609	289	+101,320	
Boating	1,114	0	+ 1,114		1,511	82	+ 1,430		562	0	+ 562	
Game Playing (playgrounds & fields)	1,456	77	+ 1,379		584	0	+ 584		806	26	+ 780	
Tennis	9	32	- 24	2.9	6	0	+ 6		4	0	+ 4	
Golf	15	0	+ 15		15	54	- 39	14.9	15	0	+ 15	
Fishing	9,191	990	+ 8,201		1,233	108	+ 1,126		3,427	551	+ 2,876	
Shooting/Hunting	160**	237	- 77	9.4	240**	199	+ 41		417**	86	+ 331	
Skiing/ Snowshoeing	4,886	2,907	+ 1,979		0	0	0		0	0	0	
Snowmobiling	1,600	22	+ 1,579		66	26	+ 45		473	0	+ 473	
Sledding-Tobogganning-Tubing	267	151	+ 116		25	22	+ 3		548	43	+ 505	
Ice Skating	2	0	+ 2		0	22	- 22	8.4	11	32	- 21	17.5
Other	0	69	- 69	8.4	0	108	- 108	41.2	0	34	- 34	28.3
Total need (deficit)			- 819	100.0%			- 262	100.0%			- 120	100.0%

*Activity days: (def.) participation by a person in an outdoor recreation activity for any period of a day.

**These supply figures were adjusted after consultation with Mr. Alan Everson, Senior Planner, Colorado Division of Parks. They were derived by totaling USFS acreages, national resource lands which have public access, Colorado Division of Wildlife acreage, U.S. Fish and Wildlife Service acreage, privately-owned hunting acreage plus lands leased by sportmens clubs.

SOURCE: Colorado Division of Parks and Outdoor Recreation.

The most popular forms of recreation in Routt, Moffat, and Rio Blanco Counties are skiing/snowshoeing, camping, and fishing, respectively. However all three counties had an ample supply of these recreation resources to prevent deficits from occurring.

Of the total deficit for each county bicycling constituted a consistently large portion of the need in all three counties. The "other" recreation activities category also accounted for a significantly large portion of the deficit in Moffat and Rio Blanco Counties.

All three counties have a surplus of recreation resources for most of the 21 activities for which data were tabulated. The greatest surpluses for the three counties occurred in the "driving for fun" category in Routt County and in the "hiking" category for Moffat and Rio Blanco Counties.

Subsequent to this strictly mathematical "needs" analysis, originally published in the 1974 Interim SCORP, is a revision based on regional coordination with county and local officials and planners; it reflects their feelings as to current needs. The following list reflects these amendments of county-wide supply-demand information from the 1976 SCORP; however, it is only valid on a State planning region basis (Figure RIV-35) and is not quantifiable.

Additional Recreation Needs Identified For State Planning Region 11:

Activity	Need	Reasons
Hiking		
Horseback Riding		
Bicycling	√	Trails and paths needed
Motorcycling	√	Need designate areas for trail use
Driving for Fun		
Four-Wheeling		
Mountain Climbing	√	Need support facilities, supply too concentrated
Swimming	√	Supply too concentrated
Picnicking	√	More picnic areas
Camping		
Boating	√	Need fast power boating support facilities
Game Playing	√	Supply too concentrated
Tennis	√	Supply too concentrated
Golf	√	Supply too concentrated
Fishiing		
Shooting/Hunting	√	Need for trap/target shooting
Skiing/snowshoeing	√	Need downhill skiing trails and support facilities
Snowmobiliing	√	Need snowmobiling trails
Sledding/tobogganning/tubing	√	Need support facilities
Ice Skating		
Other		

Additional Recreation Needs Identified For State Planning Region 12:

Activity	Need	Reasons
Hiking	√	Private land ownership, limited access, existing trails not maintained
Horseback Riding	√	Need trails along roads, existing trails not maintained
Bicycling	√	Need trails and wide shoulders on roads
Motorcycling	√	Need designate areas for trail use
Driving for Fun		
Four-Wheeling	√	Need designated areas, maintenance and law endorcement
Mountain Climbing	√	Need access, trailheads, and support facilities
Swimming		
Picnicking		
Camping	√	Need special group camping facilities
Boating	√	Need parking areas at access points
Game Playing	√	Need access and support facilities for field games
Tennis		
Golf		
Fishing	√	Privat land ownership effectively blocks access
Shooting/Hunting		
Skiing/snowshoeing	√	Cross country support facilities and designated trails
Snowmobiling	√	Need competition areas
Sledding/tobogganning/tubing	√	Need designated areas
Ice Skating		
Other		

User origin

The 1974 Interim Colorado Comprehensive Outdoor Recreation Plan also includes an analysis of recreation user residences. Four tables have been developed to indicate: first, in what State planning regions residents of Region 11 and 12 recreate (Tables RIV-31 and RIV-32), and secondly, the residence of those recreating in Regions 11 and 12 (Tables RIV-33 and RIV-34).

Tables RIV-31 and RIV-32 establish an information base from which to project future demand for recreation resources outside the study area. Tables RIV-33 and RIV-34 enable a determination of future demand for recreational resources within the study area. These projections of course must assume uniform per capita recreation participation rates as population increases occur in each region.

Population estimates essential to these projections will be derived in subsequent sections of this statement.

Most recreation users in Region 11 (73.2 percent) were residents. However in Region 12 there were more non-resident (out-of-state: 53.5 percent) users than resident. Non-residents (26.8 percent) and Region 3 residents (Denver Metro area: 14.7 percent) were the second and third greatest user groups in Region 11, while in region 12 the second and third greatest user groups came from Region 12 itself (23.7 percent) and the Denver Metro area (14.6 percent).

Social Environment

Demographic features, social support facilities, and attitudes and lifestyles are the basic elements of any social environment. The following

TABLE RIV-31

1974

Number of Recreation Users from Region 11

Using Recreational Facilities in Other Planning Regions

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	Total Users
Hiking										313,036	2,234,427	215,887	43,177	
Horseback Riding											205,092			
Bicycling											4,047,874			
Motorcycling		21,589								64,766	593,688			
Driving for Fun		43,177	172,709	194,298						313,036	939,107	107,943	43,177	
Four-Wheeling									43,177		237,475	21,589		
Mountain Climbing														
Swimming										64,766	1,133,405	43,077		
Picnicking		43,177								21,589	589,688	151,121		
Camping		75,560							43,177	215,887	302,241			
Boating										21,589	356,213			
Game Playing				21,589			43,178				1,349,292			
Tennis											194,298	32,383		
Golf											356,213			
Fishing										215,887	1,727,096	140,326		
Shooting/Hunting									43,177	43,177	431,774	21,589		
Skiing/snowshoeing											248,270	10,794		
Snowmobiling											151,121			
Sledding/tobogganing/tubing											356,213			
Ice Skating											53,972			
Other		64,766		21,589							442,568			
Region Totals		496,538	172,709	474,952			43,178		259,065	2547466	31,886,054	1,489,418	86,354	37,455,734
% of Total Use By Region 11 Residents	0.0	1.3	0.5	1.3		0.0	0.1	0.0	0.7	6.8	85.1	4.0	0.2	

Units: Activity days

TABLE RIV-32

1974

Number of Recreation Users from Region 12

Using Recreational Facilities in Other Planning Regions

Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	Total Users
Hiking			86,354									3,141,944		
Horseback Riding												604,483		
Bicycling												2,288,398	269,859	
Motorcycling												172,709		
Driving for Fun			53,971				64,766				21,589	183,504	183,504	
Four-Wheeling												140,326		
Mountain Climbing			10,794							10,794			21,589	
Swimming			43,177								21,589	582,894		
Picnicking												151,120		
Camping											86,355	151,121	21,589	
Boating												269,858		
Game Playing												302,242		
Tennis												205,092		
Golf												53,972		
Fishing												464,156	21,589	
Shooting/Hunting												107,943		
Skiing/snowshoeing			43,177									3,842,382	53,972	
Snowmobiling												183,504		
Sledding/tobogganing/tubing												237,475		
Ice Skating												485,745		
Other			53,972									118,738		
Region Totals			582,890				64,766			10,794	129,533	27,395,212	1,144,204	29,327,399
% of Total Use by Region 12 Residents	0.0	0.0	2.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.4	93.4	3.9	

Units: Activity days

TABLE RIV-33

1974

Number of Recreation Users in Region 11

Recreation users from Region:

Recreation Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	Non-resident	Total users
Hiking			334,624								2,234,427		32,383	528,540	3,129,974
Horseback Riding			550,511							43,177	205,092		32,383		831,163
Bicycling										75,560	4,047,874			42,947	4,166,381
Motorcycling			118,737								593,688			34,357	746,782
Driving for Fun		10,794	151,120							64,766	939,107	21,589		2,474,398	3,661,774
Four-Wheeling			291,447	43,177			10,794				237,475			94,483	677,376
Mountain Climbing															
Swimming			259,064	10,794							1,133,405	21,589		307,217	1,732,069
Picnicking			161,915							75,560	593,688			687,740	1,518,903
Camping			356,213	43,177	64,766		43,177			32,383	302,241	86,355	32,383	849,828	1,810,523
Boating			64,767								356,213			73,009	493,989
Game playing			43,177								1,349,292			64,420	1,456,889
Tennis											194,298			8,589	202,887
Golf			43,177								356,213			17,179	416,569
Fishing			971,490		64,766	10,794	10,794			53,972	1,727,096		64,766	473,305	3,376,983
Shooting/Hunting			151,121	43,177							431,774			142,615	768,687
Skiing/snowshoeing				10,794						10,794	248,270			182,158	452,016
Snowmobiling										43,177	151,121				194,298
Sledding/tobogganning/tubing											356,213				356,213
Ice Skating											53,972				53,972
Other										21,589	442,568			373,635	837,792
Region Totals		10,794	3,497,363	151,119	129,532	10,794	64,765	0	0	420,978	15,954,027	129,533	161,915	6,354,420	26,385,249
% of Total Region Use		0.0	13.0	0.6	0.5	0.0	0.2	0	0	1.6	59.3	0.5	0.6	23.6	

Units: Activity days

TABLE RIV-34

1974

Number of Recreation Users in Region 12

Recreation users from Region:

Recreation Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	Non-resident	Total users
Hiking		248,270	982,284	86,355							215,887	3,151,944		3,492,793	8,177,533
Horseback Riding		64,766										604,483	43,177	421,176	1,133,602
Bicycling			129,532									2,288,398		136,322	2,554,252
Motorcycling		43,178	53,971									172,709		64,420	334,278
Driving for Fun		205,098	464,156	161,915	43,177						107,943	183,504	10,794	6,686,339	7,862,926
Four-Wheeling		21,589	356,213								21,589	140,326		1,074,202	1,613,919
Mountain Climbing			129,532											47,539	177,071
Swimming			129,532	129,532							43,177	582,894		1,031,176	1,916,311
Picnicking		43,177	161,915								151,121	151,120		1,567,728	2,075,061
Camping	172,709	313,036	1,262,936	161,915								151,121		2,255,907	4,317,624
Boating		21,589	86,355	129,532								269,858		158,497	665,831
Game Playing		302,242										302,242		213,031	817,515
Tennis			21,589								32,383	205,092	21,589	200,113	480,766
Golf								10,794				53,972		358,536	423,302
Fishing	172,709	582,894	1,878,213	161,195							140,326	464,156		2,563,978	5,963,471
Shooting/Hunting		107,943	388,596	21,589					32,383		21,589	107,943	32,383	377,118	1,089,544
Skiing/snowshoeing	21,589	97,148	2,137,276	442,568			43,177				10,794	3,842,832	21,589	9,010,399	15,627,372
Snowmobiling			43,177									183,504		164,385	391,066
Sledding/Tobogganing/tubing			161,915									237,475		329,364	728,754
Ice Skating												485,745		121,438	607,183
Other												118,738		416,582	535,320
Region Total	367,007	2,050,93	3,387,192	1,294,601	43,177	0	43,177	10,794	32,383	0	744,809	13,698,056	129,532	30,691,043	57,492,701
% of Total Region Use	0.6	3.6	14.6	2.3	0.1	0	0.1	0.0	0.1	0	1.3	23.8	0.2	53.4	

Units: Activity days

description of these social elements of the study region provides the analytic base for both projection of the future social environment without the proposed actions, and determination of the social impacts of these actions.

Demographic features

Examination of Table RIV-35 indicates that over the period from 1950-1970, the three county study region experienced a slight decline in total population at an annual compound rate of -0.44%. This decrease was probably the result of two events: (1) the general national trend of migration from rural to urban areas, and (2) the decline of the region's coal industry in the early 1950s.

The age distribution of the study region's population, presented in Figures RIV-36 through RIV-38, provides further insight into the nature of the population decrease. The normal age distribution pattern for a balanced population is characterized by progressively lower percentages of population in succeeding higher age classes. The 1950 age distribution of the study region's population approximates this normal pattern with one notable exception. The 20-24 year age class, 6.55 percent of the population, is smaller than both of the adjoining age classes. This departure from the normal pattern is likely further evidence of the trend of out-migration from rural areas, and identifies the 20-24 year age class as the portion of the population who sought better employment opportunities in urban areas.

TABLE RIV-35

Salient Population and Social Statistics for the Study Region

	1950	1960	1970	1973	Colorado (1973)	Nation (1973)
Population						
Moffat	5,946	7,061	6,525	6,445		
Rio Blanco	4,719	5,150	4,842	4,403		
Routt	8,940	5,900	6,592	7,873		
Study Region Total	19,605	18,111	17,959	18,721		
Population Density (people/sq. mile)						
Moffat	1.3	1.5	1.4	1.4	24.0	59.0
Rio Blanco	1.5	1.6	1.5	1.3		
Routt	3.9	2.5	2.8	3.4		
Births 1/						
Moffat	22.9	26.6	15.3	15.7	15.5	15.0
Rio Blanco	30.7	30.3	17.1	15.0		
Routt	22.6	22.5	19.1	15.2		
Deaths 1/						
Moffat	7.4	7.2	8.9	9.5	7.5	9.4
Rio Blanco	6.2	7.8	10.3	10.2		
Routt	8.4	10.5	9.9	7.4		
Marriages 1/						
Moffat	*	10.2	11.2	11.3	11.3	10.9
Rio Blanco	*	7.0	10.1	11.4		
Routt	*	8.8	10.2	12.2		
Dissolutions 1/						
Moffat	*	3.6 4/	1.4	4.3	5.8	4.4
Rio Blanco	*	2.4 4/	1.4	4.3		
Routt	*	2.3 4/	1.8	3.8		
Median Age (years)						
Moffat	28.3	26.9	29.7	--	26.2 3/	28.0 3/
Rio Blanco	27.2	26.5	26.9	--		
Routt	28.4	32.0	28.4	--		

* Not reported.

1/, 3/, and 4/ see following page.

TABLE RIV-35 (Cont.)

Salient Population and Social Statistics for the Study Region

	1950	1960	1970	1973	Colorado (1973)	Nation (1973)
Education 2/						
Moffat			12.2	--	12.4 3/	12.3 3/
Rio Blanco			12.4	--		
Routt			12.4	--		
Crime 6/	5/	5/				
Murder and non-negligent manslaughter			5.6	5.6	7.9	9.3
Forcible rape			16.7	22.3	38.7	24.3
Robbery			16.7	11.1	162.9	182.4
Aggravated assault			45.0	234.0	204.0	198.0
Burglary			334.0	1,509.0	1,599.0	1,211.0
Larceny-theft			1,002.0	3,814.0	2,911.0	2.051.0
Auto theft			45.0	245.0	573.0	440.0

* Not reported.

1/ Rate per thousand population.
2/ Median grade completed for persons 25 years or older.
3/ 1970 figure.
4/ 1966 figure.
5/ Data not available.
6/ All crime data shown as rates per 100,000 population; three-county totals.

SOURCE: U.S. Bureau of the Census, 1950, 1960, and 1970
Colorado Department of Health, Records, and Statistics Section
Colorado Division of Criminal Justice

		Percent Male	Percent Female
65 and older:	6.39%	3.72	2.67
60-64 years:	3.75%	2.29	1.46
55-59 years:	4.51%	2.56	1.95
50-54 years:	4.69%	2.68	2.01
45-49 years:	5.37%	2.87	2.49
40-44 years:	6.62%	3.60	3.01
35-39 years:	7.74%	4.13	3.61
30-34 years:	7.82%	3.95	3.87
25-29 years:	7.79%	3.97	3.82
20-24 years:	6.55%	3.24	3.31
15-19 years:	7.57%	3.90	3.68
10-14 years:	9.06%	4.87	4.19
5-9 years:	10.34%	5.45	4.88
Under 5 years:	11.79%	5.97	5.82
Total Population:	**19,605**	52.23	46.77

Note: Percentage data may not add due to rounding.

Figure RIV-36

1950 age distribution: three county region.

		Percent Male	Percent Female
65 and older:	8.51%	4.58	3.93
60-64 yrs:	3.39%	1.83	1.53
55-59 years:	4.35%	2.28	2.07
50-54 years:	5.38%	2.97	2.41
45-49 years:	6.37%	3.47	2.90
40-44 years:	6.47%	3.14	3.32
35-39 years:	6.68%	3.53	3.15
30-34 years:	6.46%	3.27	3.19
25-29 years:	6.24%	3.15	3.10
20-24 years:	5.38%	2.42	2.96
15-19 years:	7.44%	3.91	3.53
10-14 years:	9.97%	4.93	5.05
5-9 years:	11.18%	5.64	6.09
Under 5 years:	12.23%	6.13	6.10
Total Population:	**18,111**	51.23	48.77

Note: Percentage data may not add due to rounding.

Figure RIV-37

1960 age distribution: three county region.

Age group	Percent of total	Percent Male	Percent Female
65 and older	9.50%	4.44	5.06
60-64 years	4.26%	2.24	2.02
55-59 years	5.11%	2.66	2.44
50-54 years	5.35%	2.73	2.61
45-49 years	5.88%	3.09	2.79
40-44 years	6.04%	2.98	3.06
35-39 years	5.99%	2.97	3.01
30-34 years	5.98%	2.92	3.06
25-29 years	6.33%	3.19	3.14
20-24 years	6.14%	2.88	3.26
15-19 years	10.11%	5.47	4.63
10-14 years	10.87%	5.55	5.32
5-9 years	10.50%	5.37	5.13
Under 5 years	7.97%	4.22	3.75
Total Population:	**17,959**	**50.72**	**49.29**

Note: Percentage data may not add due to rounding.

Figure RIV-38

1970 age distribution: three county region.

The 1960 regional age distribution is quite similar to that of 1950 with the same out-migration aberration in the 20-24 year age class. The most notable change from the 1950 pattern is substantial increase in the portion of the population 65 years and older; this is evidence of the national trend of increased longevity and the upward movement of the 55-64 age group from the 1950 distribution.

In the 1970 age distribution the six classes spanning the ages from 20 to 49 years are virtually equal in size; this is the result of 20 years of continued out-migration. Table RIV-35 shows a sharp drop in births per thousand population between 1960 and 1970; this end of the "baby-boom" resulted in the decline of the portion of 1970 population under five years old. If these two demographic features, out-migration and low birth rates, were to continue, the study region would continue to experience a decreasing population; however, structural changes in the economy of the region have caused a turnaround in this trend.

Table RIV-35 indicates the 1973 estimated population for the study region has increased by 762 people over 1970. An estimate of 1974 population, derived from the gravity-employment multiplier model (see Appendix D), suggests the study region has grown to 21,660 people. These increases are probably the result of renewed interest in exploition of energy resources of the region and rapid development of winter recreational facilities in Routt County.

The principal population centers in the study region are Craig, Steamboat Springs, Meeker, Rangely, Hayden, Oak Creek, Yampa, and Dinosaur.

Craig is the largest community in the region with a current population of about 6,000. (Note that this figure represents the population of the "metropolitan" community rather than the population living within the city limits; this is true of all further references to community population data.) Historically Craig has been an agricultural and retail trade center with a relatively stable population level, but in the last two years has experienced rapid growth as a result of Colorado Ute Electric Association's development of a 760-megawatt coal-fired generating plant six miles south of the town.

Steamboat Springs, with a current permanent population approaching 6,000 has also been an agricultural, coal mining, and retail trade center, but over the past five years has developed a strong year-round recreation industry. In the summer and fall the town is a base for fishermen, hunters, campers, and sightseers. In the winter months the Mt. Werner ski area and vast expanses of snow-covered terrain attract large numbers of downhill and cross-country skiers, snowmobilers, and snowshoers. Thse recreation resources have been known to attract 6,000 additonal people to the Steamboat Springs area on a peak daily basis.

Hayden, with a current population of about 1,700, has been an agricultural and coal mining center, but has experienced, like Craig, a rapid population growth in the last two years because of both the development of the Colorado Ute power plant near Craig and the construction of that company's second unit of the Hayden power plant. The Yampa Valley Airport east of Hayden is served with daily flights by Frontier Airlines and is the only airport in the study region offering direct interstate air transportation.

Meeker, with a current population of about 1,800, is an agricultural and retail trade center. With large deposits of oil shale in the Piceance Basin southwest of the town, Meeker has been experiencing some recent population growth as preliminary development of these resources proceeds.

Rangely, with a current population of about 1,700, is showing some population growth due to oil shale developments both in Colorado and Utah. Historically the town has been an agricultural and oil and gas-producing center. Most of the recent population growth has been caused by renewed oil and gas exploration and development in the area.

Oak Creek and Yampa, with current populations of about 1,100 and 350 respectively, are principally coal mining and summer recreation centers. Dinosaur, with a current population of 300, serves as the southern entrance to Dinosaur National Park and is the location of the Park headquarters.

<u>Social support facilities</u>

For the purposes of this analysis, social support facilities include housing, medical and allied health care facilities, elementary and secondary education, water and sewage treatment facilities, fire protection and law enforcement. With the exception of housing and private health care facilities all of these items fall in the category of public goods and services, i.e., those resources of an economic system that are demanded and consumed collectively by the population of that system. Corresponding decisions to allocate these resources are generally made by the censensus of the population through their representative government rather than by the mechanisms of the free market system. Housing is a private good which is allocated through the workings of the free-market system. The extent of these social support facilities in seven of the eight population centers are shown in Tables RIV-36 through RIV-38.

Generally vacant housing withing the study region is scarce. Home prices in the principal communities have risen drastically in the past few years. For example, houses in the Craig area sold for approximately 25-30 dollars per square foot in 1972. These same houses are now selling for 35-40 dollars per square foot. The number of mobile homes, in response to the shortage of permanent dwelling space, has increased from ten percent of total dwelling units in 1970 to 20 percent in 1974. Rental space in multiple family units is also in short supply, with the exception of the Steamboat Springs area where there is a traditional seasonal fluctuation in rental vacancy rates, corresponding to the winter recreational demands.

Hospital facilities in the study region vary in quality. Of the five hospitals in the study region, only two are accredited by the U.S. Public Health service. All facilities show a need for additional medical doctors.

In terms of numbers of classrooms and teachers, educational facilities in the study region are adequate to meet the needs of the existing school age population, although quality and spatial distribution of structures

TABLE RIV-36

Social Support Facilities: Moffat County

	Craig	Dinosaur	Remaining County	County Total
Housing:				
Total dwelling units	2,457	85	575	3,117
Mobile homes	675	15	63	753
Medical Care:				
Hospital?	Yes	No		NA
Number of beds	30	NA		30
Number of doctors (MD)	5	--		5
Full-time professional staff	34	NA		34
Part-time professional staff	17	NA		17
Full-time non-health staff	26	NA		26
Part-time non-health staff	6	NA		6
Hospital accredited	Yes	NA		NA
Nearest hospital or MD (miles)	NA	18		NA
Allied Health Care:				
Non-hospital RNs, LPNs	10	--		10
Dentists	8	--		8
Optometrists	2	--		2
Psychiatrists	-	--		--
Ambulances	*	*		2
Ambulance drivers, attendants	*	*		13
Licensed bed capacity of long-term care facilities	80	--		80
Elementary, Secondary Education				
Number of classrooms	107	2/		107
Number of teachers	108			108
Enrollment	1,994			1,994
Water Treatment				
Treatment capacity (1,000 gal/day)	600	80		
Average use (1,000 gal/day)	1,000	40		
Sewage Treatment:				
Treatment capacity (1,000 gal/day)	600	80		
Average use (1,000 gal/day)	1,000	40		
Fire Protection:				
Number of pumpers	2	2		4
Total pumping capacity (gal/min)	1,750	750		2,500
Number of firemen	20	20		40

TABLE RIV-36 (Cont.)

Social Support Facilities: Moffat County

	Craig	Dinosaur	Remaining County	County Total
Law Enforcement:				
Number of officers	1/	1/	11	11
Number of vehicles			7	7
Capacity of jail			24	24

* No community data available.

1/ Moffat County and Craig have a joint police-sheriff's department.
2/ Dinosaur data included with Craig.

SOURCE: Housing Data: Don Gibony, Moffat County Planner

Medical and Health Care: EPA, 1975; Colorado Department of Health

Education: Ed Townsend, Superintendent of Schools

Water Treatment: EPA, 1975

Sewage Treatment: Colorado Department of Health, 1974 and VTN, 1975

Fire Protection: Craig: VTN, 1975 Dinosaur: Jim Lee, Fire Chief

Law Enforcement: Bob Kelly, Moffat County Sheriff

TABLE RIV-37

Social Support Facilities: Rio Blanco County

	Meeker	Rangely	Remaining County	County Total
Housing:				
Total dwelling units	670	600	861	2,131
Mobile homes	50	150	122	322
Medical Care:				
Hospital?	Yes	Yes		NA
Number of beds	20	28		48
Number of doctors (MD)	2	3		5
Full-time professional staff	15	13		28
Part-time professional staff	6	14		20
Full-time non-health staff	12	20		32
Part-time non-health staff	2	2		4
Hospital accredited	Yes	No		NA
Allied Health Care:				
Non-hospital RNs, LPNs	*	*		10
Dentists	1	1		2
Optometrists	--	--		--
Psychiatrists	--	--		--
Ambulances	*	*		3
Ambulance drivers, attendants	*	*		18
Licensed bed capacity of long-term care facilities	25	--		25
Elementary, Secondary Education:				
Number of classrooms	44	46		90
Number of teachers	39	46		85
Enrollment	694	591		1,285
Water Treatment:				
Treatment capacity (1,000 gal/day)	200	1,440		
Average use (1,000 gal/day)	275	720		
Sewage Treatment				
Treatment capacity (1,000 gal/day)	200	1,440		
Average use (1,000 gal/day)	275	720		
Fire Protection:				
Number of pumpers	4	2		6
Total pumping capacity (gal/min)	1,225	1,000		3,255
Number of firemen	30	25		55

TABLE RIV-37 (Cont.)

Social Support Facilities: Rio Blanco County

	Meeker	Rangely	Remaining County	County Total
Law Enforcement:				
Number of officers	3	2	6	13
Number of vehicles	2	2	5	9
Capacity of jail	1/	4 1/	12 1/	16

* Community data not available.

1/ Meeker and Rangely use the Rio Blanco County jail in Meeker. Rangely's jail facilities are for temporary detention only.

SOURCE: Housing: Duane Rehborg, Moffat County Planner; Jim Calhoun, Meeker Town Manager-Clerk; Dan Giltz, Rangely Town Administrator

Health care: EPA, 1975; Colorado Department of Health

Education: Betty Gilbow, Rangely School District; Bob King, Superintendent, Meeker School District

Water treatment: VTN, 1975; Dan Giltz, Rangely Town Administrator

Sewage Treatment: VTN, 1975; Dan Giltz, Rangely Town Administrator

Fire Protection: Bill Lucki, Meeker Fire Chief; Don Chism, Rangely Fire Chief

Law Enforcement: Robert Craft, Moffat County Sheriff; Dan Giltz, Rangely Town Administrator

TABLE RIV-38

Social Support Facilities: Routt County

	Hayden	Oak Creek	Steamboat Springs	Yampa	Remaining County	County Totals
Housing:						
Total dwelling units	545	693	2,780	3/	655	4,683
Mobile homes	169	87	352		122	730
Health Care:						
Hospital?	Yes 1/	No	Yes	No		NA
Number of beds	10	NA	20	NA		30
Number of doctors (MD)	--	1	7	--		8
Full-time professional staff	--	NA	28	NA		28
Part-time professional staff	--	NA	5/	NA		
Full-time non-health staff	--	NA	6/	NA		
Part-time non-health staff	--	NA	6/	NA		
Hospital accredited	--	NA	No	NA		
Nearest hospital or MD (miles)	17	NA	NA	8		NA
Allied Health Care:						
Non-hospital RNs, LPNs	*	*	*	*		22
Dentists	1	--	5	--		6
Optometrists	--	--	2	--		2
Psychiatrists	--	--	--	--		--
Ambulances	*	*	*	*		5
Ambulance drivers, attendants	*	*	*	*		50
Licensed bed capacity of long-term care facilities	--	--	60	--		60
Elementary, Secondary Education:						
Number of classrooms	28	30	72	4/		130
Number of teachers	32	35	80			147
Enrollment	445	400	1,198			2,043
Water Treatment:						
Treatment capacity (1,000 gal/day)	120	300	4,450	500		
Average use (1,000 gal/day)	170	250	1,400	250		

TABLE RIV-38 (Cont.)

Social Support Facilities: Routt County

	Hayden	Oak Creek	Steamboat Springs	Yampa	Remaining County	County Totals
Sewage Treatment:						
Treatment capacity (1,000 gal/day)	250	250	1,950	500		
Average use (1,000 gal/day)	170	150	1,650	250		
Fire Protection:						
Number of pumpers	2	2	3	1		8
Total pumping (gal/min)	750	1,250	1,250	250		3,500
Number of firemen	13	23	14	10		60
Law Enforcement:						
Number of officers	2	2	13	1	10	28
Number of vehicles	1	1	5	1	4	12
Capacity of jail	2/	2/	2/	2/	15	15

* Not reported by community.

1/ Hayden hospital is closed until a doctor is hired.
2/ Hayden, Oak Creek, Yampa, and Steamboat Springs use the Routt County Jail in Steamboat Springs.
3/ Included in remaining county data.
4/ Included in Oak Creek data.
5/ Included in full-time.
6/ Not reported.

SOURCE: Housing: Charles Gathers and Associates, 1975

Health Care: EPA, 1975

Education: George Sauer, Superintendent, Steamboat Springs School District; Bill Meek, Superintendent, South Routt County School District; Doug McClure, Hayden School District

Water treatment: Ed Carpenter, Plateau Engineering; John Yurich, Oak Creek Superintendent of Public Works; Jim Vogel, City of Steamboat Springs; John Fetcher, Mt. Werner Water and Sanitation District; Daryl Hansen, Yampa Town Board

TABLE RIV-38 (Cont.)

SOURCE: Sewage Treatment: (same as water treatment)

Fire Protection: Michael Green, Hayden Fire Chief; John Yurich, Oak Creek Superintendent of Public Works; Bill Davis, Steamboat Springs Fire Chief; Aaron Huffstetler, Yampa Fire Chief

Law Enforcement: Jack Falk, Hayden Police Chief; John Yurich, Oak Creek Superintendent of Public Works; Chuck Gubisch, City of Steamboat Springs; Gale May, Routt County government Officer Booth, Town of Yampa are not reflected in these data. School boards in Hayden, Craig, Meeker, and Rangely are seriously concerned about rapid increases in enrollment that are resulting from expanded energy development in the study region. Craig schools will go to double sessions for grades kindergarten through twelve in the fall of 1976.

Adequacy of water treatment facilities varies widely in the study region. In Craig and Yampa there is sufficient capacity to meet some increase in use. In the Steamboat Springs area, substantial excess capacity exists in the Mt. Werner District, but the "old town" area has experienced some difficulty in meeting peak demands in summer months. In Hayden, the water treatment plant and pump line from the plant to the elevated storage is inadequate to meet existing requirements; the city is considering refurbishing this system. In Meeker the water treatment plant is over-utilized; the city is considering alternative plans to upgrade and expand the system. The systems in Rangely, Oak Creek, and Dinosaur all have difficulty in meeting peak demands.

Sewage treatment facilities in the population centers of the study region also vary in adequacy. Most are subject to some overloading from infiltration of ground water through deteriorating collection lines. (Note that the following discussion emphasizes capabilities to treat volumes of sewage flow; the chemical characteristics of sewage plant effluents are tabulated in Appendix D and discussed in this chapter under surface water quality). The systems in Craig and Meeker are seriously over-utilized. Both communities are planning to upgrade their systems. In the Steamboat Springs area, the system cannot meet peak demands; a 201 study is being prepared in accordance with the Clean Water Act (P.L. 92-500) as a step toward upgrading the system's effluent quality to meet EPA standards.

The Hayden plant is seriously overburdened on peak days but is usually able to meet existing effluent standards due to dilution from infiltration. Hayden is currently seeking funds to begin a 201 study. The systems in Oak Creek, Yampa, Rangely, and Dinosaur are adequate to meet the needs of the existing population.

Fire protection facilities are generally adequate to meet the needs of the existing population in the major communities. However, in summer months fire departments serve dual and sometimes overburdening roles as both protectors of urban structures and of rural farm and rangelands. Therefore, unlike purely urban-serving facilities, fire departments in the study region are equipped with tank trucks to transport water to these remote areas.

The marked increase in the study region's population over the last few years has placed increasing demands on the region's law enforcement agencies. This has been especially true in Hayden and Craig where power plant construction projects have had the most significant population effects. Considerable new demands have been placed on the Steamboat Springs and Routt County departments because of population growth from the ski area development, which has drawn up to 6,000 non-resident tourists during the peak Christmas holiday season. In summer months break-ins and vadalism occur at remote, unoccupied vacation homes and condominiums. Table RIV-35 indicates that the incidence of assault, burglary, larceny, and auto theft increased significantly over 1970-73 period. In 1973 the study region's rates for assault, burglary, and larceny exceeded corresponding national figures.

<u>Community attitudes and life style</u>.

The study area, with its low population density and strong agricultural economy, exhibits many features of traditional rural American life style. The previous demographic analysis indicates that although population has declined throughout most of the past twenty-five year period, there is a significant portion of the population that has established family and cultural ties to the region. In the period of declining population there was little evidence of traditional urban problems through 1970; crime rates were lower than comparable State and national rates. Family units were for the most part stable, as indicated in Table RIV-35 by marriage rates higher than State and national rates, and dissolutions lower than the State and national figures. In recent years, however, the increase in population associated with energy exploitation has generated some "boom-town" conditions in Craig, Meeker, Rangely, and Hayden. Recreation development has created similar problems in the Steamboat Springs area.

Proximity and ease of accessibility of vast natural recreational resources combined with economic dependence on agricultural resources has generated a strong native interest in, and appreciation of maintenance of, the quality of natural surroundings. Refer to the Aesthetics section in this chapter for a detailed description of these natural values.

The region has experienced boom-bust cycles of mineral resource development. Coal mining was a key element of the economy until the introduction of the diesel locomotive and the conversion to natural gas and electricity for space heating. Uranium was just beginning to be developed in the late 1950s when the removal of government price guarantees brought the potential boom to only a fizzle. Oil shale development has been predicted seberal times but never realized. One local official was prompted to say, "we've heard about the smoke for years, but never seen the fire." As a result there is some skepticism toward another boom, although local people are generally in favor of managed growth and local officials are quite cognizant of the planning problems associated with this growth.

Economic Conditions

The parameters that will be used to describe the economic system of the study region are employment levels, earnings, and standard of living. The following description of these elements provides the basis for both projection of the future economic environment without the proposed actions and the determination of the economic impact of the proposed action.

Employment levels

Table RIV-39 presents 1970 employment data for each of the counties in the study region and comparative data for the State and nation.

The data indicate that the private service sector is the leading employer in the study region, and, on a percentage basis, that sector employs almost twice as many people as the nation. The second leading employment sector, wholesale and retail trade, provides approximately the same portion to total employment as on both the State and national level. The study region's third leading sector, agriculture, employs about three times the people as on both the State and national level. The employment levels in these leading sectors confirm the agricultural and trade center nature of the economy of the study region.

Assuming that the national employment data in Table RIV-39 represent a self-sufficient (i.e., no exports or imports) system and that a positive correlation exists between employment and output, one can then perceive additional characteristics of the region's economy. The ten-to-one ratio of regional to national percent employed in the mining sector indicates that the study region's economy is highly dependent upon the export of the products (e.g., coal) of the mining industry. The three to-one ratio in

TABLE RIV-39

1970 Employment by Sector in the Study Region

	Moffat County	Rio Blanco County	Routt County	Region Total	Percent of Total (a)	State Percent (a)	National Percent (a)
Labor Force	2,622	1,981	2,607	7,210			
Unemployed	119	35	80	234	3.25	3.3	4.9
Total Employed	2,503	1,946	2,527	6,976			
Agriculture	351	294	362	1,007	14.44	4.63	4.67
Mining	124	280	175	579	8.30	1.72	.84
Construciton	294	152	232	678	9.72	6.41	4.57
Manufacturing	42	42	95	179	2.57	14.83	26.13
Transportation, Communications and Utilities	185	94	228	507	7.27	7.33	6.07
Wholesale and Retail Trade	628	272	541	1,441	20.66	22.27	20.14
Finance, Insurance, and Real Estate	54	56	73	183	2.62	5.63	4.98
All other Privat Services	689	603	711	2,003	28.71	30.45	15.68
Public Administration	136	153	110	399	5.72	6.73	16.93

(a) Percent unemployed is percent of labor force. Percents by sectors are percents of total employed.

SOURCE: U.S. Bureau of the Census, 1970.

the agricultural industry indicates a similar reliance of the region's economy on the export of cattle, sheep, and hay. Significant exports also occur in the construction and other private services sectors.

Conversely, the one-to-ten ratio of regional to national percent employed in the manufacturing sector indicates that the study region is highly dependent on imports of finished manufactured goods such as automobiles, refrigerators, and mining and farm machinery. Other import dependencies are indicated in the finance, insurance, real estate, and public administration sectors.

Earnings

The raw material exporting and finished good importing characteristics of the study region's economy are confirmed by the earnings data shown in Table RIV-40. Earnings are defined as the pre-tax sum of wages and salaries, other labor income (fringe benefits), and proprietors' income.

The data indicate that on a percentage basis the regional agriculture sector generated four times the earnings as the national sector. Similarly, the regional mining sector produced fifteen times the national percentage of earnings. The lack of a strong manufacturing industry in the study region is indicated as one-to-three ratio of regional to national percentage earnings. Earnings in the remainder of the region's industrial sectors are essentially balanced with the national counterparts.

On an absolute dollar basis the public administration sector generates most earnings in the study region. Wholesale and retail trade generates the second largest amount, followed by other private services, mining, and agriculture. These five sectors account for close to eighty-percent of all earnings in the region.

TABLE RIV-40

1971 Earnings by Sector in the Study Region
(Thousands of Current Dollars)

	Moffat County	Rio Blanco County	Routt County	Region Total	Percent of Total	National Percent
Total Labor and Proprietors income	17,549	15,997	15,354	48,900	10,000	10,000
Agriculture	2,475	1,853	2,469	6,797	13.90	3.40
Mining	1,783	1,990	1,404	6,964	14.24	.97
Contract Construction	923	1,602	1,378	3,903	7.98	6.25
Manufacturing	625	2,638	385	3,648	7.46	26.77
Transportation, Communication and Utilities	1,474	963	1,064	3,501	7.16	7.24
Wholesale, Retail Trade	3,599	1,746	2,238	7,583	15.51	16.65
Finance, Insurance and Real Estate	486	340	556	1,382	2.83	5.37
All other Private Services	2,411	2,038	2,519	6,968	14.25	15.34
Public Administration	3,642	2,827	3,281	9,750	19.94	18.00
Other	131	--	60	191	.39	--

SOURCE: U.S. Bureau of Economic Analysis, "Regional Economics Information System"

Standard of living

The previous employment and earnings data provide insight on the sectoral structure of the regional economy, but these measures do not indicate individual economic welfare of the regional population. The traditional measure for individual economic well-being is the ratio of total regional product to total population -- the standard of living. However, regional product data are not available, but an alternate measure is tabulated by the Bureau of Economic Analysis -- county per capita personal income. These data are presented in Table RIV-41 with comparative values for the State and nation.

For each tabulated year except 1970, when farm income was depressed, Moffat County had per capita income greater than both State and national averages. Rio Blanco and Routt counties were below State and national figures in each year. As a result of the low figures in these two counties, per capita income in the three county region was lower than both State and national measures in each of the selected years. This disparity of regional income with super-regional averages can be attributed to the lack of a strong manufacturing sector in the study region. The super-regional averages are more heavily weighted by the manufacturing sector where incomes are somewhat higher than those from the regionally dominant public administration and service sectors.

TABLE RIV-41

Per Capita Personal Income in Selected Years, 1950-1973

	1950	1959	1965	1970	1973
Moffat: current dollars	1,517	2,292	2,795	3,209	5,190
1974 constant dollars	2,969	3,673	4,172	4,031	5,780
Rio Blanco: current dollars	1,260	1,795	2,596	3,423	4,770
1974 constant dollars	2,466	2,876	3,875	4,300	5,312
Routt: current dollars	1,043	1,822	2,343	3,061	4,363
1974 constant dollars	2,041	2,920	3,497	3,845	4,859
Three county average:					
Current dollars	1,239	1,998	2,587	3,212	4,718
1974 constant dollars	2,425	3,201	3,862	4,035	5,254
Colorado: current dollars	1,484	2,182	2,656	3,855	4,966
1974 constant dollars	2,904	3,497	3,964	4,843	5,530
USA: current dollars	1,500	2,166	2,774	3,945	5,014
1974 constant dollars	2,935	3,471	4,140	4,956	5,584

SOURCE: County, Colorado data from U.S. Dept. of Commerce, Bureau of Economic Analysis, "Local Area Personal Income Series."

U.S.A. data from Economic Report of the President, (February, 1975) pp. 268-269.

Note: Current dollar incomes are deflated to 1974 constant dollar with the implicit price deflator for personal consumption expenditures from Table C-3, Economic Report of the President (February, 1975) p. 252.

The three county averages are generated by weighting individual county data with the county's population in the appropriate year.

Transportation Networks

Highways

The area is served by narrow two-lane paved highways designed primarily for lightweight traffic. The only major road is U. S. Highway 40, a widened two-lane highway, running east-west through Craig between Denver, Colorado, and Salt Lake City, Utah. See Figures RIV-32 to 34 for traffic volumes in the area. Highway 40 between Steamboat Springs and Craig is operating below designed average capacity; however at shift changes at the Hayden power plant (7:00-8:00 a.m. and 5:00-6:00 p.m.) the traffic is congested and slow.

Colorado 13 between Meeker and Craig, the main north-south route, is not heavily traveled and currently is being used by only one coal mine (Silengo mine) hauling approximately 65 truck trips per day. Only the northern nine miles from Hamilton to Craig are suitable for heavy truck traffic; that section is in excellent condition (VTN 1974). There are three restricted-weight (40-ton combined vehicle) bridges 5, 6, and 8 miles south of Hamilton, and the stretch of highway for 10 miles south of Axial is subjected to extensive frost-snow damage each spring and early summer. Colorado 13 has no shoulder adjacent to the paved strip north of Craig; vehicles drop off the edge of the driving lane, resulting in numerous accidents each year.

Colorado 64, along the White River between Meeker and Rangely and North from Rangely into Utah, is also a narrow two-lane road designed primarily for normal traffic. The road is somewhat winding and has many blind dips and curves which make passing difficult. Recent oil shale developments south of the White River are contributing increased truck and industrial traffic load not easily accommodated by the highway.

Colorado 131, south from Steamboat Springs toward Eagle, serves as a lightly used connection between Highway 40 and I-70 to the south. It is used mainly by residential traffic between the Phippsburg-Oak Creek areas and Steamboat Springs.

Colorado 317 east from Hamilton to Pagoda is a very narrow paved road serving a few local residents and some oil-gas field traffic.

Colorado 318, from Highway 40 to Maybell, Colorado, toward Rock Springs, Wyoming, via Moffat County Route 10, is paved to Browns Park and gravelled north of Browns Park to the Wyoming State-line. This road is only lightly used by scattered local residents and provides no traffic services for a 100-mile stretch.

Colorado 139 south from Rangely to Grand Junction is a lightly traveled highway used by local residents. Traffic from oil and gas and oil shale development is increasing. At Douglas Pass, where this route crosses extensive active landslides, road damage and failure are a continual problem.

County roads in Routt, Moffat and Rio Blanco Counties provide access from the main highways to a major portion of the area. The primary roads (Hayden-Oak Creek, Axial-Lay, Craig-Hiawatha Camp, Rangely-Blue Mountain, Hamilton-Meeker via Yellow Jacket Pass, and Meeker-Maybell) are only lightly used by local residents and there is limited oil-gas field traffic. An exception is the Hayden-Oak Creek route which receives traffic from several coal mines between the Hayden power plant and Oak Creek. These roads are gradually being upgraded from gravelled to paved roads and serve as trunk lines for numerous branching county and private roads.

Railroads

Railway freight service for the area is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. D&RGW also has a spur from Milner south along Trout Creek to coal mines in the Twentymile Park area. Passenger service to this area was discontinued by D&RGW in 1968, and the railroad is not considering resuming service (Northwest Colorado Council of Government (NWCCOG) - Region 12, 1975). The trip from Craig to Denver takes 12 hours. According to D&RGW representatives, labor restrictions are such that the longest train possible between Craig and Denver, even with helper service, is 84 cars of 100 ton capacity (W.R. Grace railroad feasibility study, Morrison-Knudsen Co., 1974).

Airlines and buslines

Steamboat Springs is served by scheduled flights from Denver by Rocky Mountain Airways. Yampa Valley Airport at Hayden is served by Frontier Airlines on a route connecting Denver-Hayden-Vernal-Rock Springs and Salt Lake City. The Hayden Airport is currently undergoing a $10 million expansion and improvement program. Craig serves as the connection depot for east-west Continental Trailways bus lines, and southbound Wilderness Transit between Craig and Grand Junction, Colorado.

Future Environment Without the Proposed Action

Geologic and Geographic Setting

Without the present proposals, mining would still continue on private and State lands and on federally leased coal covered by approved mining plans. The land surface would continue to have combinations of disturbed and original landforms, but with a lower percentage disturbed.

W. R. Grace, without the proposed railroad to Craig or some alternate destination, could not develop its large stripping operation at Streeter Creek. It is doubtful that these coal beds, or perhaps none lower than the "X" bed, would be mined by stripping without such a railroad. The environment without the railroad would continue in its present form, without the numerous cuts and fills, channel diversions of the Yampa or Williams Fork River, and high rock cuts along one or the other of these rivers. Development of the extensive coal deposits in the Danforth Hills would probably not take place without the railroad.

Fossils will suffer disturbances without the proposed action, due to surface disturbances from other actions. The degree of disturbance will depend ultimately on the location of the actions with respect to fossiliferous formations (see Figure RIV-1a and Appendix A, Geologic Map of Northwest Colorado).

The impact will generally occur in direct proportion to acreage disturbances. Projected annual disturbance from oil and gas exploration equals 3,000 acres, from oil and gas wells - 150 acres, from pipelines - 600 acres, from powerlines - 1,800 acres and from State coal and existing Federal coal leases - 820 acres. An additional 20,400 acres would be replaced by the proposed Juniper and Pothook reservoirs. Also by 1990, a projected 2,400 acres would be needed for urban growth (see Table RIV-42).

More fossil collecting will also occur from increased population growth due to other actions in the study region. This ordinary population growth for the three-county study area is as follows: by 1980 - 35,817 (6.9 percent/yr.), by 1985 - 45,217 (4.7 percent/yr.) and by 1990 - 49,792 (1.9 percent/yr.) (see Table RIV-51).

Mineral Resources

Without the proposed action most of the study region's coal resources would be left undisturbed and intact. By 1980 about 8.2 million tons of coal per year would be depleted by existing operations on Federal coal, and by existing and future operations on State and private coal, which is required to meet current contractual agreements.

The depletion of the study region's resources of minerals other than coal, such as oil, gas, uranium and oil shale, will continue to the extent of future market demands for these commodities. Sand and gravel depletion without the proposed action will be somewhat less because of smaller demands for concrete aggregates.

Water Resources

Ground water

Due to the absence of suitable aquifers no large development of ground water can take place with or without the action. With the projected population increase without the Federal action there will be some increase in the number of domestic wells in the area; the amount of water that is pumped from this type of well is small and will have no noticeable effects on the ground water in the area. Coal mining that takes place on private and State properties and on

Federal leases that have approved mining plans may have localized effects on ground water availability, depending on the degree of aquifer disturbance.

Surface water

Present activities in the study area and those actions which will occur even if the proposed coal mining and associated activities do not take place, will have an impact on the future environment. An important consideration relative to impacts on water resources is the increase or decrease in dissolved solids load in critical downstream reaches of the Colorado River Main Stem. The Colorado River will be subject to an increase in dissolved solids without the proposed action taking place. Table RIV-7 indicates estimates of sources of dissolved solids and the expected increase in concentration in the Colorado River below Hoover Dam without action.

Anticipated increase in dissolved solids concentration in the Lower Colorado is due to reduction in flow in the Yampa River Basin. This reduction will be caused mainly by evaporation from steam generating power plants and export of water from the basin. Consumptive use by evaporation will increase from 4,000 acre-feet in 1975 to 19,800 acre-feet in 1990 and the export of water will increase from 2,800 to 45,000 acre-feet from 1975 to 1990. Loss due to evaporation will leave behind salts which are removed and buried. Exported water will be diverted from streams in the upper reaches of the basin, and thus are lower in dissolved solids compared with water leaving the basin. Consequently, this water will not be available to dilute runoff from lower, more concentrated reaches of the basin.

Whether the diversion increases or decreases, the weighted-average concentration of the master stream at a downstream point depends on the relation of the weighted-average concentration of the diverted water to the original weighted-average concentration of the master stream at the downstream point. If the diverted water is more dilute, the effect will be to increase the concentration of the master stream; and if less dilute, the effect will be to decrease the concentration of the master stream. If no changes in water loss are assumed to occur in the master stream channel, the relation between water discharges and weighted-average concentration would be as follows:

$$Cc(Qa + Qb) = QaCa + QbCb \text{ or}$$

$$Ca = \frac{Cc(Qa + Qb) - QbCb}{Qa}$$

where

Qa = average discharge of master stream at downstream point when water is being diverted,

Qb = average discharge of diversion,

Cb = weighted-average concentration of diverted water,

Cc = weighted-average concentration of master stream at downstream point when no water is being diverted,

Ca = weighted-average concentration of the water in the master stream when water is being diverted.

(Irons and others 1965)

The application of this formula to expected new transbasin diversions from the Yampa River basin indicates that these diversions would increase the concentration of dissolved solids below Hoover Dam by 0.4 mg/l in 1975, 1.3 mg/l by 1980, and 3.8 mg/l through 1990. This concentration is included in the concentrations of dissolved solids generated from data in Table RIV-7.

Air Quality

Without the proposed action, the Yampa project, including coal mining and power plants at Craig and Hayden, and the resultant increasing population, will be the major source of air quality degradation.

The Yampa project involves two units currently under construction at Craig and the addition of a second unit at Hayden. With all four units operating, the point of maximum annual impact will be just east of the Craig facility. If Federal and State emissions regulations are maintained, the annual increase of total suspended particles (TSP) will be about 2 $\mu g/m^3$. The annual increase of ambient sulfur dioxide ($SO_2$2) will be about 4 $\mu g/m^3$. If SO_2 emissions are not maintained at 150 ppm (Colorado new source standard), the SO_2 impact will be doubled.

A few days each year, TSP concentrations may be increased by 40 $\mu g/m^3$ over a 24-hour period. Maximum 24-hour SO_2 impact from the power plants will increase the background concentration by 80 $\mu g/m^3$.

The ambient levels of TSP and SO_2 in the air due to the power plants will be within all Federal air quality standards. However the Federal Class II 24-hour non-degradation limit for TSP of 30 $\mu g/m^3$ will be threatened.

The State of Colorado TSP standards will be maintained. However the Colorado 24-hour SO_2 standard of 15 $\mu g/m^3$ cannot be maintained. Since 15 $\mu g/m^3$ is typical background for rural areas, the Colorado standard will be exceeded under any circumstances.

In addition to the power plants, the Yampa project will be mining coal south of Craig. A substantial amount of dust will be generated at this facility. It was estimated from mining plans that 1,300 tons of suspended particles will be emitted per year from coal mining and processing. Concentrations of TSP are expected to exceed the annual Federal secondary standard (60 $\mu g/m^3$) out to 2.5 kilometers (1.6 miles) from the center of mining activity, and the Colorado standard (45 $\mu g/m^3$) for a distance of three kilometers (1.9 miles).

EPA non-degradation guidelines for Class II areas specify an allowable increase of 10 $\mu g/m^3$, annual average, and 30 $\mu g/m^3$, a 24-hour average, for TSP. These values will be exceeded in the prevailing wind direction at the mine for distances of six kilometers (3.7 miles) annual average, and eight kilometers (five miles), 24-hour average.

Population projections to the year 1990 without the proposed development are provided in Table RIV-51. The towns of Rangely and Meeker are expected to boom due to oil shale development. It is estimated that ambient SO_2 levels will increase by three to five $\mu g/m^3$ in the towns of Rangely, Meeker, Steamboat Springs, and Craig, due to increased fuel consumption for home and commercial heating.

The State of Colorado annual TSP standard is already exceeded in Craig, Meeker, and Steamboat Springs. Increased population would increase the ambient TSP level in Rangely above the Colorado standard by 1990. The national TSP standard is presently exceeded in Steamboat Springs. It is expected that the national standard (75 $\mu g/m^3$) will be threatened in Craig by 1990 even without the proposed action.

Soils and Vegetation

Without any future Federal coal development soil and vegetation segments of the environment would be impacted significantly less. Most of the coal of the region is owned by the United States of America, and if not developed would significantly slow the development of State and private coal because of ownership pattern.

Impacts that would affect soils and vegetation without Federal coal development would arise from the following major actions: existing mines on current Federal leases, State and private coal, oil, gas, oil shale, and water developments, and urbanization (Table RIV-42).

TABLE RIV-42

Extimated Vegetation and Soil Disturbance by Major Actions in the Study Region Excluding Future Development of Federal Coal (acres).

	Future Disturbance
Oil and Gas Exploration	3,000/year 1/
Oil and Gas Wells	150/year 2/
Pipelines	600/year 3/
Powerlines	1,800/year 3/
Water Developments	20,430/ 4/
State Coal and Existing Federal Leases	820/year 5/
Urbanization	2,400 6/

1/ Area of disturbance has increased substantially in the past five years, and is expected to remain relatively constant at approximately 3,000 acres of disturbance/year until the area has been closely explored.

2/ Approximately 150 new acres are disturbed each year by drill pads, of which approximately 80 percent are unsuccessful.

3/ This figure is an estimate of disturbances on private and Federal lands.

4/ This figure includes acreage requirements for the proposed Juniper reservoir and the portion of the Savery-Pot Hook project that occur in Colorado. These figures depict totals for the study period.

5/ From 1980 through 1990.

6/ This is the acreage that will be required by 1990 for population increases that are not associated with Federal coal development.

Disturbances associated with urbanization and water developments will be permanent; mined lands will be reclaimed to some degree, and oil and gas development pipelines and powerlines would be returned to nearly existing conditions in the time frame of this study.

Terrestrial Fauna

Northwestern Colorado is growing in terms of human population and people usage; thousands of acres have been converted from native wildlife habitat to some form of people habitat. Roads, powerlines, pipelines, towns, and croplands have changed the wildlife density and species composition of this portion of the State of Colorado. Additional changes are expected and these changes will accelerate in the next few years, even without the proposed actions covered in this report.

Livestock grazing has and will continue to exert a major influence on wildlife and wildlife habitat. Many livestock operators have changed or are considering changing from sheep to cattle on private and State lands. This will likely affect wildlife by lessening competition with deer and pronghorns, while increasing competition between livestock and elk. Pressure on browse and forbs will be lessened especially on critical deer and pronghorn winter ranges.

Oil shale mine development in Rio Blanco County is expected to cause an increase in population and people usage within the study area. Both mine personnel and support services will be located within the region, resulting in a loss of existing habitat values. Approximately 2,400 acres will be converted from present use to provide homes, schools, etc. for this influx of people.

Additional people-related losses of habitat values will result from the increase in recreation activities, such as off-road-vehicle use. With added people will come increased probability of animal-vehicle collisions resulting in loss of wildlife.

People usage of wildlife has increased over the past years, as evidenced by the hunter data (see Recreation Section). Much of this increase is accounted for outside the regional human population. This trend is expected to continue whether or not the proposed action takes place.

Some native wildlife habitat has been converted to agricultural use. Over 250,000 acres are currently in crops within Moffat, Rio Blanco, and Routt Counties. These acreages appear fairly stable with little additional acreage being converted to this use. Long-term predictions are questionable at this time; however little change is expected unless there is a significant change in the nation's economy or the price of wheat and other seed crops that can be grown in this area.

Oil and gas exploration and oil field development has in the past five years accounted for the alteration of over 10,150 acres, primarily deer winter range and yearlong pronghorn habitat. This alteration of habitat has been caused by a reduction of vegetation resulting from road and pad construction. The overall outcome has been a lowering of the region's carrying capacity for mule deer and pronghorns by approximately 317 deer and 65 pronghorns. Based on past records and the national policy to make the U.S. self-sufficient in energy, the next five years will probably show an increase in habitat loss over the past five years, unless technology improves exploration techniques and results in less damaging exploration methods.

Several major reservoirs and canals are proposed for construction within the next few years. Elkhead Reservoir has recently been completed and filled. Approximately 20,430 acres of wildife habitat will be inundated by stored waters from the Juniper and Cross Mountain reservoirs and the Pot Hook Canal. This will cause a major loss of wildlife habitat and forage. These major construction projects would result in the loss of the region's ability to support about 640 deer and 135 pronghorns. These figures do not include animal losses as a result of direct influences on migration routes.

Many miles of roads, powerlines, and pipelines will further reduce or alter terrestrial wildlife habitat within the study region. Further disturbances from similar actions are expected in the future regardless of the approval of the proposed actions.

Aquatic Biology

The aquatic communities in the study region would be significantly impacted during the next 15 years without the implementation of the proposed actions, because of other future developments. The projected demands on water supply in the analysis area are outlined in Table RIV-7. Numerous reservoirs in various stages of planning, anticipated for construction in northwestern Colorado (e.g., Juniper Reservoir) would dramatically impact the existing stream biota. For instance, the construction of Juniper Reservoir would transform the existing cold water stream fishery in the Yampa River into a warm water lake fishery; with foresighted planning, a tailwater trout fishery could be developed in Yampa River below Juniper Reservoir.

The most critical impact of proposed reservoir construction along the White and Yampa Rivers would be the desecration of the existing endangered species habitat. The range of the four endangered fish species, the Colorado squawfish, bonytail chub, humpback chub, and humpback sucker, has already been severely limited by the construction of dams throughout the Colorado River Basin.

Sediment increases in all of the major drainages in the study region could be expected during the next 15 years from non-coal related development. In addition alterations in drainage patterns and flow characteristics could be expected as a result of the influx of industry into northwestern Colorado with its appurtenant facilities. Any changes in the hydrologic cycle of a drainage basin would affect the local aquatic community; for instance, channelization of a stream would favor the dominance of organisms which could adapt to fast flowing water and elimination of the forms which find recluse in pools and eddies in the meanders of the natural stream channel.

If the majority of the non-coal related projects currently planned for the analysis area become reality, downstream aquatic populations (i.e., in the Green and Colorado River Basins) would be significantly impacted. A substantial increase in the consumptive use of water (e.g., irrigation) would diminish average daily stream flow in the lower Colorado River Basin. As previously discussed, any definite detectable alterations of stream flow characteristics would produce concurrent changes in the composition of the existing aquatic community.

Archeological Resources

Cultural resources will be impacted by the increasing alterations of the natural landscape. The amount of impact will most certainly depend upon the richness of the resource and its density. However, as a general guideline, archeological resource destruction will be proportionate to acreage disturbances.

Projected annual disturbance from oil and gas exploration equals 3000 acres, from oil and gas wells - 150 acres, from pipelines - 600 acres, from powerlines - 800 acres, and from State coal and existing Federal coal leases - 820 acres. An additional 20,400 acres would be replaced by the proposed Juniper and Pothook reservoirs. Also by 1990, a projected 2,400 acres would be needed for urban growth.

Increased vandalism and pothunting will also result from population increases without the proposed action. This growth for the three-county study area is as follows: by 1980 -35,817 (an increase of 6.93 percent per yr.), by 1985 - 45,217 (an increase of 4.73 percent/yr.), and by 1990 - 49,792 (an increase of 1.90 percent/yr.).

Historical Resources

Impacts will also accrue to historical resources as outlined above under Archeological Resources. Acreage disturbance and population projections are applicable.

Land Use

One factor which will have a direct affect on future land uses is population. Estimates from this study are that population of the tri-county region of Moffat, Routt, and Rio Blanco Counties will increase by about 24,200 by the year 1990 without the proposed actions. As a result of this growth, land uses will likely change from undeveloped grazing or farm land to more intensively developed areas to accommodate increased human activity. Over 2,400 acres throughout the region may be needed for such uses as residential, community facilities, streets and roads, commerce and industry.

Increased interest in recreational homesite and subdivisions will likely occur; this will cause a shift in land use but the extent is not predictable. The areas involved will generally be the mountainous or forested areas with highest scenic attributes, located around Steamboat Springs, northeast of Craig, and east of Meeker.

As population increases, greater demands will be placed on the lands for hunting and other recreation uses; over the next 15 years such uses will increase approximately 2 1/2 - 3 percent annually. (Refer to the Recreation section for further information.)

Although it is difficult to predict with certainty, a significant increase in crop production land is not anticipated. As in recent years there will be fluctuations in acreages being farmed due to price changes in the market place. For example, the high wheat prices in the last two years have enticed farmers into clearing and planting new wheat areas; however economic conditions are so unstable that this can hardly be considered a trend that will continue. More likely major changes in farming will be the methods involved; i.e. the amount of dryland farming may decrease but the amount of irrigated land may increase. Two studies, Water and Related Land Resources White River Basin in Colorado, (USDA 1966 and the Colorado Water Conservation Board), and Economic Survey of the White River Valley, prepared by the Bureau of Business Research at the University of Colorado (1959) indicate that as much as 74 percent of lands not dryland farmed will be irrigated by the year 2020.

Livestock grazing, which is the most extensive land use in the region, is not expected to change significantly. Any changes in grazing land acreages will be light decreases due to changes to more intensively developed lands.

Aesthetics

Continuing aesthetic impacts can be expected without the proposed action that will be commensurate with the amount of development already scheduled and approved.

Continuing oil and gas exploration and development is expected to occur on known geologic structures (see Chapter IV--Future Environment Without the Proposals--Soils and Vegetation). Impacts from these operations will result from minus deviations created by pipelines (600 acres/year) transmission lines (1,800 acres/year), roads, and other rights-of-way. Other minus deviations will result from oil and gas facility development whose usual bright colors and strong line dominance do not borrow from the characteristic landscape.

Records show that a total of 1,605 miles of exploration roads and trails was constructed in 1974; an estimated 2,200 miles are to be constructed in 1975. These projections are equivalent to an annual disturbance of 3,000 acres. Producing oil and gas wells are expected to disturb only 150 acres each year in the form of drill pads. These disturbances are producing strong form and line-dominant minus deviations; inherent in these activities is the blading of native vegetation across long straight tangents. Where exploration trails and roads to drill pads encounter steep terrain, additional minus deviations of form and line are produced by sizeable cuts and fills.

Producing oil and gas fields are scattered throughout the region (see Map Foldout 1 in Appendix B). The greatest visual impacts will be experienced where the region's Federal, State and county roads provide visual access to such exploration (see Table RIV-42).

This development will also alter the natural character of lands that have not been significantly changed by man; impacts will therefore also result to mood-atmosphere values.

Range, forestry, wildlife, and watershed improvements, plus the conversion of rangeland acreage to cropland will also result in minus deviations due to the surface disturbance and landscape alteration inherent in these actions. However those projects that borrow landscape dominance elements from the characteristic landscape may result in plus deviations and may improve the aesthetic attractiveness of a landscape; examples include scattered dryland grainfields or irrigated meadowland.

Increased housing development adjacent to the principal communities (2,400 acres by 1990) in the study region will continue to result in a variety of minus deviations, as these developments generally fail to borrow form, line, color, and texture from the characteristic landscape. Necessary amenities such as roads and utility lines often result in the most significant aesthetic impact. Additional areas will be needed for building materials, and these will also result in minus deviations; new gravel pits west of Steamboat Springs on U.S. 40 are good examples.

Other aesthetic impacts would result from recreational developments such as the construction of the Juniper and Pot Hook Reservoirs. Earth-moving operations, recreation facility development and use will result in visual as well as mood-atmosphere impacts on 20,430 acres. However beneficial impacts can also result from these projects; examples include an aesthetically attractive reservoir (see Table RIV-42).

Recreation

Letters of request were sent to all recreation-managing agencies in the study area (see Chapter XI) to obtain their recreation development plans for the three benchmark years: 1980, 1985, and 1990. The first part of this section deals with their responses to these requests as relates to the future recreation environment.

Analysis of future use levels can be made by referencing the recreation user-origin data presented earlier in this chapter. Assuming uniform per capita participation rates, recreation uses for the three benchmark years can be projected for both State planning regions encompassed by the study area, Regions 11 and 12 (see Figure RIV-35).

Agency proposals

U.S. Bureau of Reclamation

The Savery-Pot Hook project (north of Craig near the Wyoming State line on Slater Creek) has been authorized for construction and is in the advance planning stage; 20 acres of recreation developments are planned. Recreational activities will include picnicking, camping, boating, and fishing; facilities are planned to include picnic-camping units, boat launch ramp, access roads, parking areas, and sanitation facilities. Estimated usage at the proposed development has been projected by the Bureau of Reclamation as follows:

1980; 10,000 recreation days,

1985: 18,000 recreation days, and

1990: 25,000 recreation days.

In 1969 feasibility studies were initiated on the Lower Yampa Project. It involves three potential reservoir sites within Moffat County; they include Juniper Reservoir (in portions of T.6N., R.91, 92 and 94W. and in portions of T.5N., 92-94W.), Pilot Knob reservoir within the boundaries of Routt National Forest (T.9N., R.97W.), and Fortification Creek (T.9N., R.91W). The Upper Colorado Resource Study which was scheduled for initiation in fiscal year 1976 (indicated by BLM) may resume study on these projects.

More specific information has been obtained from the Western Colorado Projects Office of the Bureau of Reclamation regarding the proposed Juniper Reservoir; the official high water level at the dam has been set at 6,110 feet. Water backed up to this contour would produce a reservoir approximately 16,000 acres in size.

Presently seven separate reservoir sites are being evaluated for the Yellow Jacket Project. Three of these lie within the study area: Lost Park Reservoir (White River National Forest; T.2N., R.90W.), Thornburgh Reservoir (White River National Forest; T.?N., R.91W.), and Powell Park Reservoir (T.1N., R.95 and 96W.). Until actual site selections are made, the Bureau of Reclamation will be unable to provide any recreation usage or development data; no development plans will be scheduled until the ongoing feasibility studies have been completed.

U.S. National Park Service

Dinosaur National Monument has completed an environmental statement (1974) for designation of 165,341 acres within its boundaries as wilderness; Senate Bill S1102 presently calls for designation of this wilderness acreage plus 10,274 acres of potential addition (see Regional Analysis, Chapter IV--Present Environment). No further information concerning the time-frame for wilderness designation at Dinosaur National Monument is available.

Dinosaur National Monument has indicated that the only new development at the Monument in the foreseeable future will be paving of the access road into the Gates of Lodore on the north end of the Monument.

Colorado Division of Wildlife (DOW)

Currently there are two ongoing DOW recreation development projects in the study area; they are the development of Elkhead Reservoir (see Regional Analysis, Chapter IV, Existing Environment) and the acquisition of Yampa River stream fishing easements. The master plan for Elkhead Reservoir includes plans for three campgrounds, two water skiing areas, two boat ramps, and five fishing access points. No estimates of user capacity are available.

During 1975-76 the following three projects have been approved for expenditures. An additional 66,000 acres of land in game management units 11 and 12 are to be opened for hunting; access to public lands is also to be acquired in this area. An additional four-mile long, 15-year fishing lease is to be acquired on the White River.

Other recreational projects have been considered by the DOW, but no development time table is known and no funding is available. Three tracts of land in Rio Blanco County (3,000, 6,610, and 3,763 acres) containing deer and/or elk winter range are being considered for acquisition. Plans to purchase an additional 3,160 acres for big game habitat and for access to National Forest lands in Rio Blanco and Moffat counties are being formulated.

Colorado Division of Highways (DOH)

At the present time the Division of Highways has indicated that there appears to be little need for additional roadside parks, rest areas, and scenic overlooks in the study area; they estimate that none will be constructed before 1990.

Soil Conservation Service

Both the Craig and Steamboat Springs Soil Conservation District Offices have indicated that no private cooperators within their jurisdiction are planning expanded or new recreation facilities.

Bureau of Land Management.

The recently-completed land-use plans for the Williams Fork Planning Unit (1974) and the White River Resource Area (1975) propose several recreation developments. However there are currently no manpower nor fiscal allocations to guarantee their completion.

Municipalities

Neither Rangely nor Meeker have any recreation development plans within the study region. However Meeker has tentative plans to establish a greenbelt and add a recreation area in town; plans for a recreation complex south of White River is in its formulative stages. A five-year recreation development plan for Steamboat Springs proposes several improvements at the present Howelson Hill Recreation Complex, a multi-purpose recreation center, rebuilding of the ski jumping complex, rodeo ground improvements, an ice skating rink and two baseball diamonds.

Future recreation use

The recreation user origin data in Chapter IV of the Regional Analysis can be combined with population projections to provide estimates of the future recreation participation rates in the study area. Table RIV-33 and RIV-34 (shown earlier in this chapter) provide a 1974 data base showing the residence of users that recreate in both State planning regions 11 and 12. Assuming that per capita recreation participation rates will remain uniform with population increases, recreation-use projections can be made. Table RIV-43 indicates population projections for 1980, 1985, and 1990 by the 13 State planning regions as well as nationwide projections for non-resident (out-of-state) recreation users if the proposed action does not occur.

By combining the 1974 base tables and population projections, Table RIV-44, RIV-45, and RIV-46 were derived to indicate projected recreation use in Region 11 for each benchmark year; Tables RIV-47, RIV-48, and RIV-49 indicate projected recreation use in Region 12 for the three benchmark years. Though these projections are available only for units as small as State planning regions, they are valuable indicators of trends in the study area; they enable our assessment of future recreation environment without the proposed action.

TABLE RIV-43

State Planning Region and National Population Projections, without the Proposed Actions; 1980, 1985, and 1990

Area	1974	1980	Average* Annual Growth Rate(%) 1974-1980	1985 1/	Average* Annual Growth Rate(%) 1980-1985 1/	1990 1/	Average* Annual Growth Rate(%) 1985-1990 1/
Colorado--State Planning Region							
1	65,756	69,001	0.81	71,827		74,769	
2	227,418	256,647	2.04	283,854		313,946	
3	1,486,837	1,858,979	3.79	2,239,324		2,697,489	
4	295,897	350,528	2.86	403,684		464,900	
5	19,837	20,536	0.58	21,137		21,756	
6	59,965	62,326	0.65	64,364		66,469	
7	151,278	158,178	0.75	164,168		170,384	
8	41,544	42,401	0.34	43,129		43,869	
9	42,262	44,553	0.88	46,557		48,651	
10	46,419	55,732	3.09	64,905		75,588	
11	89,374	114,950	4.28	137,971 2/	3.72 2/	160,762 2/	3.10
12	46,347	61,193	4.74	73,666 2/	3.78 2/	86,465 2/	3.26
13	44,674	50,750	2.49	57,377		64,869	
National	211,894,000	224,132,000	0.94	235,116,000 3/	0.96 3/	246,639,000	0.96

* Compounded annually

1/ Computed using average annual growth rate 1974-1980.
2/ See Regional Analysis, Chapter IV, Future Social Environment Without Proposed Action.
3/ Computed using average annual growth rate 1980-1990.

SOURCES: For Planning Regions 1-10 & 13; Colorado Regional and County Population Estimates--1970-1980: Methods and Results.
For Planning Regions 11 and 12; see 2/ above.
For National; U.S. Bureau of Census; Current Population Reports, June, 1975, and Statistical Abstract of the U.S., 1974

TABLE RIV-44

Number of Recreation Users in Region 11 (Activity Days) in 1980

Recreational Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	Non-resident	Total Users	Average Annual Increase(%) 1974-1980
	Recreation Users from Region:															
Hiking			418,302								2,873,242		37,532	559,059	3,888,135	3.68
Horseback Riding			688,175							51,826	263,727		37,532		1,041,260	3.83
Bicycling										90,697	5,205,148			45,427	5,341,272	4.23
Motorcycling			148,429								763,421			36,341	921,191	3.56
Driving for Fun		12,184	188,910							77,740	1,207,594	28,504		2,617,675	4,132,607	2.04
Four-Wheeling			364,328	51,137			11,289				305,368			99,939	832,061	3.49
Mountain Climbing																
Swimming			323,847	12,784							1,457,442	28,504		324,956	2,147,533	3.65
Picnicking			202,404							90,697	763,522			727,452	1,784,075	2.72
Camping			445,290	51,137	67,053		45,157			38,870	388,651	114,015	37,532	898,899	2,086,604	2.39
Boating			80,963								458,053			77,225	616,241	3.75
Game Playing			53,974								1,735,050			68,140	1,857,164	4.13
Tennis											249,847			9,085	258,932	4.15
Golf			53,974								458,053			18,171	530,198	4.10
Fishing			1,214,427		67,053	11,222	11,289			64,784	2,220,867		75,065	500,635	4,165,342	3.56
Shooting/Hunting			188,911	51,137							555,217			150,850	946,115	3.52
Skiing/Snowshoeing				12,784						12,956	319,250			192,676	537,666	2.93
Snowmobiling										51,826	194,326				246,152	4.02
Sledding/Tobogganing/Tubing											439,253				439,253	3.55
Ice Skating											69,402				69,402	4.28
Other										25,914	569,097			395,209	990,220	2.83
Region Totals															32,831,423	3.39

TABLE RIV-45

Number of Recreation Users in Region 11 (Activity Days) in 1985

Recreational Activities	Recreation Users from Region: 1	2	3	4	5	6	7	8	9	10	11	12	13	Non-resident	Total Users	Average Annual Increase(%) 1980-1985
Hiking			503,810								3,448,933		42,444	586,414	4,581,601	3.34
Horseback Riding			828,851							60,343	316,568		42,444		1,248,206	3.69
Bicycling										105,603	6,248,066			47,650	6,401,319	3.69
Motorcycling			178,771								916,382			38,119	1,133,272	4.23
Driving for Fun		13,479	219,218							90,517	1,449,551	34,314		2,745,759	4,552,838	1.96
Four-Wheeling			438,804	60,564			11,719				366,552			104,829	982,468	3.38
Mountain Climbing																
Swimming			390,047	14,720							1,749,459	34,314		340,856	2,529,396	3.33
Picnicking			243,779							105,603	916,503			763,047	2,028,932	2.61
Camping			536,316	60,564	69,020		46,876			45,258	466,522	137,256	42,444	942,883	2,347,139	2.38
Boating			97,481								549,830			81,004	728,315	3.40
Game Playing			65,007								2,082,689			71,474	2,219,170	3.63
Tennis											299,907			9,530	309,437	3.63
Golf			65,007								549,830			19,060	633,897	3.64
Fishing			1,462,678		69,020	11,591	11,719			75,431	2,665,846		84,887	525,131	4,906,303	3.33
Shooting/Hunting			227,528	60,564							666,462			158,231	1,112,785	3.30
Skiing/Snowshoeing				14,720						15,086	383,215			202,104	615,125	2.73
Snowmobiling										60,343	233,262				293,605	3.59
Sledding/Tobog-ganning/Tubing											527,263				527,263	3.72
Ice Sakating											83,308				83,308	3.72
Other										30,173	683,123			414,547	1,127,843	2.64
Region Totals															38,362,222	3.16

TABLE RIV-46

Number of Recreation Users in Region 11 (Activity Days) in 1990

	Recreation Users from Region:															
	1	2	3	4	5	6	7	8	9	10	11	12	13	Non-resident	Total Users	Average Annual Increase(%) 1985-1990
Hiking			606,799								4,017,705		47,998	615,108	5,287,610	2.91
Horseback Riding			998,284							70,261	368,774		47,998		1,485,318	3.54
Bicycling										122,958	7,278,450			49,981	7,451,389	3.08
Motorcycling			215,315								1,067,505			39,984	1,322,804	3.14
Driving for Fun		14,911	264,030							105,393	1,688,560	40,284		2,880,110	4,993,288	1.86
Four-Wheeling			528,503	69,734			12,165				427,001			109,958	1,147,361	3.15
Mountain Climbing																
Swimming			469,780	16,948							2,037,967	40,284		357,534	2,922,513	2.93
Picnicking			293,612							122,958	1,067,646			800,383	2,284,599	2.40
Camping			645,943	69,734	71,045		46,876			52,696	543,457	161,136	47,998	989,018	2,627,909	2.29
Boating			117,408								640,504			84,967	842,879	2.96
Game Playing			78,296								2,426,150			74,971	2,579,417	3.05
Tennis											349,365			9,996	359,361	3.04
Golf			78,296								640,504			19,993	738,793	3.11
Fishing			1,761,677		71,045	11,973	12,165			87,828	3,105,477		95,996	550,826	5,696,987	3.03
Shooting/Hunting			274,039	69,734							776,370			165,973	1,286,116	2.94
Skiing/Snowshoeing				16,968						17,565	446,412			211,993	692,938	2.41
Snowmobiling										70,261	271,730				341,991	3.10
Sledding/Tobogganing/Tubing											614,215				614,215	3.10
Ice Skating											97,047				97,047	3.10
Other										35,132	795,779			434,831	1,265,742	2.33
Region Totals															44,038,277	2.80

TABLE RIV-47

Number of Recreation Users in Region 12 (Activity Days) in 1980

Recreational Activities	Recreation Users from Region: 1	2	3	4	5	6	7	8	9	10	11	12	13	Non-resident	Total Users	Average Annual Increase(%) 1974-1980
Hiking		280,251	1,227,920	102,274							277,608	4,161,538		3,694,474	9,744,065	2.96
Horseback Riding		73,109										798,104	50,043	445,496	1,366,752	3.17
Bicycling			161,924									3,021,391		144,194	3,327,509	4.51
Motorcycling		48,740	67,467									228,029		68,140	412,376	3.56
Driving for Fun		231,518	580,226	191,764	44,702						133,107	242,282	12,510	7,072,422	8,508,531	1.32
Four-Wheeling		24,370	445,290								27,762	185,274		1,136,228	1,818,924	2.01
Mountain Climbing			161,924											50,284	212,208	3.06
Swimming			161,924	153,411							55,521	769,600		1,090,718	2,231,174	2.57
Picnicking		48,739	202,404								194,326	199,525		1,658,252	2,303,246	1.75
Camping	181,274	353,360	1,578,754	191,764								199,526		2,386,168	4,890,846	2.10
Boating		24,370	107,949	153,411								356,296		167,649	809,675	3.31
Game Playing		341,175										399,053		225,332	965,560	2.81
Tennis			26,988								41,641	270,785	25,022	211,668	576,104	3.06
Golf								11,016				71,260		379,239	461,515	1.45
Fishing	181,274	657,979	2,347,891	191,764							180,445	612,829		2,712,027	6,884,209	2.42
Shooting/Hunting		121,848	485,771	25,569					34,131		27,762	142,518	37,532	398,894	1,274,025	2.64
Skiing/Snowshoeing	22,660	109,662	2,671,737	524,154			45,157				13,880	5,073,724	25,022	9,530,678	18,016,674	2.40
Snowmobiling			53,974									242,282		173,877	470,133	3.12
Sledding/Tobogganing/Tubing			202,404									313,540		348,382	864,326	2.88
Ice Skating												641,333		128,450	769,783	4.04
Other												156,771		440,636	597,412	1.85
Region Total															66,505,047	2.46

TABLE RIV-48

Number of Recreation Users in Region 12 (Activity Days) in 1985

Recreational Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	Non-resident	Total Users	Average Annual Increase (%) 1980-1985
	Recreation Users from Region:															
Hiking		310,027	1,478,930	117,760							333,230	5,009,821		3,875,246	11,125,014	2.69
Horseback Riding		80,876										960,789	56,591	467,294	1,565,550	2.75
Bicycling			195,024									3,637,267		151,249	3,983,540	3.66
Motorcycling		53,918	81,960									274,510		71,474	481,862	3.16
Driving for Fun		256,116	698,835	220,800	46,013						159,777	290,270	14,147	7,418,479	9,104,437	1.36
Four-Wheeling		26,959	536,316								33,324	223,040		1,191,824	2,011,463	2.03
Mountain Climbing			195,024											52,744	247,768	3.15
Swimming			195,024	176,640							66,645	926,474		1,144,087	2,508,870	2.37
Picnicking		53,917	243,780								233,262	240,196		1,739,391	2,510,546	1.74
Camping	188,736	390,903	1,901,480	220,800								240,197		2,502,924	5,445,040	1.80
Boating		26,959	130,016	176,640								428,923		175,852	938,390	2.99
Game Playing		377,424										480,395		236,356	1,094,175	2.53
Tennis			32,504								49,984	325,981	28,296	222,025	658,790	2.72
Golf								11,205				85,786		397,795	494,786	1.40
Fishing	188,736	727,888	2,827,843	220,800							216,599	737,747		2,844,728	7,764,341	2.44
Shooting/Hunting		134,794	585,071	29,440					35,659		33,324	171,569	42,444	418,412	1,450,713	2.63
Skiing/Snowshoeing	23,592	121,313	3,217,890	603,520			46,876				16,661	6,107,946	28,296	9,997,019	20,163,113	2.28
Snowmobiling			65,007									291,668		182,385	539,060	2.77
Sledding/Tobog-ganning/Tubing			243,780									377,452		365,428	986,660	2.68
Ice Skating												772,062		134,735	906,797	3.33
Other												188,727		462,197	650,924	1.73
Region Total															74,631,839	2.33

TABLE RIV-49

Number of Recreation Users in Region 12 (Activity Days) in 1990

Recreational Activities	Recreation Users from Region: 1	2	3	4	5	6	7	8	9	10	11	12	6	Non-resident	Total Users	Average Annual Increase (%) 1985-1990
Hiking		342,266	1,781,250	135,591							388,184	5,881,428		4,064,864	12,593,583	2.51
Horseback Riding		89,469										1,127,947	63,997	490,159	1,771,572	2.50
Bicycling			234,890									4,270,078		158,650	4,663,618	3.20
Motorcycling		59,647	97,870									322,269		74,971	554,750	2.86
Driving for Fun		283,327	841,690	254,233	47,363						186,126	340,771	15,999	7,781,468	9,750,977	1.38
Four-Wheeling		29,824	645,949								38,820	261,844		1,250,140	2,226,577	2.05
Mountain Climbing			234,890											55,325	290,215	3.21
Swimming			234,890	203,386							77,636	1,087,662		1,200,068	2,803,642	2.25
Picnicking		59,646	293,613								271,730	281,985		1,824,500	2,731,474	1.70
Camping	196,505	432,436	2,290,178	254,233								281,986		2,625,393	6,081,731	2.24
Boating		29,824	156,594	203,386								503,547		184,457	1,077,808	2.81
Game Playing		417,524										563,974		247,923	1,229,421	2.36
Tennis			39,149								58,227	382,695	31,999	232,889	744,959	2.49
Golf								11,396				100,711		417,260	529,367	1.36
Fishing	196,505	821,651	3,405,908	254,233							252,319	866,100		2,983,921	8,780,637	2.49
Shooting/Hunting		149,115	704,671	33,898					37,256		38,820	201,419	47,998	438,885	1,652,062	2.63
Skiing/Snowshoeing	24,563	134,203	3,875,687	694,903			48,660				19,409	7,170,605	31,999	10,486,174	22,486,203	2.20
Snowmobiling			78,296									342,412		191,309	612,017	2.57
Sledding/Tobog-ganning/Tubing			293,613									443,121		383,309	1,120,043	2.57
Ice Skating												906,385		141,328	1,047,713	2.93
Other												221,562		484,812	706,374	1.65
Region Total															83,454,743	2.26

Recreation use in Region 11, which includes Routt County, will increase at an average annual rate of 3.39 percent to 1980, 3.16 percent to 1985, and 2.81 percent to 1990. The most rapid growth, listed in decreasing order of magnitude from 1974-1980 will be in ice skating, bicycling, tennis, game playing (i.e., playgrounds and field games), and golf. Activities experiencing the most rapid growth from 1980-1985 will be motorcycling, ice skating, sledding, bicycling, and horseback riding. Horseback riding, four-wheeling, motorcycling, golf, skating, sledding, snowmobiling, and bicycling will increase at the fastest rates from 1985-1990.

Participation in largely urban recreation activities will increase most rapidly in Region 11; participation in the more traditional forms of recreation such as camping, picnicking, and pleasure driving will still increase but at slower rates.

Recreation use in Region 12 will increase at a slower average annual rate than in Region 11: 2.46 percent to 1980, 2.33 percent to 1985, and 2.26 percent to 1990. Until 1980 the most rapid increases will be experienced in bicycling, ice skating, motorcycling, and boating. From 1980-1985 participation in bicycling, ice skating, motorcyling, mountain climbing, and boating will increase most rapidly. Most rapid increases from 1985 to 1990 will be in mountain climbing, bicycling, ice skating, motorcycling, and boating.

Urban recreation activities in Region 12 will not be increasing as fast as in Region 11. Instead dispersed activities such as cycling, boating, and mountain climbing will increase much faster, although ice skating will also increase. Participation in camping and picnicking, golf, and pleasure driving will still increase, but at slower rates. Bicycling and ice skating will rapidly continue to become more popular in both regions. These data can be further analyzed with the supply-demand analysis in Chapter IV of the Regional Analysis (see Figure RIV-30).

The supply of boating and mountain climbing resources appears to be adequate in Routt County. Deficits already exist for bicycling, swimming, tennis, and hunting; only a small supply of ice skating exists. Resources for these five activities will be the most critical to meet the increasing demand. Construction of the proposed recreation complex at Howelson Hill in Steamboat Springs will help meet an anticipated shortage of ice skating resources.

In Moffat County bicycling, ice skating and golf resources are already in deficit, and only small supplies of tennis and sledding resources are now available; the most rapidly increasing recreation demand in this region will occur in these same deficit areas. Demand will be rapidly increasing for other activities including horseback riding, game playing, and snowmobiling of which Moffat County has an ample supply.

Recreation activities in Rio Blanco County that are in deficit or small supply include those for which projected demand will increase most rapidly: bicycling, ice skating and tennis. Rio Blanco County appears to have an ample supply of horseback riding, game playing, snowmobiling, and sledding resources.

Social Environment

This section presents the population growth and related effects that are expected to take place in the study region without implementation of the proposed Federal action. The following projections provide a base over which impacts of the actions can be assessed.

Demographic features

The construction of Colorado Ute's mine-mouth power plant south of Craig is having and will continue to have a substantial expansionary effect on the study region's population. Other anticipated non-coal related developments, such as oil shale, recreation, and water impoundment projects, could have similar population effects. To project the effects of these developments, a survey of the proponents of these developments was conducted to obtain best-guess employment and start-up dates. Representative results of the survey are shown in Table RIV-50. The complete data set is shown in Appendix D. Note that the summation of the proponents' estimates represent a worst-case projection because the effects on their developments of labor, equipment, and financing shortages were not considered.

The employment data in Table RIV-51 were incorporated into three models, described in detail in Appendix D, to generate a population estimate for the study region. An export base employment model produced an estimate of induced employment effects. The results of this model were then incorporated into a cohort survival model to project total population effects. This second model applies trends in birth, death, and migration rates to each class of the region's age distribution to project population in succeeding years. Employment and population were then allocated to the population centers in the study region using a gravity allocation model. Generally this model utilizes gravity coefficients to allocate the employment at each project to surrounding communities. Gravity coefficients are measures of the relative attractiveness of communities within a specified maximum travel distance from the individual project sites. The ratio of a community's population to its distance from the project allows a small, proximate community to be as attractive to new employees

TABLE RIV-50

Representative Employment Input Data for Gravity-Employment Multiplier Model (Construction/Permanent)

	1975	1980	1985	1990
Bureau of Reclamation				
Yellow Jacket	--	370/--	--/10	--/10
Savery-Pothook	250/--	--/10	--/10	--/10
Juniper-Cross Mountain	--	380/--	--/10	--/10
Oil Shale	35/--	710/750	1,000/3,380	--/3,970
Yampa Project	335/39	--/275	--/275	--/275
Hayden Expansion	350/25	--/35	--/35	--/35

SOURCE: Communications with industry representatives.

Note: Detailed input data is contained in Appendix D.

"--" represents zero.

as a more distant, large community. The combination of these three models are hereafter referred to singularly as the gravity-employment multipler model.

It is significant that the model does not allocate any population to unincorporated rural areas; therefore individual community populations may be somewhat overstated. However the source of error is essentially eliminated in the accumulation of community populations to the county level. It is additionally significant that population effects from recreation development in Routt County were not analyzed in the gravity-employment multiplier model. Instead incremental population growth associated with this development was drawn from the draft Routt County Comprehensive Plan (Charles Gathers and Associates, 1975) and allocated to Hayden (20%), Oak Creek (15%), and Steamboat Springs (65%).

The population results of the modeling are presented in Tables RIV-51 and RIV-52. These projections, hereafter referred to as the base scenario, indicate that the most substantial growth without the proposed action can be expected in Rio Blanco county as the result of oil shale developments in the Piceance basin and in Utah. Growth in Routt county communities is due principally to projected recreation developments in the area. Figure RIV-39 is a graphic presentation of the projected base scenario population of the study region. The rapid increase in population from 1979 to 1982 is mostly a reflection of oil shale developments. The slight decline to 1985 indicates the departure of temporary oil shale construction forces.

Social support facilities

Growth in population associated with the base scenario will require additions to the existing social support facilities. Additional requirements

TABLE RIV-51

Base Scenario Population Projection

	1975	1980	1985	1990
Moffat County	9,001	10,154	11,234	13,547
Craig	8,016	8,945	9,320	11,373
Dinosaur	300	408	947	975
Other areas	685	801	967	1,199
Rio Blanco County	5,431	11,171	16,978	18,541
Meeker	1,809	5,672	6,629	7,353
Rangely	1,705	3,356	7,838	8,094
Other areas	1,917	2,143	2,511	3,094
Routt County	11,084	14,492	17,005	17,704
Hayden	1,839	2,212	2,520	2,533
Oak Creek	1,286	1,868	2,224	2,287
Steamboat Springs	5,853	8,089	9,631	9,885
Yampa	357	408	498	600
Other areas	1,749	1,915	2,132	2,399
Study Region Total	25,516	35,817	45,217	49,792

TABLE RIV-52

Difference in Base Scenario Population from 1975 Population

	1980	1985	1990
Moffat County	1,153	2,233	4,546
Craig	929	1,304	3,357
Dinosaur	108	647	675
Other areas	116	282	514
Rio Blanco County	5,740	11,547	13,110
Meeker	3,863	4,820	5,544
Rangely	1,651	6,133	6,389
Other areas	226	594	1,177
Routt County	3,408	5,921	6,620
Hayden	373	681	694
Oak Creek	582	938	1,001
Steamboat Springs	2,236	3,778	4,032
Yampa	51	141	243
Other areas	166	383	650
Study Region Total	10,301	19,701	24,276

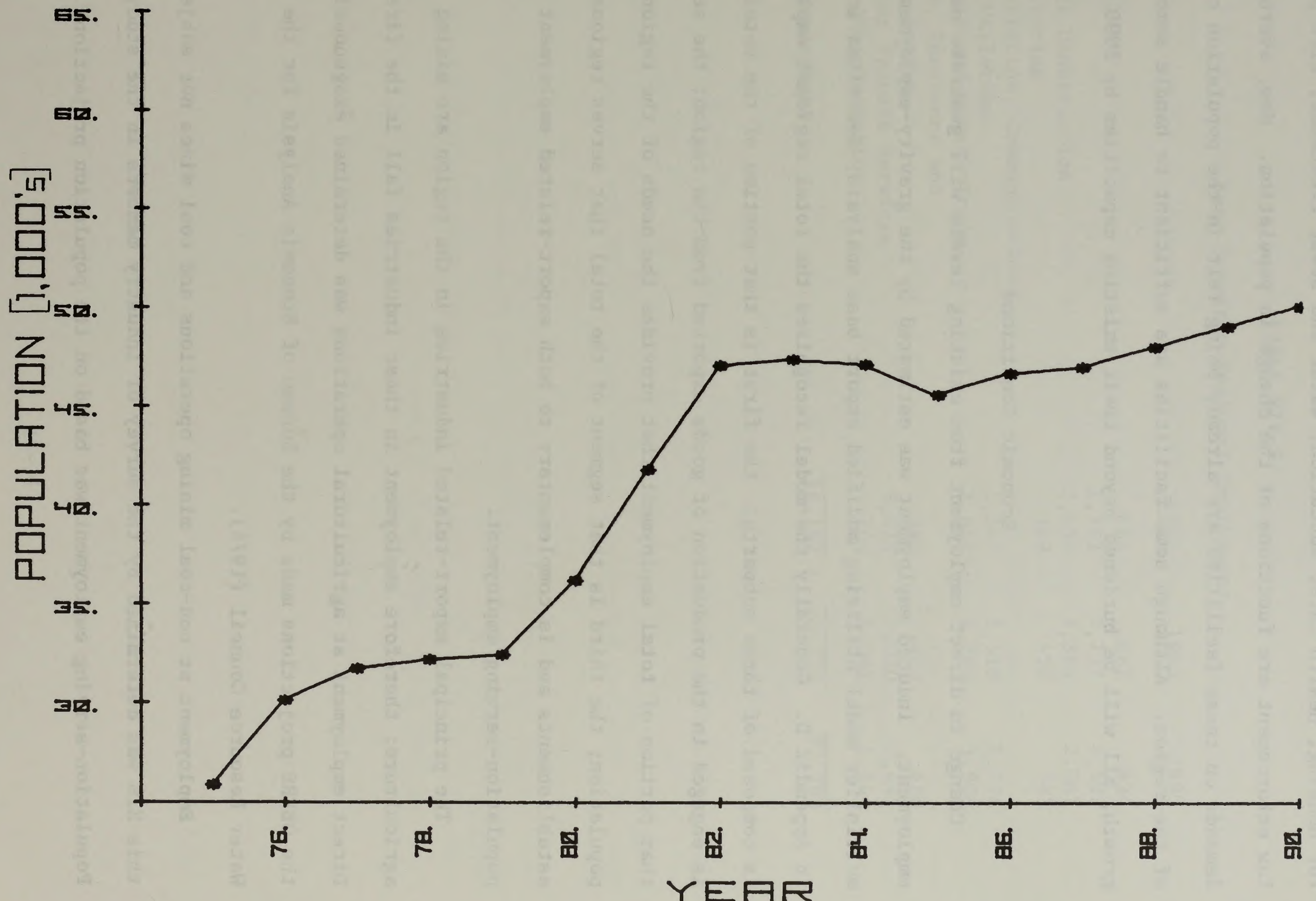

FIGURE RIV-39

Base scenario population projection.

for housing, health care, education, water and sewer treatment, fire protection, and law enforcement are functions of the change in population. New, overburdening demands on these facilities are already being felt in the population centers of the region. Although some facilities are sufficient to handle some population growth, all will be burdened beyond their existing capacities by 1990.

Economic Conditions

Change in direct employment from existing levels will generate new induced employment. Induced employment was estimated by the gravity-employment multiplier model utilizing modified export base analysis, described in detail in Appendix D. Generally the model recognizes the total regional employment is composed of three subparts: the first is that portion of the total that is engaged in the production of goods exported from the region; the second is that portion of total employment that provides the needs of the regional population; the third is that segment of the total that serves regional business establishments and is complementary to both export-related employment and population-serving employment.

The principal export-related industries in the region are mining and agriculture; therefore employment in these industries fall in the first category. Direct employment at agricultural operations was determined exogenously from the OBERS projections made by the Bureau of Economic Analysis for the U.S. Water Resource Council (1974).

Employment at non-coal mining operations and coal mines not subject to this EIS was determined by the survey of industry members in the study region. Population-serving employment was based on the population projections presented

TABLE RIV-53

Base Scenario Regional Employment

	1980	1985	1990
Agriculture	911	867	824
Mining	1,743	3,737	4,592
Contract Construction	2,659	2,384	2,061
Manufacturing	369	450	545
Transportation, Communications, and Utilities	1,249	1,518	1,796
Wholesale and Retail Trade	2,687	3,292	3,908
Finance, Insurance and Real Estate	340	423	478
All Other Private Services	5,473	7,020	7,445
Public Administration	766	1,061	1,144
Total Employment	16,197	20,752	22,793

TABLE RIV-54

Base Scenario Regional Earnings 1/

(Thousands of 1974 constant dollars)

	1980	1985	1990
Agriculture	10,923	11,765	12,681
Mining	31,069	82,455	113,350
Contract Construction	35,072	25,474	34,707
Manufacturing	5,202	7,146	9,461
Transportation, Communications, and Utilities	17,035	23,226	30,801
Wholesale and Retail Trade	26,305	35,785	47,209
Fianance, Insurance, and Real Estate	4,464	6,239	7,944
All other Private Services	46,551	62,056	75,641
Public Administration	11,682	16,531	22,218
Total	188,303	380,677	354,312
Total Personal Income 2/	241,028	259,267	457,062
Per Capita Personal Income 3/	6,664	7,884	9,132

1/ Based on projected national sectoral earnings per employee from U.S. Dept. of Commerce, Bureau of Economic Analyis, OBERS Projections, 1974

2/ Based on the ratio of projected national personal income to national earnings from U.S. Dept. of Commerce, Bureau of Economic Analysis, OBERS Projection, 1974.

3/ Based on population estimates from Table RIV-51.

in the section dealing with the social environment without the proposed action. Business serving employment was determined by employment levels in the other two categories.

The implementation of this model resulted in the regional employment estimates by sector shown in Table RIV-53. From these employment data, estimates of earnings by sector were generated, using national earnings averages from the OBERS projections for all sectors except mining. These earnings estimates are shown in Table RIV-54. The mining sector earnings are based on data provided by industry members. The per capita personal income data shown in Table RIV-54 were calculated from the previous earnings data and the population estimates shown in the section on social impacts without the proposed action.

Transportation Networks

The following transportation and utilities developments are anticipated regardless of whether the proposed actions are approved.

Highways

Even without the proposed coal developments, many of the highways still need to be upgraded and improved because of recent expansion in coal mining, oil and gas developments, and oil shale projects. Most of the existing highways were designed for lightweight traffic and are not suitable for industrial hauling.

U.S. Highway 40, as part of the national highway system, will continue to be widened and improved to accommodate increased local and through traffic.

Colorado 13 between Craig and Meeker must be improved similarly to the 9-mile stretch immediately south of Craig to handle increased traffic to several growing oil and gas fields, the oil-shale developments to the south, and the coal mines and power plant construction a few miles south of Craig. North of Craig, which is a sub-service center, Colorado 13 is the route used by service trade from Laramie, Casper, and Sinclair, Wyoming, to the growing oil and gas developments surrounding Craig. This traffic will probably require improvements to the highway in the near future.

Colorado 64 along the White River between Meeker and Rangely is tentatively planned for extensive remodeling (perhaps realined and four-laned) to accommodate the traffic that will result from oil shale developments south of the White River.

Several of the smaller State, county, and private roads branching off the main arteries will also be proportionately upgraded.

Public Transportation

Without the proposed W. R. Grace mine at Axial, the railroad system in the region will need little modification or extension. Consideration of the present rate of population growth has led the local council of governments (NWCCOG - Region 12) and others to urge the D&RGW Railroad to resume passenger service from Denver into northwestern Colorado.

Oil shale developers consider rail service essentail to their plans. Superior Oil Company favors a high-speed rail line from Piceance Creek up into the Union Pacific system in Wyoming, over the slower D&RGW system into Denver.

As mentioned in the present environment, the Yampa Valley Airport at Hayden is undergoing a $10 million expansion.

Chapter V

Environmental Impacts of the Proposed Action

THE FOLLOWING CHAPTER DISCUSSES THE CUMULATIVE IMPACTS THAT WOULD RESULT FROM IMPLEMENTATION OF THE PROPOSED ACTIONS. THE IMPACTS ARE IDENTIFIED AS THEY WOULD OCCUR PRIOR TO APPLICATION OF ANY MITIGATING MEASURES. IN THIS MANNER ALL PROBABLE IMPACTS CAN BE IDENTIFIED AS THE BASE FOR DETERMINING MITIGATING MEASURES AND UNAVOIDABLE ADVERSE IMPACTS IN THE TWO SUCCEEDING CHAPTERS. WHERE DATA ARE AVAILABLE, IMPACTS ARE LINKED TO SPECIFIC ASPECTS OF THE PROPOSED ACTIONS AND ARE QUANTIFIED AS TO MAGNITUDE, INTENSITY, DURATION, AND INCIDENCE.

CHAPTER V

ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

Non-living Components

Geologic and Geographic Setting and Paleontology

Strip mining in the past in northwest Colorado has resulted in an elevated hummocky surface obviously different from the surrounding natural surface (Figure RV-1). It is assumed, however, that no such hummocky landforms would result from present and future strip mining of the region; elevated landforms would result with more smoothly contoured surfaces, designed to blend with the natural surface. However some sloped highwalls would remain, as well as some ponds or small lakes where the last cuts are made.

One visible impact of dip-slope strip mining, which is the most common mode used in the Yampa coal field, is the debris that flows down the steep back slopes of the ridge or cuesta where mining has taken place. This debris flows intermittently as a result of spoils dumped high and in steep piles at the very crest of the ridge. Here they are subject to erosion by rainfall or snowmelt, or more commonly the debris fails by landslide, slump, and mudflow. Figure RV-2 shows the occurrence of debris flows at the Edna Mine near the town of Oak Creek. Underground mining may result in subsidence and disruption of surface values, depending on the depth of working faces and the nature of overlying strata.

Cuts and fills for the various coal haul roads, and roads to market or loading facilities, would be the major off-site impacts to the topography under the present proposals.

Impacts to fossils of the region would result both from surface-disturbance and from greater visitor-use pressures. In terms of surface

FIGURE RV-1

Aerial oblique photograph showing contrasting landforms on hummocky old coal mine spoil area and natural land surface.

FIGURE RV-2

Aerial oblique view, looking west in Sections 18 and 19, T.4N.,R.85W. Edna strip mine is on top of the 750 foot high ridge, where dip slope to northwest held the mined coal bed. Oak Creek and the Denver and Rio Grande Railroad are along the bottom, below mine buildings. Note debris slides at upper right.

disturbing activities, destruction of the resource would proceed at roughly the same rate: 9,385 acres by 1980, 23,415 acres by 1985, and 39,210 acres by 1990 (see Table RV-14). Whether or not these adverse impacts would be significant depends on the relationship of the project to potential fossil-bearing strata. Fossils contained within the coal itself would be destroyed in its use; those in adjacent formations would be destroyed or damaged in the mining operation.

Commercially valuable coal deposits of the study region are largely found in the Williams Fork and Iles Formations. Lower grade coal is found in the Wasatch, Fort Union, and Lance formations. Six vertebrate fossil bearing formations accompany these strata and can be impacted by coal mining operations. Older formations also contain vertebrate fossils and can be impacted by coal related developments such as linear rights-of-way. However, beneficial impacts could be realized through the disclosure of heretofore unknown fossils of significant value, such as fossilized vertebrate mammals.

Greater numbers of collectors would result from local population growth. Projected increases in recreational activity days of four-wheel driving are indicators of this recreational growth: 29,261 by 1980, 25,946 by 1985, and 27,413 by 1990 (see Table RV-23).

Mineral Resources

The major impact of the proposals on the coal resources of the region is the removal of about 340 million tons of coal by the year 1990. Based on Landis' (1959) estimate of approximately 38 billion tons of measured, indicated, and inferred coal reserves in the study region and a weighted average surface and underground recovery ratio of 55 percent, this loss of coal represents about 2 per cent of the recoverable coal in the study region.

Another impact is that some of the most readily strippable coal beds will be removed, so that remaining coal resources will include less accessible reserves.

Sand and gravel resources of the study region will be removed for uses in construction aggregates for power plants and new housing that will result from the implementation of the proposed action.

Water Resources

Ground water

Due to the lack of suitable aquifers in the area there can be no large scale development of ground water; most of the new population and new industrial users must be supplied from surface water sources. As discussed in Chapter II, coal production and associated activities require very little water. Some increase in ground water use will arise due to an increase in population in rural areas. No data are available upon which to base a reliable estimate of the size of the increase; however for the purposes of this analysis we will assume a rural population increase of 1,000 people by the year 1990. Should this population all be supplied from wells at an average rate of use of 50 gallons/day/person, the additional use of ground water would be about 18 million gallons or about 60 acre feet/year. As the drainage area of the Yampa River above Maybell receives about 200,000 acre feet of ground water recharge, it can safely be inferred that this increase in the rural use of ground water would not have any serious regional impact on the ground water.

There is always concern about the pollution of ground water and surface water in the vicinity of mining activities. The pollution of ground water in the vicinity of a mine in this area is unusual, but where it occurs it is confined to the part of the water bearing bed that lies between the mine and the place of natural discharge from the bed. In the case of coal and associated rocks, neither of which is very permeable, the principal point of natural discharge is usually less than a mile from the mine. Samples from wells indicate that water occurring in coal beds and associated rocks is similar in concentration and composition to the water from mine pits (see Table V-8 in Appendix D). Similarity between these waters occurs because the water derives its soluble material from contact with the same part of the same geologic formation; the source of the water in the mine pits is a combination of normal ground water in the formation, surface runoff from the mined area, and ground water that moved through the spoils. The fact that there is little difference between water in the pits and normal ground water indicates that if there is any significant additional leaching of soluble material from the spoils material it does not materially degrade the water that accumulates in the pits. In such areas water from the mines cannot be considered to be polluting the ground water, since it is causing no appreciable change in its composition.

The explanation for the lack of acid and other contaminants in the mine pits follows: mine spoils tend to produce toxic materials and polluting leachants largely as the result of changing the environment of the minerals in the rocks from a reducing condition to an oxidizing condition. Minerals, particularly sulfide minerals, that were formerly below the water table where little oxygen could reach them, may end up in a position above the water table where they can be oxidized. Many of these minerals when oxidized produce soluble products that are added to the water that percolates through the spoils. Two conditions must prevail for this type of pollution from mine spoils to take place: (1) part of the overburden must lie below the water table, and (2) there must be sulfides or other minerals that are subject to oxidation in that part of the overburden.

In mineralized areas, many if not all of the metals mined are found in the overburden in the form of sulfides; oxidation takes place in the spoils, and metal ions and oxides are produced, as well as large amounts of sulfuric acid. The sulfuric acid in turn attacks other minerals releasing ions. In the absence of secondary mineralization, coal deposits normally contain only one significant sulfide, iron sulfide or pyrite. Coal deposits that contain large amounts of pyrite produce acid mine drainage plus high concentrations of iron, and possibly other trace irons.

Very little data are available on the overburden in the study region; however, some appraisal of pollution from mine spoils can be made. Most of the material overlying the coal is above the water table in most strip-mine areas. As sulfides cannot exist in this environment none can be expected in this part of the overburden. The lack of any external source for sulfides other than iron makes their presence in the saturated part of the overburden highly unlikely. Although there is some pyrite in association with the coal, the amount is small; this is one of the reasons for the low sulfur content of the coal that makes it so attractive to utilities.

In summary there are no indications of present or potential pollution from leaching of mine spoils, nor would any toxic materials be expected in the mine spoils that would adversely affect rehabilitation if the material were placed at the surface of the reshaped spoils.

The mining will result in the destruction of minor aquifers that supply a relatively few wells and springs. Energy 1 mine will destroy two springs and may cause a third spring to dry up. Energy 2 mine will destroy three wells and three springs. There are no known wells or springs that will be affected by the Energy 3 mine, the Colowyo mine, or the Ruby Construction mine. Seneca 2-W mine will destroy two wells and a spring and may stop the flow of a third well. Some ephemeral streams that are at present fed by ground water during the spring runoff will be destroyed.

Those water sources are at present used primarily for watering livestock. As mining moves into their areas the livestock will be removed, and will not be returned to the area until the surface is rehabilitated and new vegetation established in the area. After vegetation is reestablished the need for the replacement of water sources or development of new water sources will depend on the fencing pattern and the availability of surface water.

A secondary use of the destroyed water sources is by wildlife. The impact on the amphibians that depend upon this water is greatest because it destroys a necessary part of their habitat. All of the water sources are within a mile of perennial streams so the impact on larger or more mobile animals and birds is relatively small.

Surface water

Table RV-1 shows the effects the proposed power plants in the Yampa River system will have on the increase of dissolved solids in the Colorado River below Hoover Dam. These estimates of dissolved solids were computed in the same fashion as described in Chapter IV, Future Surface Water Environment Without the Proposed Action. Table RV-1 indicates that due to the implementation

TABLE RV-1

Sources and Estimates of Dissolved Solids and Downstream Effects with the Proposed Actions

		1975	1980	1985	1990
1	Total undepleted supply (ac-ft):	1,702,400 [1]	1,702,400 [1]	1,702,400 [1]	1,702,400 [1]
2	Consumptive use:				
3	Irrigation (ac-ft)	69,700 [2]	69,700 [2]	86,500 [3]	88,000 [4]
4	Reservoir evap. (ac-ft)	9,300 [5]	9,300 [5]	49,300 [6]	54,300 [7]
5	Riparian vegetation (ac-ft)	18,000	20,400	20,800	21,200
6	Power Plants (ac-ft)	4,000	19,000 [8]	19,000 [8]	19,000 [8]
7	Export from basin (ac-ft)	2,800	2,800	45,000 [9]	45,000 [9]
8	[10]Net discharge without action (ac-ft)	1,598,600	1,581,200	1,481,800	1,474,900
9	Additional power plants (Craig 3 & 4) (ac-ft)	---	---	12,000	12,000
10	Net discharge with action (ac-ft)	1,598,600	1,581,200	1,469,800	1,462,900
11	Water quality (polluting sources) without action:				
12	Natural sources (tons)	343,400	343,400	343,400	343,400
13	Irrigation (tons)	80,000	80,000	98,000	100,000
14	[11]Municipal (tons)	620	760	890	950
15	Mining operations (tons)	150	200	200	200
16	Less load due to power plants and exports (tons)	-2,000	-6,500	-22,800	-22,800
17	Dissolved solids in Yampa (tons) lines 12 thru 16	422,170	417,860	419,690	421,750
18	Water quality (polluting sources):				
19	Municipal (increase in dissolved load due to action) tons	0	210	390	590
20	Mining operations (increase in dissolved load due to action) tons	0	100	300	500
21	Less load due to additional power plants (Craig 3 & 4) tons	0	0	-3,600	-3,600
22	Net dissolved load with action-line 17 plus lines 19,20 less line 21 (tons)	422,170	418,170	416,780	419,240
23	Discharge weighted average of dissolved solids in Yampa River (mgl)	195	194	208	211
24	Increase in dissolved solids in Colorado River below Hoover Dam without action (mgl)	0.4	1.3	3.8	3.8
25	Increase in dissolved solids in Colorado River below Hoover Dam with action (mgl)	0.4	1.3	4.5	4.5
26	Total-line 25 less line 24	0	0	0.7	0.7

[1] Irons and others, 1965

[2] 71,400 - (2,390 x 0.7) = 69,700
71,400 ac-ft = 102,000 ac x 0.7 (ac-ft water applied per acre)
2,390 = Irrigated acreage on Vermillion Creek (from Division of Water Resources.)

[3] 86,500 = 69,700 + (24,000 x 0.7)
24,000 = Estimated increase in irrigated land

[4] 88,000 = 86,500 + 1,500
1,500 = estimated increase in irrigation water consumption due to Juniper Reservor.

[5] From CWCB &USDA, 1969

[6] 49,300 = 9,300 + 40,000
Juniper Reservoir: 33,000 ac-ft
Savery-Pot Hook Reservoir: 7,000 ac-ft

[7] Increase due to Cross Mountain Reservoir: 5,000 ac-ft

[8] Increase in evaporation when Hayden enlargement and Craig 1 and 2 come on line.

[9] Increased export of water from basin when High Mountain Line Company and Rawlins diversions begin.

[10] No action other than power plants under construction.

[11] Based on 100 gallons of sewage per day per person and increase in dissolved solids load of 200 mg/1.

of the proposed action the concentration of dissolved solids would increase by 0.7 mg/1 below Hoover Dam in 1985 and continue through 1990.

Mining and associated activities, construction of power plants, construction of roads and railroads, population increase, and mine facilities would create a potential for an increase in sediment yield from the areas affected. Table RV-2, 3, and 4 indicate the estimated total sediment yield that would result from the several activities listed for the periods 1976-80, 1981-85, and 1986-90. Computation methods and estimates used are given in Appendix D.

The estimates of sediment yield in this section of the report, as well as in the site specific reports, are only approximate. A more detailed analysis would require soil samplings and testing several years of observations, and statistical analysis of data, all which are beyond the scope of this study. Because of the uncertainty with regard to this subject, and in order to avoid understating the problem, unusually high values of sediment yield rates were assumed for use in the computations.

The true values for sediment yield from the various sources could very well be half or less than the amounts presented in this report. Since even the possibly inflated values of sediment yield would not in most cases materially increase the present sediment loads in the streams, the true and probably lower sediment yields would have even less impact. It is unlikely that sediment yield will have more than a very local impact. Unless a disturbed area is immediately adjacent to or has a direct access to a well defined stream channel, very little sediment is likely to reach the stream. Also, unless the stream flows continuously at a rate such that it can carry an appreciable amount of sediment, much or all of the load will be deposited in the channel to wait for another flow event to carry it further downstream. Thus, years of flow events may be required for a specific load to reach the main stream of a drainage system.

Air Quality

Emission sources

In order to determine the change in air quality due to expected coal development in northwestern Colorado, it is necessary to estimate the quantity of each pollutant emitted into the atmosphere. Emissions come from all facets of development, including: (1) external combustion for power generation and home and commercial fuel use, (2) transportation systems, (3) small point sources such as solid waste disposal, and (4) mining operations. The following sections discuss emissions from each of these potential pollution sources for the years 1974, 1980, 1985, and 1990.

TABLE RV - 2

Total Sediment Yield due to Mining and Associate Activities

1976-1980

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	4,825	22,100	90	19,900	2,200
Surface mines, revegetated	1,434	770	50	380	390
Underground mines	200	430	90	390	40
Power plants	1,000	2,150	80	1,730	430
Roads, new	420	1,930	80	1,540	390
Roads, revegetated	250	270	50	140	130
Railroads, new	420	4,000	80	3,200	800
Railroads, revegetated	420	1,150	50	580	580
Population	1,070	2,310	60	1,390	920
Mine facilities	400	1,840	90	1,660	180

TABLE RV - 3

Total Sediment Yield due to Mining and Associate Activities

1981-1985

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	9,470	43,500	90	39,200	4,300
Surface mines, revegetated	7,528	6,000	50	3,000	3,000
Underground mines	300	650	90	580	70
Power plants	1,000	2,160	80	1,730	430
Roads, new	1,150	5,280	80	4,220	1,060
Roads, revegetated	850	1,590	50	800	790
Railroads, new	60	320	80	260	60
Railroads, revegetated	480	10,400	50	5,200	5,200
Population	0	0	60	0	0
Mine facilities	300	1,380	90	1,240	140

TABLE RV - 4

Total Sediment Yield due to Mining and Associate Activities

1986-1990

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	9,670	44,400	90	40,000	4,400
Surface mines, revegetated	9,596	17,300	50	8,650	8,650
Underground mines	0	0	90	0	0
Power plants	1,000	2,160	80	1,730	430
Roads, new	1,385	6,360	80	5,090	1,270
Roads, revegetated	1,130	4,190	50	2,100	2,090
Railroads, new	1,020	5,510	80	4,410	1,100
Railroads, revegetated	1,500	34,600	50	17,300	17,300
Population	120	260	60	160	100
Mine facilities	500	2.300	90	2,070	230

External Combustion

Power plants. Most of the available information concerning power plant facilities and expected growth in northwestern Colorado is in the Yampa Project Environmental Impact Statement (1974). The Yampa project started in 1969 when three utilities, Colorado-Ute Electric Association, Inc., Public Service Company of Colorado, and Salt River Project Agricultural Improvement and Power District, began planning construction of a large generating project to serve their combined needs for 1976 and later years. Two of these companies were already partners in Hayden station unit 1. Hayden unit 1 started operation in 1965 and was upgraded to a 180-megawatt (mw) unit in 1974. Hayden unit 2 is scheduled to start operation in 1976 and will have a 250-mw rating. The Yampa project also provides for construction of two 380-mw units at the Craig power station which will start operations in 1978 and 1979 respectively. No other specific plans have been announced except that the Craig location has provisions for two additional units.

Determination of the power needs for 1985 required making estimates from the best engineering, economic, and social information available. The Yampa project plans for the period up to 1980 assumed a continuation of previous historical growth presumably by mathematical projections such as the least squares method. At the present time, various engineering-econometric simulation models are being devised to provide quantitative understanding of the many variables involved in electricity (Baughman and Joskow 1974). These models are presently most useful during the five-year lead time to adjust the mix of fossil and nuclear plants, and there appears at this time to be little benefit in applying them to the Yampa area, given the large number of unknowns. The essentially rural area could undergo a wide variety of changes that are difficult to quantify at this time. There is no apparent agreement on the effect of voluntary conservation of electrical energy, and there has not been a substantial reduction of electrical sales within the area to be served by the Yampa project.

As a result of the above situation, a plot was made of the total projected peak demand in the Yampa area, Figure RV-3. It then appears that the Craig III and IV will be needed in late 1980 and 1981.

The only other power generating facilities anticipated at this time are near Rangely, Colorado. A proposal for a facility was submitted to the BLM by Moon Lake Electric Association and then withdrawn. The necessity of a Moon Lake facility depends primarily on oil shale development. By estimating power needs of complete oil shale development, it was determined that full 1000-mw Moon Lake capacity would be required by 1985. At this time, there appears to be no plan to increase power generating capacity between the years of 1985 and 1990. A plant on the Williams Fork River was suggested to the BLM, but there has been no written documentation of such development.

Operating parameters for units on line in 1980 and 1985 are shown in Table RV-5 and RV-6, respectively. Stack parameters and fuel use for the Yampa project units were obtained from the Yampa Project Environmental Analysis. Since there are no specific plans on the number and type of units to be built by Moon Lake, it was assumed that by 1985 the Moon Lake Plant would operate four 250-mw units with similar plant operating parameters as those of Hayden Unit 2.

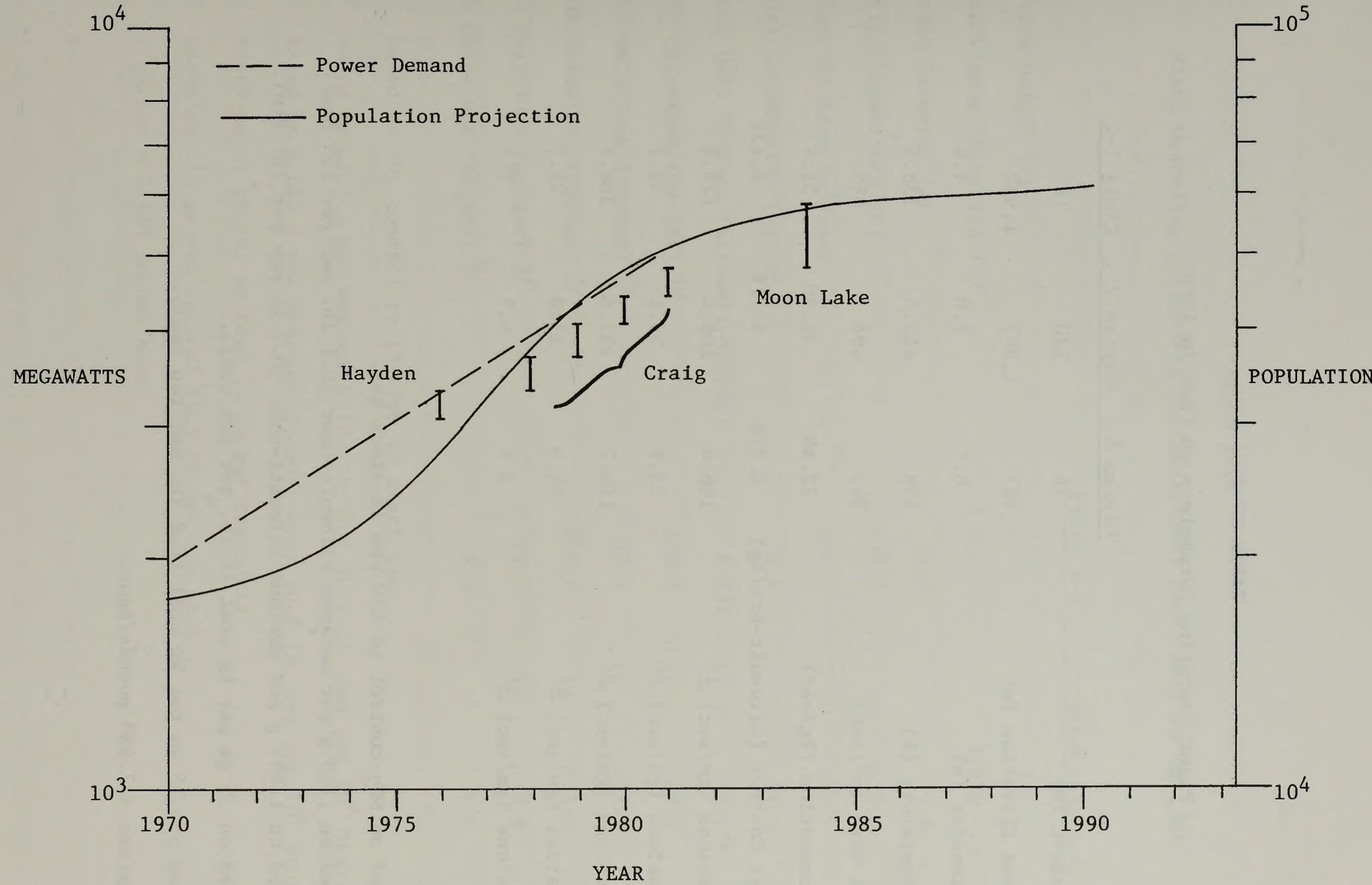

FIGURE RV-3

Estimated start-up time of power plant units.

TABLE RV-5

Plant Operating Parameters on Line in 1980

	Hayden 1	Hayden 2	Craig 1-2
Stack Height (m)	76	120	183
Stack Base Elevation (m)	1,987	1,987	1,932
Stack Diameter (m)	6.7	7.0	4.0
Exit Temperature (K)	398	413.5	338.5
Flue Gas Rate (m^3/sec)	342	498	699
Fuel Consumption (kg/sec)	22.68	31.50	55.4
Coal Heat Content (kilowatt-hrs/kg)	6.778	6.778	6.132
SO_2 Emissions (gm/sec) 1/	108.4	108.4	176.8
TSP Emissions (gm/sec) 2/	23.8	33.1	52.7
NOX Emissions (gm/sec) 3/	166.7	231.6	368.7
CO Emissions (gm/sec) 4/	11.3	15.8	27.7
HC Emissions (gm/sec) 5/	3.4	4.7	8.3

1/ Based on SO_2 control to 150 ppm in stack gas.

2/ Based on .155 g per maximum kilowatt-hour (0.1 lb. max per 10^6 Btu).

3/ Based on 1.085 g per maximum kilowatt-hour (0.7 lb max per 10^6 Btu).

4/ Based on .5 gm per kg coal (1 lb. per ton coal).

5/ Based on .15 gm per kg coal (0.3 lb. per ton coal).

1 gm/sec = 7.938 pounds/hour.

TABLE RV-6

Plant Operating Parameters for Additional Units on Line in 1985

	Craig 3-4	Moon Lake 1-4
Stack Height (m)	183	122
Stack Base Elevation (m)	1,932	1,829
Stack Diameter (m)	4.0	7.0
Exit Temperature (K)	338.5	413.5
Flue Gas Rate (m^3/sec)	699	498
Fuel Consumption (kg/sec)	55.4	31.5
Coal Heat Content (kilowatt-hrs/kg)	6.132	6.778
SO_2 Emissions (gm/sec) 1/	176.8	108.4
TSP Emissions (gm/sec) 2/	52.7	33.1
NOX Emissions (gm/sec) 3/	368.7	231.6
CO Emissions (gm/sec) 4/	27.7	15.8
HC Emissions (gm/sec) 5/	8.3	4.7

1/ Based on SO_2 control to 150 ppm in stack gas.

2/ Based on .155 g per maximum kilowatt-hour (0.1 lb. max per 10^6 Btu).

3/ Based on 1.085 g per maximum kilowatt-hour (0.7 lb. max per 10^6 Btu).

4/ Based on .5 gm per kg coal (1 lb per ton coal).

5/ Based on .15 gm per kg coal (0.3 lb per ton coal).

1 gm/sec = 7.938 pounds/hour.

Emissions estimates of the presently regulated pollutants shown in Tables RV-5 and RV-6 were computed assuming that Federal and State emissions regulations would be maintained through the use of electrostatic precipitators, wet scrubbers, efficient boiler design, or other acceptable control devices. Colorado State standards limit the sulfur oxide content of the stack exit gas to a maximum of 150 parts per million (ppm). State standards also require that particulate emissions be less than 0.1 pound maximum per million Btu. Federal emissions standards require that nitrogen oxide emissions be no greater than 0.7 pounds maximum per million Btu. While there are no regulations specifically limiting emissions of carbon monoxide and hydrocarbons, ambient air quality standards for these pollutants must be maintained.

Emissions from the power plant stacks would contain a number of trace elements and radionuclides. These elements are contained in the coal and would be volatilized or concentrated in the ash during combustion. Chemical analyses for trace elements in nine samples of coal and remaining ash were compiled for the Yampa Project. A rough approximation of trace element emissions can be obtained by assuming that the total suspended particulate matter emitted from the stack has the same percent of each trace element as the ash. While this approximation is good for many trace elements, recent studies (Zoller et al 1974) have shown that suspended particulates emitted from coal fired plants are more enriched in some trace elements than the remaining ash content would predict. This is due to the complex volatilization chemistry of trace elements. Those elements which are most volatile are usually enriched. One theory is that trace elements volatilize during combustion, and later after the gases cool in the control devices, they condense on the small submicron particles in the flue gases and are then emitted into the air.

Little is known about the magnitude of enrichment for individual elements. Therefore, Table RV-7 showing expected trace element emissions from each of the power plants has been prepared assuming that the trace element content of suspended particulate emissions is directly proportional to the content in the ash. The highest content of each element was selected from the nine ash samples reported by the Yampa project. Elements which are most likely to be enriched are indicated with an asterisk.

Each of the power plant units would be expected to be equipped with a mechanical draft cooling tower. Each cooling tower would require about 260 liter/second of water evaporation. Drift deposition poses a potentially adverse environmental impact on areas surrounding cooling towers. The drift consists of liquid droplets carried out of the cooling tower which are eventually deposited on the ground. Drift from a mechanical draft cooling tower is usually characterized by the percentage of circulating cooling water lost. The Yampa project estimates that each tower would emit drift at a rate of 26 liters/second (414 gallons/minute).

Mined coal received at the power plants must be processed before burning. Coal conveying, sorting, crushing, and storage are processes that produce fugitive dust. That portion of fugitive dust which remains airborne is called suspended particulates.

Process emissions of suspended particulates involve two types. Fugitive dust is generated by material transport, spilling, transfers between conveyors, and mechanical operations of crushing and sorting. Process emissions also include fine particulate matter emitted directly to the atmosphere from control device exhausts. Dust that is captured by a collection system, such as a hood

TABLE RV-7

Trace Element Emissions (g/sec) from Each Unit
Anticipated in Northwestern Colorado

Element	Max. Concentration in Ash (ppm)	Hayden I (g/sec)	Hayden II (g/sec)	Craig I-IV (g/sec)	Moon Lake I-IV (g/sec)
Uranium	31.00	7.382×10^{-4}	1.027×10^{-3}	1.633×10^{-3}	1.074×10^{-3}
Thorium	56.00	1.334×10^{-3}	1.856×10^{-3}	2.949×10^{-3}	1.940×10^{-3}
Lead *	110.00	2.619×10^{-3}	3.645×10^{-3}	5.793×10^{-3}	3.811×10^{-3}
Thallium	8.20	1.953×10^{-4}	2.717×10^{-4}	4.319×10^{-4}	2.841×10^{-4}
Mercury *	0.13	3.096×10^{-6}	4.308×10^{-6}	6.847×10^{-6}	4.504×10^{-6}
Lanthanum	290.00	6.906×10^{-3}	9.610×10^{-3}	1.527×10^{-2}	1.005×10^{-2}
Barium	5,900.00	1.405×10^{-1}	1.955×10^{-1}	3.107×10^{-1}	2.044×10^{-1}
Tellurium *	0.69	1.643×10^{-5}	2.286×10^{-5}	3.634×10^{-5}	2.391×10^{-5}
Antimony *	9.90	2.358×10^{-4}	3.281×10^{-4}	5.214×10^{-4}	3.430×10^{-4}
Cadmium *	1.70	4.048×10^{-5}	5.633×10^{-5}	8.953×10^{-5}	$5,890 \times 10^{-5}$
Selenium *	3.60	8.573×10^{-5}	1.193×10^{-4}	1.896×10^{-4}	1.247×10^{-4}
Arsenic *	7.00	1.667×10^{-4}	2.320×10^{-4}	3.687×10^{-4}	2.425×10^{-4}
Zinc	450.00	1.072×10^{-2}	1.491×10^{-2}	2.370×10^{-2}	1.559×10^{-2}
Nickel *	500.00	1.191×10^{-2}	1.657×10^{-2}	2.633×10^{-2}	1.732×10^{-2}
Cobalt	40.00	9.525×10^{-4}	1.325×10^{-3}	2.107×10^{-3}	1.386×10^{-3}
Manganese	244.00	5.811×10^{-3}	8.086×10^{-3}	1.285×10^{-2}	8.454×10^{-3}
Chromium *	130.00	3.096×10^{-3}	4.308×10^{-3}	6.847×10^{-3}	4.504×10^{-3}
Vanadium *	330.00	7.858×10^{-3}	1.094×10^{-2}	1.738×10^{-2}	1.143×10^{-2}
Flourine	1,700.00	4.048×10^{-2}	5.633×10^{-2}	8.953×10^{-2}	5.890×10^{-2}
Boron	2,800.00	6.668×10^{-2}	9.278×10^{-2}	1.475×10^{-1}	9.702×10^{-2}
Beryllium	47.00	1.119×10^{-3}	1.557×10^{-3}	2.475×10^{-3}	1.629×10^{-3}
Lithium	260.00	6.192×10^{-3}	8.616×10^{-3}	1.369×10^{-2}	9.009×10^{-3}

* Trace element enrichment by volatilization and condensation may be significant.

over a crusher, can be retained by a control device (e.g., a baghouse) with efficiencies of 99 percent or better. The uncaptured portions from conveyors, transfer points, and spillage are emitted directly to the atmosphere. As a means of estimating total generation of particulates, essentially all as coal dust, an emission factor of 0.05 kilograms of dust per metric ton of coal has been applied. This was obtained by interpolating between emission factors given for several different crushing operations in EPA (1973). Half of the emissions are assumed to result as fugitive dust and half as particulates that are 99 percent collected in control devices. The "controlled" emissions are thus one percent of one-half the "uncontrolled". This distinction is made to indicate the difference between generation of dust and emission of suspended particulate. The expected process emissions of suspended particulates for each of the units are shown in Table RV-8.

Commercial, industrial, and residential fuel use. Emissions of particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide from commercial, industrial, and residential fuel use were obtained from the National Emissions Data System (NEDS) for air quality control region 040. Air quality control region 040 includes all of Routt, Moffat, and Rio Blanco Counties. NEDS emissions data were divided into 18 areas by population. The areas, shown in Figure RV-4, include five towns, 3 densely populated town perimeters, and 9 larger areas.

The total emissions for the tri-county area are given in Table RV-8. Projections to the years 1980, 1985, and 1990 were made by applying a linear increase in emissions with population increase. Detailed tabulations of emissions within each of the 18 areas are provided in Appendix D.

TABLE RV-8

Present and Projected Emissions in the Study Region (gm/sec)

	TSP				SO_x			
	1974	1980	1985	1990	1974	1980	1985	1990
Power Plants								
Hayden	23.8	56.9	56.9	56.9	108.4	216.8	216.8	216.8
Craig	0.0	105.4	210.8	210.8	0.0	353.6	707.2	707.2
Moonlake	0.0	0.0	132.4	132.4	0.0	0.0	433.6	433.6
Coal Processing	.57	4.13	10.04	10.04	0.0	0.0	0.0	0.0
Commercial, Industrial, and								
Home Fuel Use	14.2	31.7	37.1	39.9	11.2	25.0	29.3	31.4
Transportation Systems								
Roads*	3.31	32.06	33.53	34.17	1.10	2.74	3.23	3.45
Railroads	.23	1.02	1.02	1.02	.49	2.2	2.2	2.2
Solid Waste Disposal	6.36	6.36	6.36	6.36	.09	.09	.09	.09
Coal Mining								
Materials Handling	33.48	185.77	193.32	199.27	0.0	0.0	0.0	0.0
Vehicle Emissions within Mine	.01	.09	.09	.09	0.0	.10	.10	.10
Unpaved Road Emissions	28.47	71.95	71.95	71.95				
Total	110.43	495.38	753.51	762.9	121.28	600.53	1,392.52	1,394.84

* Includes Seneca unpaved haul road after 1974.

TABLE RV-8 (cont.)

Present and Projected Emissions in the Study Region (gm/sec)

	HC				CO			
	1974	1980	1985	1990	1974	1980	1985	1990
Power Plants								
Hayden	3.4	8.1	8.1	8.1	11.3	27.1	27.1	27.1
Craig	0.0	16.6	33.2	33.2	0.0	55.4	110.8	110.8
Moonlake	0.0	0.0	18.8	18.8	0.0	0.0	63.2	63.2
Coal Processing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Commercial, Industrial, and Home Fuel Use	3.7	8.3	9.7	10.4	15.6	34.9	40.8	43.8
Transportation Systems								
Roads*	32.86	27.05	32.1	22.76	320.58	236.80	236.80	187.69
Railroads	.805	3.577	3.577	3.577	1.12	4.987	4.987	4.987
Solid Waste Disposal	10.0	10.0	10.0	10.0	118.3	118.3	118.3	118.3
Coal Mining								
Materials Handling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vehicle Emissions	.14	.62	.62	.62	1.40	3.41	3.41	3.41
Total	50.905	74.247	115.397	107.457	468.3	480.987	649.997	559.287

* Includes Seneca unpaved haul road after 1974.

TABLE RV-8 (cont.)

Present and Projected Emissions in the Study Region (gm/sec)

	NO_x			
	1974	1980	1985	1990
Power Plants				
Hayden	166.7	398.3	398.3	398.3
Craig	0.0	737.4	1,474.8	1,474.8
Moonlake	0.0	0.0	926.4	926.4
Coal Processing	0.0	0.0	0.0	0.0
Commercial, Industrial, and Home Fuel Use	6.3	14.1	16.5	17.7
Transportation Systems				
Roads*	34.15	49.64	58.46	45.79
Railroads	3.19	14.2	14.2	14.2
Solid Waste Disposal	.92	.92	.92	.92
Coal Mining				
Materials Handling	0.0	0.0	0.0	0.0
Vehicle Emissions within Mine	.10	1.67	1.67	1.67
Unpaved Road Emissions				
Total	211.36	1,216.23	2,891.25	2,879.28

* Includes Seneca unpaved haul road after 1974.

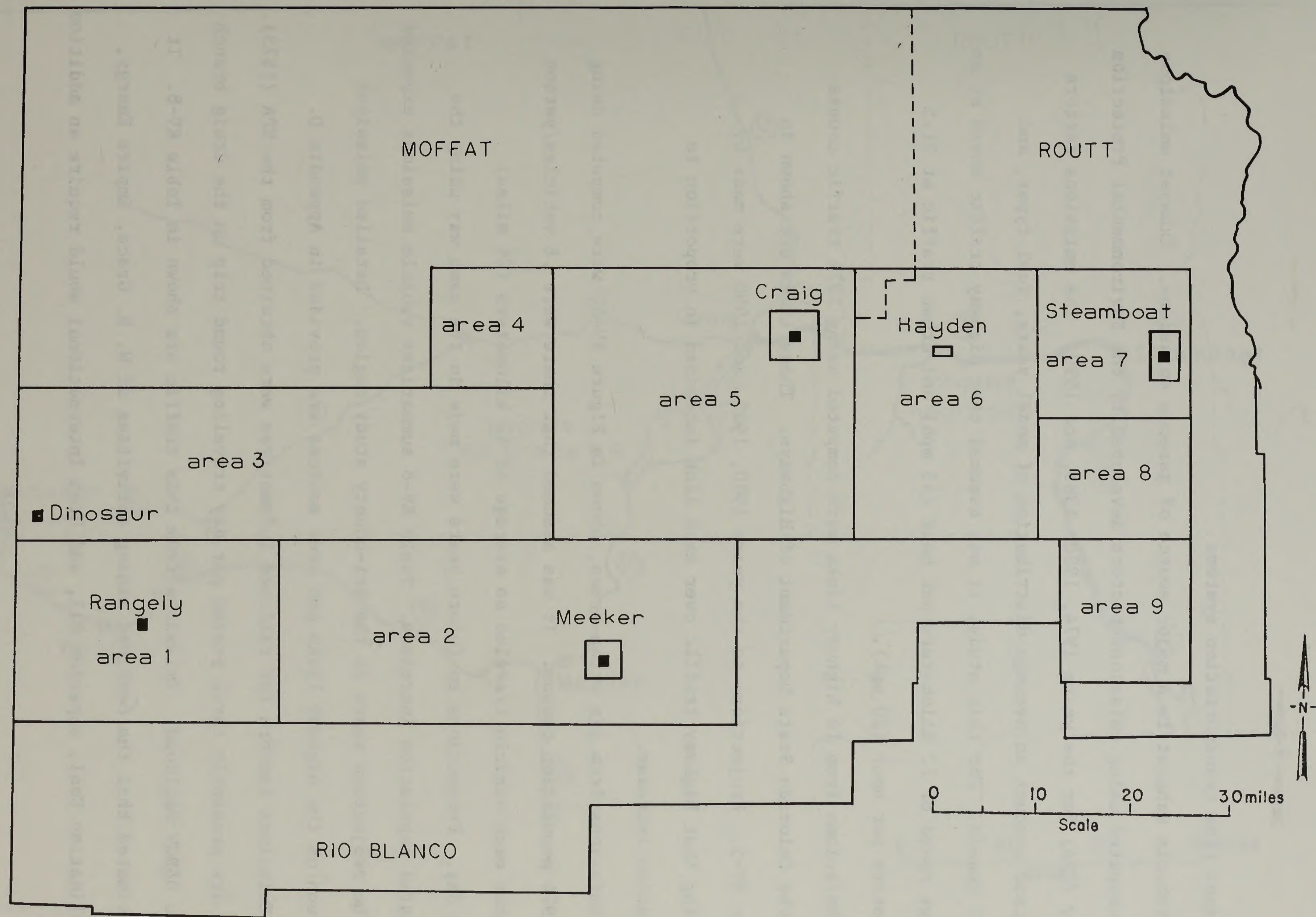

FIGURE RV-4

Areas for which emissions from external fuel consumption were estimated.

Emissions from transportation systems

Vehicle exhaust is a major source of gaseous emissions. Exhaust emissions were computed using emissions factors developed by the Environmental Protection Agency (EPA) for the years 1974, 1980, 1985, and 1990. The emissions factors take into account an average distribution of model years, fuel types, and travel speeds. For this study, it was assumed that highway traffic moved at an average speed of 72 kilometers per hour (45 mph) and urban traffic at 31.5 kilometers per hour (20 mph).

Emissions from 14 highway links were computed using 1974 traffic counts from the Colorado State Department of Highways. Those links are shown in Figure RV-5. Projections to the years 1980, 1985, and 1990 were made by assuming that highway traffic over each link increased in proportion to population increase.

Emissions from six urban areas, shown in Figure RV-5, were computed using the 1974 population census. It was assumed that there were .6 vehicles/person and that each vehicle traveled an average of 42 kilometers (26 miles) every day. Projections to future years were made in the same way using the estimated population increases. Table RV-8 summarizes vehicle emissions expected for the projection years in the tri-county study region. Detailed emissions for each of the highway links and area sources are provided in Appendix D.

Emissions factors for railroad locomotives were obtained from the EPA (1973). There are presently three trains per day traveling round trip on the Craig branch of the D&RGW Railroad. Emissions from this traffic are shown in Table RV-8. It is estimated that the combined mining activities of W. R. Grace, Empire Energy, Consolidation Coal, Superior Oil, and Utah International would require an addition of

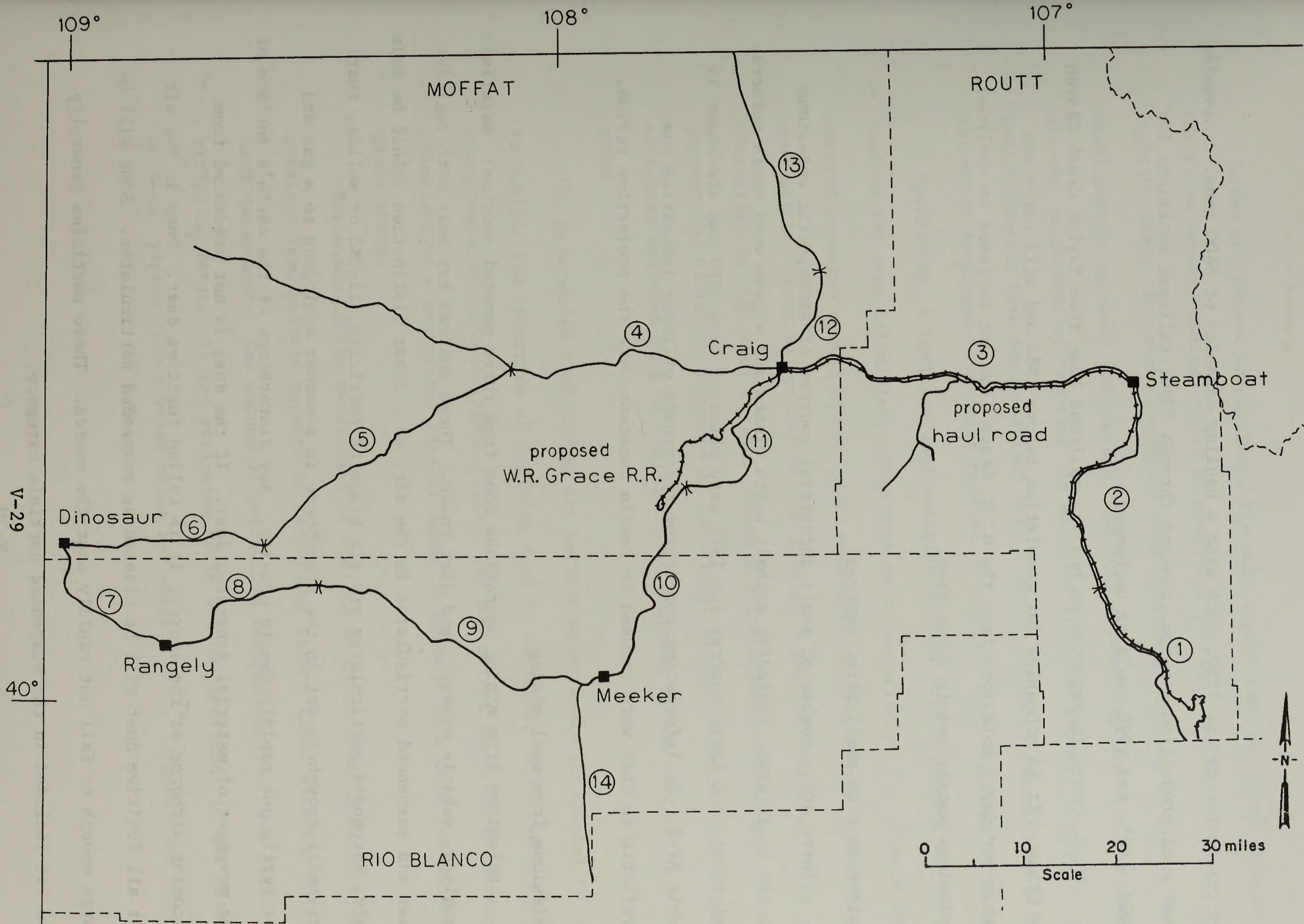

FIGURE RV-5

Road links, railroad links and urban areas for which vehicle emissions were estimated.

13 trains per day by 1980, each with a hauling capacity of 8400 tons. Assuming that coal production remains constant through 1990, railroad emissions for 1980, 1985, and 1990 would be unchanged.

W. R. Grace is expected to build a railroad line from Taylor Creek Canyon to Craig. It is scheduled for completion before 1980 and will carry one train per day. Emissions from the W. R. Grace line are included in railroad emissions summarized in Table RV-8.

Emissions from small point sources

There are a number of small industrial sources of atmospheric emissions in the study area, including asphalt batch plants and wigwam wood waste burners. Emissions from these sources for 1974 were obtained from NEDS and are shown in Table RV-8. No information concerning the growth of these industries was available so they were assumed to remain constant over the projection period.

Emissions from coal mining

Emissions from mining operations come from three general sources: materials handling, vehicle exhaust, and dirt roads. These sources may emit both fugitive dust and suspended particulates in the air, so a clear distinction should be made here. Suspended particulates are all kinds of particles, liquid or solids, that are small enough to act in the atmosphere in a manner analogous to a gas and not settle out rapidly due to gravity. Any disturbance of the earth's surface or the movement of material generates dust. If the dust is not prevented from becoming airborne at the source, it is called fugitive dust. Once in the air not all fugitive dust will be classed as suspended particulates. Some will be large enough to fall out rapidly near the source. These particles generally are not included in the suspended particle category.

Based on current regulations, the only significant pollutant generated by the first source, mining, would be suspended particulates which result from fugitive dust. Emissions estimates from materials handling in mining have been developed for topsoil, overburden, and coal separately, but with the same methodology. All the operations of removing the material from the ground, transport, piling, and redistribution have been combined into a single emission calculation using estimates developed from other studies of fugitive dust (Cowherd 1974; EPA 1973).

For mining, a fugitive dust emission rate of 0.0055 percent of the material handled has been calculated. This rate must be corrected for climate and control measures at the mines. Wet, snow-covered, and frozen ground limits dust generation; about 65 percent of the days in a year are expected to be so classified in the study region. Using a calculational scheme that takes into account the differing response of individual mining activities to climate, the corrected emission rate of fugitive dust would be 0.0024 percent of material moved.

It is expected that during dry periods water would be applied to surfaces to inhibit the formation of fugitive dust by vehicles. Efficiencies would be poor, about 30 percent (PEDCo 1973). The net effect would be to reduce emissions to a controlled rate of about 10 percent less than the uncontrolled rate given above.

Estimates of the quantities of coal to be mined from 13 surface mines were obtained from private reports or letters of intent filed with the Bureau of Land Management. The amount of overburden removed per year was obtained from the stripping ratio. If the stripping ratio was not provided, it was assumed to be 6 cu. yd/ton, the average value for western coal. Topsoil was assumed to be

.3 meters deep at all mines. Estimates of the quantity of material moved at each mine and the corresponding suspended particulate emissions are in Appendix D. A summary of total suspended particulate emissions from coal mining in the study region is shown in Table RV-8. Included in Table RV-8 are emissions from underground mining operations.

The only emissions from underground mining operations would come from coal conveying, sorting, and storage processes that produce fugitive dust. An emissions factor representing the percent of dust emitted from these processes/mass of coal handled was computed (EPA 1973) and found to be 0.005 percent. When control devices such as baghouses and watering are employed, the emissions factor would be reduced to .0025 percent.

There are seven underground mines included in the study. One of the mines, the Apex Mine, is presently producing about 11,000 tons of coal/year. It is expected that after 1980 the total production of the seven mines will be about 2,900,000 tons/year. Therefore, assuming control devices are used, the expected particulate emissions in the study region would be about 2.07 grams/second (16.4 lbs/hour).

As an operation of mining, blasting has not been included in the previously described emission calculations. Overburden and coal are loosened for removal by blasting on a regularly scheduled daily basis. Each blast normally takes place in a fraction of a minute. Unfortunately, no emissions factors are available for blasting, but the quantities of fugitive dust produced would be small compared to other mining activities simply because blasting is so intermittent.

At each surface mine, there would be vehicle exhaust emissions from heavy diesel mine equipment and haulage trucks, and gasoline powered cars, and trucks.

Emissions from haulage trucks are calculated by considering the total yearly truck miles required to move coal to the loading facilities at the mine. Other mine diesel vehicles are considered to be a much smaller source than haulage trucks and have not been included.

It was assumed that each haulage truck had a capacity of 25 tons and traveled 4 kilometers (2.5 miles) round trip to loading facilities. EPA emissions factors were used to estimate exhaust emissions at each mine. Gasoline powered vehicles were assumed to travel 4 kilometers (2.5 miles) per day within a surface mine area. The number of gasoline powered vehicles equaled expected mine employment.

Roads would be expected to be unpaved within each mine site and are therefore a source of fugitive dust. Fugitive dust emissions from unpaved roads were studied by PEDCo (1973) in an arid climate. The average emission factor obtained was about one kilogram of suspended particulate/vehicle-kilometer. This value was applied to all mines in the tri-county region and the estimated emissions are shown in Table RV-8, together with vehicle exhaust emissions. Independent tabulations for each mine are given in Appendix D.

Another possible source of emissions related to mining would be the spontaneous or accidental ignition of coal fires in overburden piles and exposed coal seams. If a fire occurs, clouds of smoke containing suspended particulates, carbon monoxide, nitrogen oxides, sulfur oxides, hydrogen sulfide, and hydrocarbons could result. Estimates of frequency or quantity of emissions at any one mine cannot be made. However, if a fire occurs, emissions might be substantial. McNay (1971) indicates that in the United States there were 270 burning coal refuse piles in 1968, 15 of which were in Colorado, over an area of about 130 acres. All were in older mined areas.

Emission rates listed in Table RV-8 are given as yearly averages although it is recognized that all activities are not continuous. As such, they are realistic approximations of the complex interaction of variables that affect pollutant emissions. Uncertainties (two standard deviations) are estimated to be on the order of a factor of two.

Modeling techniques

Diffusion modeling is a mathematical tool used in the field of air pollution meteorology to simulate the various processes that affect airborne effluents from a pollutant source or group of sources, from the time the effluent plume leaves the source until the time it arrives at any one of several receptor sites. A model takes into account physical atmospheric processes that transport and diffuse an effluent. By use of a computer, one can calculate the impact on ground level pollutant concentrations of various meteorological conditions and source characteristics.

Once a pollutant source at or near the ground emits an effluent into the atmosphere, meteorological conditions affect both transport and diffusion of the effluent. Plume transport is determined largely by wind speed and direction; a plume will follow the trajectory of the local wind. An increase in wind speed tends to stretch a plume in the downwind direction, thus decreasing its concentration, and a change in wind direction could act in a similar manner to spread a plume over a larger air volume and decrease the concentration over time at any one point.

A wind speed class is defined by the range of wind speeds likely to accompany a particular weather condition or stability class. For example in an unstable weather condition wind speeds are likely to range from 1-6 mps (2-12 mph). It is physically impossible to have an unstable condition with winds of 25 mps (56 mph). However during neutral stability, winds up to 17 meters/second would be reasonable. Thus when a model considers neutral weather conditions, the appropriate wind speed classes will have winds from 2-17 mps (4 to 38 mph). For purposes of modeling, 16 wind directions are defined by dividing a 360° circle into 16 sectors, with each sector incorporating a 22.5° segment of the circle.

Plume diffusion is primarily a function of atmospheric turbulence or stability; turbulent air downwind will cause dilution of the plume. There are two categories of turbulence: (1) turbulence generated when the motion of the air interacts with topographic features (e.g., trees and buildings) is called mechanical turbulence; (2) convective turbulence results when the air is cooler than the ground surface over which it flows and is heated by contact with the ground.

The intensity of turbulence, which affects how quickly the effluents will be dispersed, is dependent upon the thermal stratification or stability of the atmospheric layer within which the plume is located. Stability conditions are classsified in three broad categories: unstable, neutral, and stable. Under stable -- i.e., inversion or subadiabatic* -- conditions, air temperature increases or is isothermal with height and the atmosphere is stagnant and very calm. Consequently any pollutant emitted at ground level tends to accumulate, while effluents from elevated sources stay elevated and do not normally reach the ground until the plume has traveled many kilometers. Ground-level sources are generally the major contributors to ambient pollutant concentrations under

*Theoretically when a small volume of warm air is forced upward in the atmosphere, it will encounter lower pressure, expand and cool. If we assume that there is no exchange of heat between the environment and the small volume, we can define the rate at which cooling occurs during the ascent as the dry adiabatic lapse rate (-9.8° C/km).

stable conditions. This thermal stratification is common during clear nights with light wind speeds.

Unstable conditions occur on days with light-moderate wind speeds, when strong solar heating occurs, or when cold air is transported over a much warmer surface. In this case air temperature decreases with height at a rate exeeding 1°C/100 m. Unstable conditions are usually confined to the lowest 200 meters of the atmosphere and cause low-level emissions to disperse upward rapidly and bring elevated plumes to the ground rapidly. As a result elevated sources frequently make large contributions to ambient pollutant concentrations under unstable thermal stratifications.

Finally when the air temperature lapse rate remains approximately adiabatic, and there is no tendency for a displaced parcel to gain or lose buoyancy, the stratification is called neutral. Near-neutral stability is common under cloudy or windy conditions at any time of day in most locations. The wind flow over the underlying surface under such conditions generates mechanical turbulence and good mixing. During high wind speeds and neutral conditions, emissions from sources with tall stacks often result in high ground-level concentrations because of the suppression of plume rise. For ground-level emissions, the concentrations for near-neutral conditions normally range between those for stable and unstable conditions.

The most direct method for determining local stability (and the dispersive capability of the atmosphere) entails frequent soundings to monitor the actual temperature gradient to a height of several thousand feet. Temperature soundings and wind speed measurements were made for a period of two years near Craig and Hayden for the Yampa project. A stability wind rose was generated from the Hayden data and used in this study. A stability wind rose delineates the joint frequency distribution of each wind speed class, wind direction, and atmospheric stability. It is presented in Appendix D.

Modeling long-term concentrations

In order to assess the regional impact on air quality of atmospheric emissions listed in Table RV-8 , diffusion modeling techniques were applied. Two computer models were used to evaluate long-term annual concentrations of total suspended particulates, sulfur oxides, and nitrogen oxides. Both models are based on the solution of the Gaussian plume equation which estimates ground-level pollutant concentrations by the methodology presented in the Workbook of Atmospheric Diffusion Estimates (Turner 1972). The general form of the equation for the coordinate system presented in Figure RV-6 is:

$$\chi(0,0,z) = \frac{q(x,-y,H)}{2\pi\sigma_y\sigma_z u} \exp\left[-\tfrac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \cdot \left\{\exp\left[-\tfrac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\tfrac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}. \quad \text{Eq. 1}$$

where

(x,y,z) are the (upwind, cross-wind, and vertical) components of a Cartesian coordinate system, such that the receptor point is located at or vertically above the origin (expressed in units of length) and the source at the point (x, -y, H),

$\chi(0,0,z)$ is the ground-level pollutant concentration at a receptor (0,0,z) (mass/length^3),

H is the effective height of emission and, therefore, the centerline

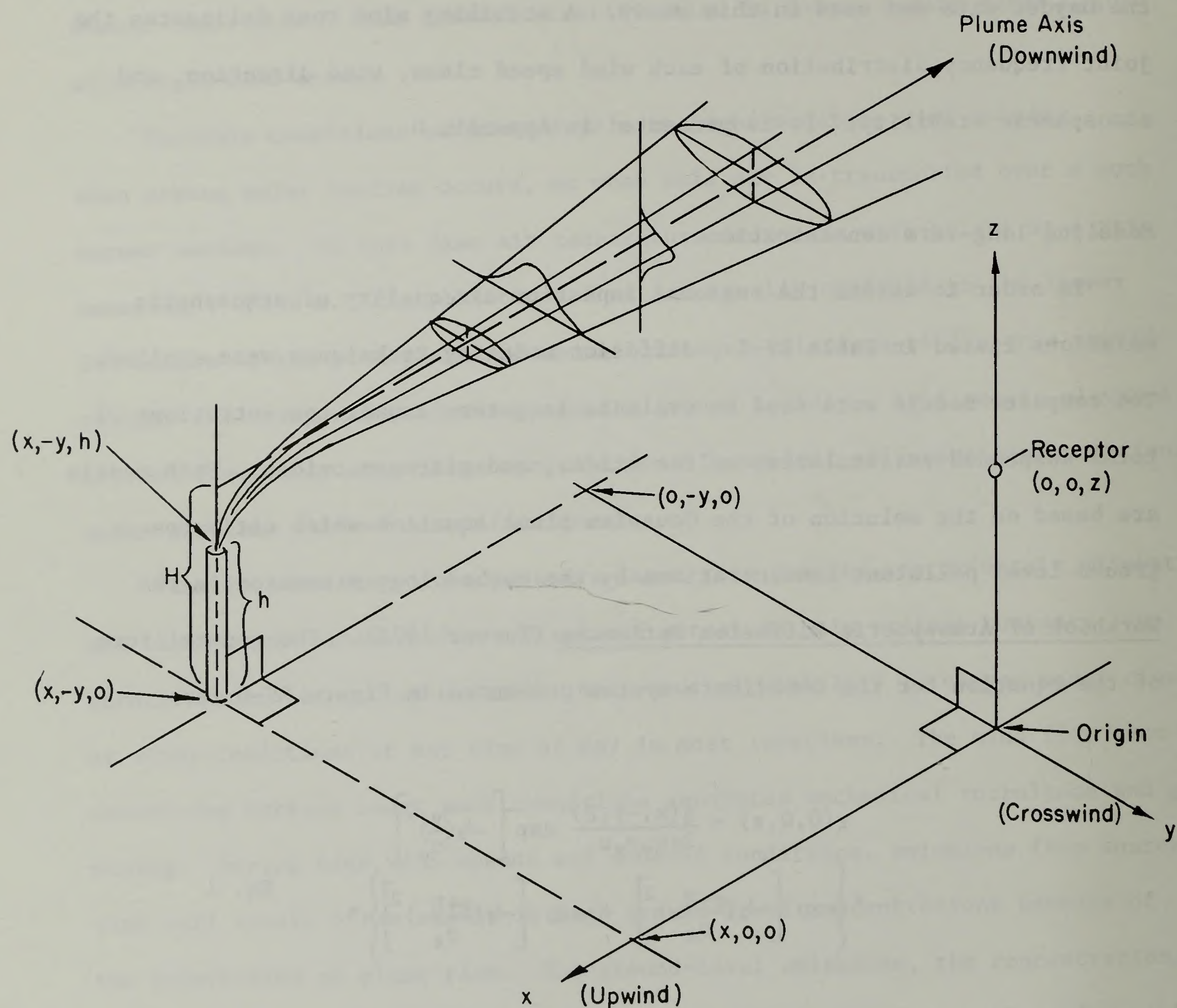

FIGURE RV-6

Coordinate system showing Gaussian distributions in the crosswind and vertical directions.

height of the plume (length)

q — is the source strength (mass/time),

$\sigma y, \sigma z$ — are dispersion coefficients that are measures of cross-wind and vertical plume spread. These two parameters are functions of downwind distance and atmospheric stability* (length),

u — is average wind speed (length/time),

and t — is the travel time from source to receptor and equals x/u (time).

The Point Source Diffusion Model (PSDM) was used to evaluate the impact of power plant emissions. This model solves Equation 1 using dispersion coefficients specified by the American Society of Mechanical Engineers (ASME) for elevated point sources. Terrain is included in the modeling by permitting the plume to be lifted one-half of the difference between the height of the receptor (the point on the ground for which the concentration is being computed) and the height of the stack base, with the additional restriction that the plume shall always be at least half the height above the ground that it would be were there not topography (Figure RV-7).

Because the emissions from the power plant stacks are much hotter than the surrounding air, they are expected to rise until thermal equilibrium is reached. PSDM accounts for plume rise using the most recent Briggs plume rise equations (Briggs 1970) in forms that depend on atmospheric stability. The simultaneous consideration of both the plume rise as a function of downwind distance and of the topography surrounding the point source provides a realistic simulation of the downwind transport of effluent released in areas characterized by irregular terrain.

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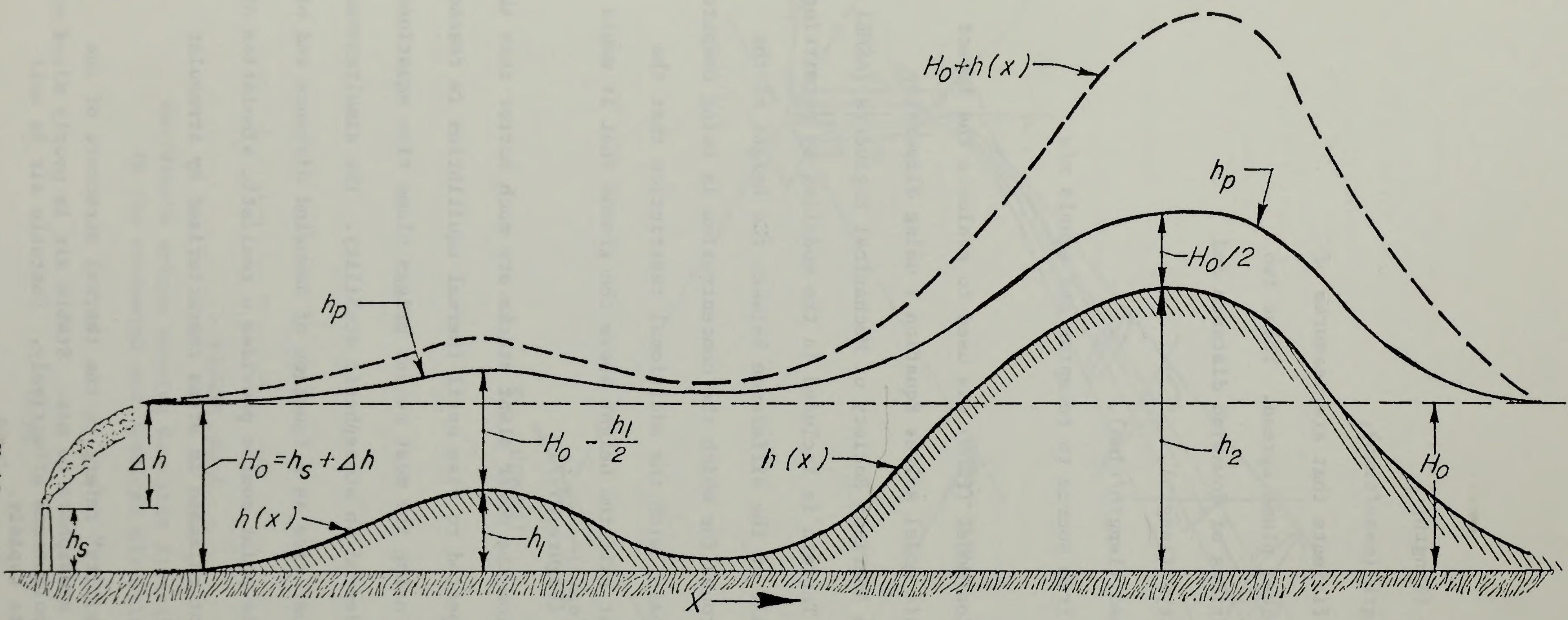
* The term "atmospheric stability" refers to the thermal structure of the atmosphere or ability of the atmosphere to mix. Stable air is poorly mixed and therefore does not disperse pollutants effectively. Unstable air is well mixed and disperses pollutants rapidly.



h_s	physical stack height
h	plume rise
H_o	effective stack height (physical stack height plus plume rise)
$h(x)$	terrain height above stack base elevation
h_p	plume centerline height above stack base elevation

FIGURE RV-7

Treatment of terrain influence upon plume height used in model PSDM.

The Environmental Research and Technology Air Quality Model (ERTAQ) was used to estimate long-term impact of all emissions shown in Table RV-8 except the power plants. ERTAQ (fully described in Appendix D) uses dispersion coefficients specified by Calder (1971) to solve various forms of Equation 1. Emissions can be specified in terms of area sources, line sources, and point sources; therefore, a whole region can be modeled at one time.

Modeling short-term concentrations

Three of the air pollutants governed by Federal regulations involve exclusively short-term standards compared with annual averages. These are carbon monoxide, non-methane hydrocarbons, and photochemical oxidant. For the purposes of this regional analysis, simple impact estimation models have been used. The emission inventory is crude and is based on annual averaged data, and the emissions of hydrocarbons and carbon monoxide are small. Therefore, a well mixed box model has been used for these pollutants with the following assumptions:

1. The Yampa River Valley is the critical exposure region containing the principal emitters;
2. The worst case annual inversion height in the morning will provide an upper limit for ground level concentration;
3. Atmospheric turnover time for pollutants in this area is approximately twenty-four hours, *
4. Annual averaged concentration could be scaled to suitable short-term averages for worst case conditions by factors derived

* This assumption has proved to be a reasonable approximation for such calculations in many areas, including Los Angeles.

statistically by Larsen (1975) *

As a consequence of the first two assumptions, the air volume into which the emissions are mixed is 4.4 x 10^{12} $meters^3$ (1060 $miles^3$).

The expected short-term concentrations of photochemical oxidant were calculated using the modified rollback approach (NAS 1974). The NO_x to hydrocarbon ratio in the area is similar to Los Angeles. The relationship between three-hour averaged morning non-methane hydrocarbons and estimated one-hour maximum oxidant concentrations was taken from the upper limit curve given in USDE HEW, 1970, or by the Schuck and Papetti curve (NAS, 1974), both of which were based largely on data from Los Angeles. The use of these curves in the extreme low range of non-methane hydrocarbon concentration should provide a reasonable estimate of maximum impact on oxidant levels in the area. It should be noted that the modified rollback approach has been criticized for being a possibly over-simplified approach to estimating oxidant in many applications (NAS, 1974); thus it is expected that this part of the air quality analysis is more uncertain quantitatively than for the non-reactive or oxidant precursor species.

Resultant air quality

Total suspended particulates

The largest sources of total suspended particulate emissions are the power plants. However, the power plant emissions have a small impact on total air quality because the sources are elevated and the air is frequently stable. Most of the emissions are widely dispersed or transported into the upper atmosphere and, therefore, show little surface impact.

The largest annual increase in total suspended particulate concentrations

* For "design" purposes, Larsen (1975) recommends that an eight-hour standard should be 9.8 the annual median; a three-hour standard should be 13 times the annual median, and a one-hour standard would be 18 times the annual median.

due to power plants alone would be just east of the Craig station. Model results show that with all four Craig units operating the increase in annual concentration at this location would be less than 2 μg/m^3. The largest 24-hour concentration from the Craig power station would be expected to be 60 μg/m^3. The impacts near Hayden and Moon Lake would be smaller. Therefore no regulated standard for TSP would be threatened by the power plant operations alone.

Figures RV-8 through RV-11 show lines of constant concentration (isopleths)* of TSP predicted for 1974, 1980, 1985, and 1990 respectively. The isopleths represent annual average concentrations due to all TSP emissions listed in Table RV-8. Annual rural concentrations increase from a background of 20 μg/m^3 to 26 μg/m^3 due to the expected activity. The maximum 24-hour rural concentration is expected to be about 45 to 80 μg/m^3, not greater than the maximum of 150 μg/m^3 allowed by Colorado State regulations.

EPA non-degradation guidelines for Class II areas specify an allowable increase of 10 μg/m^3 annual average, and 30 μg/m^3 24-hour average for TSP ambient concentrations. These values would not be exceeded in rural areas in general. However within about a one-two kilometer radius of the largest surface mines, both annual and 24-hour Colorado standards would be expected to be exceeded (see Site Specific Impact Statements). Concentrations would decrease rapidly with distance from the mine activity so that the region as a whole would not be seriously impacted.

The towns of Craig, Steamboat Springs, Meeker, and Rangely have the highest TSP concentrations in the area. All but Rangely already exceed the Colorado

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*Isopleths in this section are drawn with finer resolution than model predictions in order to represent spatial trends. Model estimates are accurate to within a factor of three.

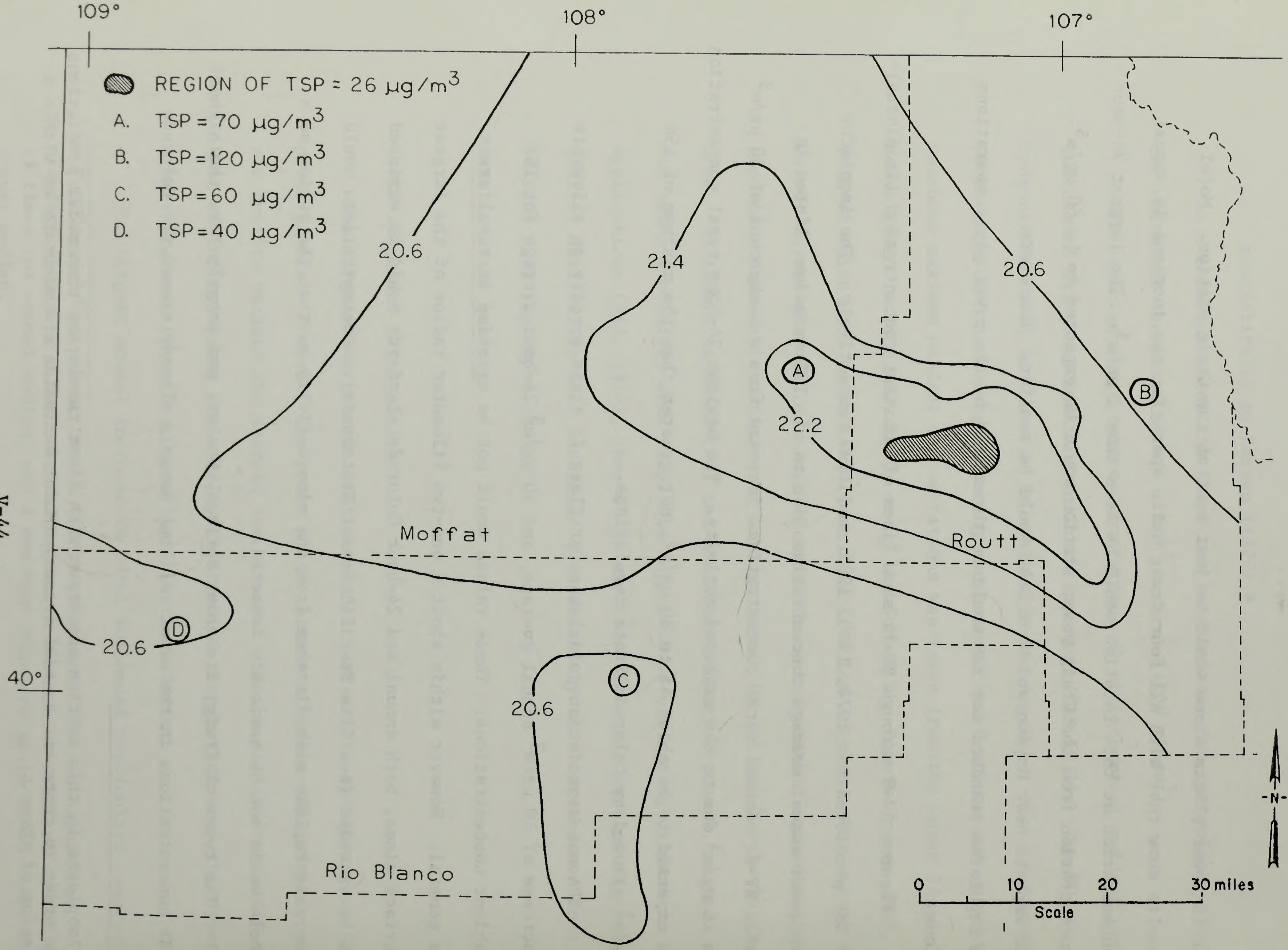

FIGURE RV-8

Annual average TSP concentrations for 1974; A is Craig, B is Steamboat, C is Meeker and D is Rangely.

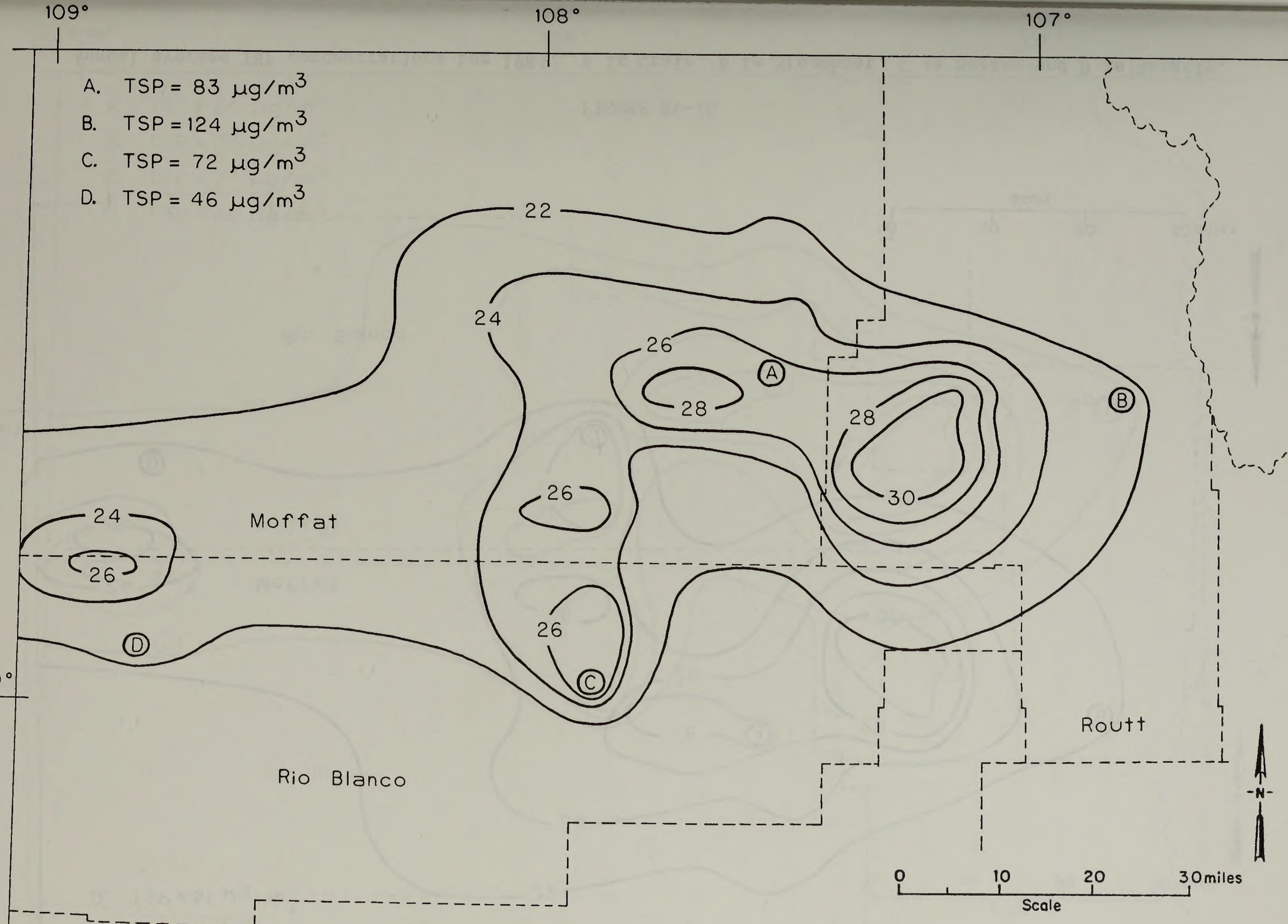

FIGURE RV-9

Annual average TSP concentrations for 1980; A is Craig, B is Steamboat, C is Meeker and D is Rangely.

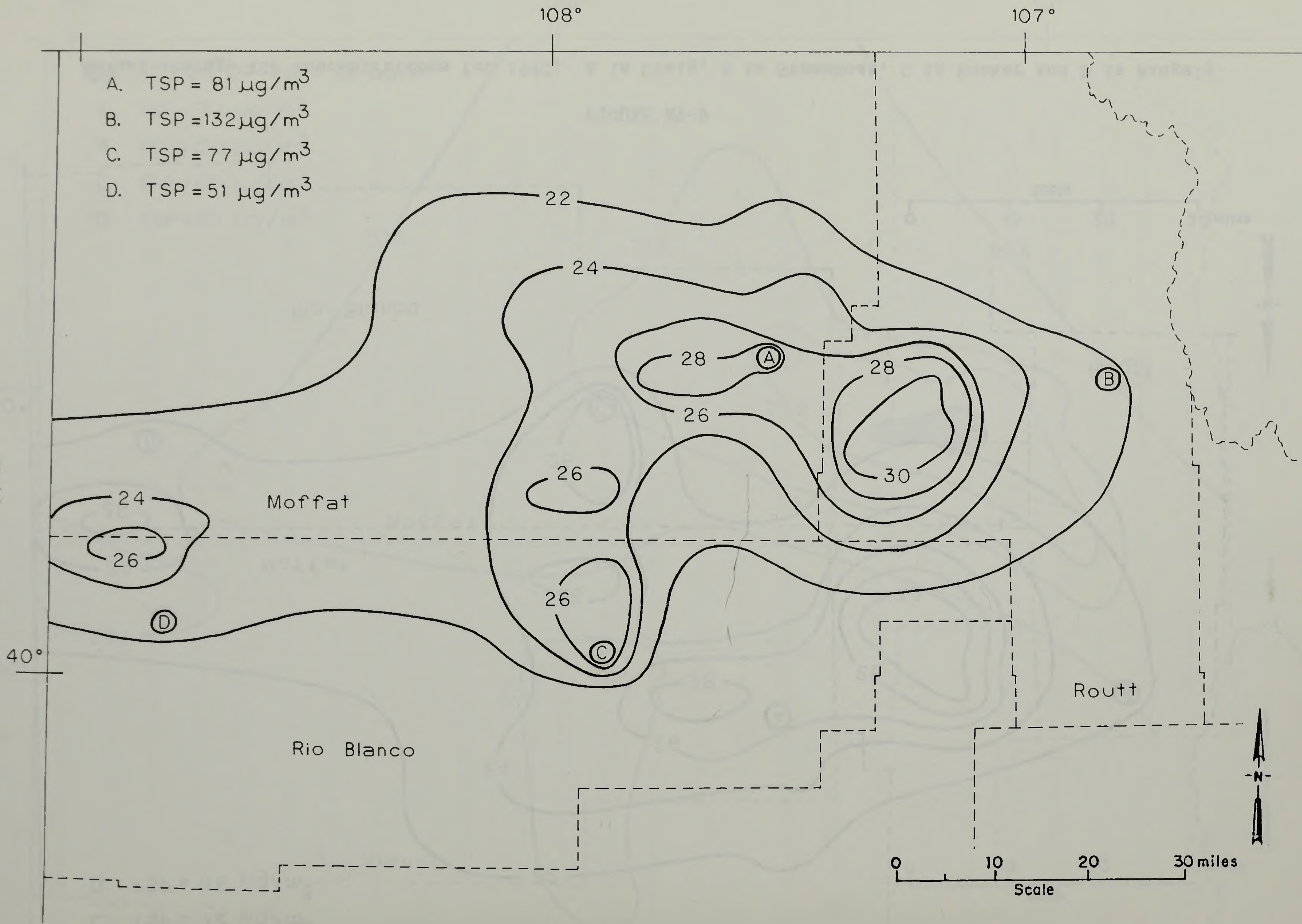

FIGURE RV-10

Annual average TSP concentrations for 1985; A is Craig, B is Steamboat, C is Meeker and D is Rangely.

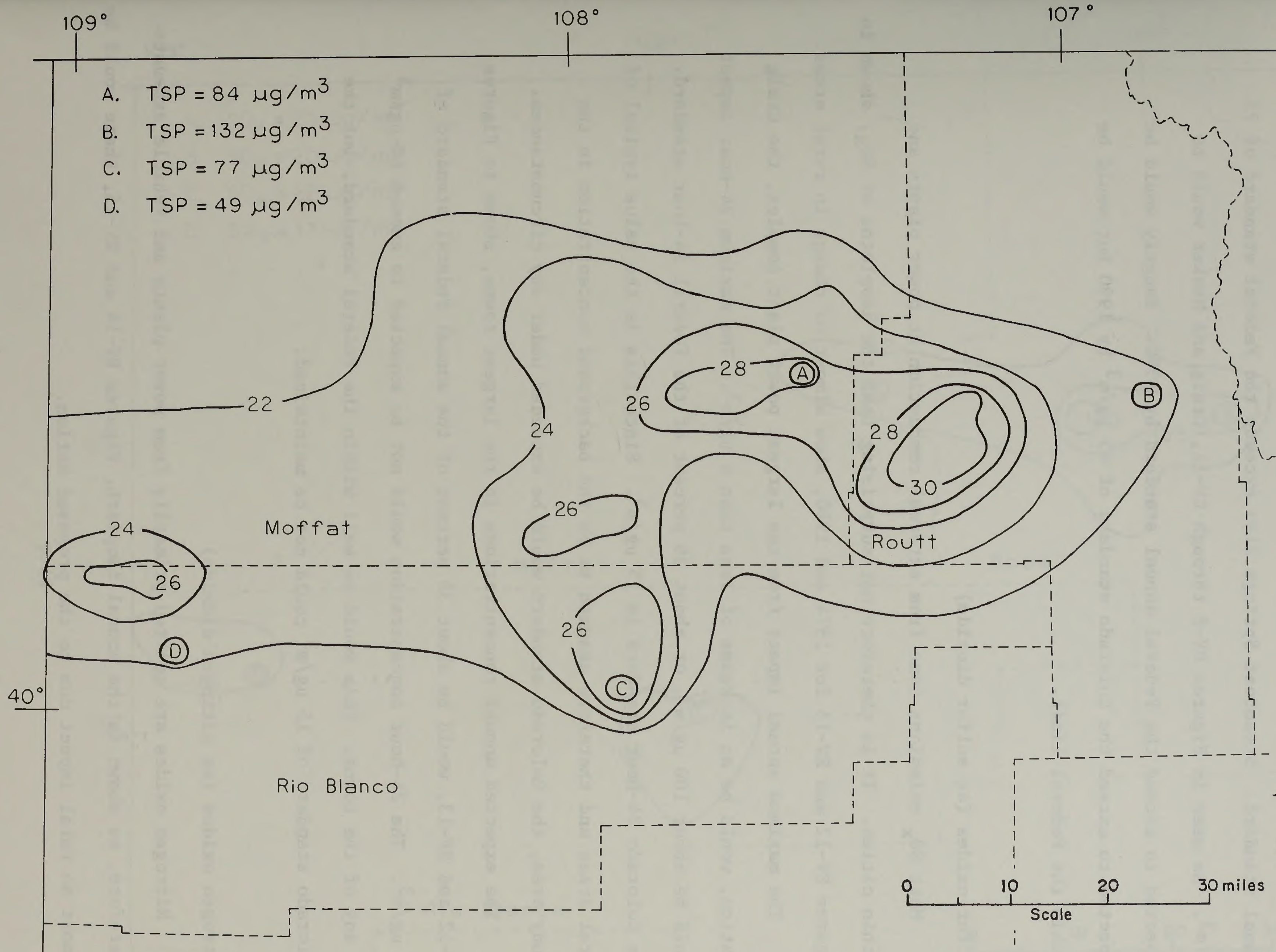

FIGURE RV-11

Average annual TSP concentrations for 1990; A is Craig, B is Steamboat, C is Meeker and D is Rangely.

annual standard. Steamboat Springs also exceeds the Federal standard of 75 μg/m^3. As seen in Figures RV-8 through RV-11, Craig and Meeker would be expected to exceed the Federal annual standard by 1990. Rangely would be expected to exceed the Colorado standard of 45 μg/m^3 by 1990 but would be within the Federal limit.

Sulfur oxides (as sulfur dioxide)

Most SO_x emissions come from external combustion at power plants and within cities. It is therefore not surprising that the isopleths of SO_x, shown in Figures RV-12 and RV-13 for 1974 and 1990, show almost no change in rural areas.

The maximum annual impact from the largest power plant complex, the Craig station, would be an increase of less than 4 μg/m^3. The maximum 24-hour impact would be about 100 μg/m^3, or about 36 percent of the Federal 24-hour standard. The Colorado 24-hour standard is 15 μg/m^3. Since this is the value typical of rural areas and therefore assumed to be the background concentration in the study area, the Colorado standard would be exceeded under any circumstances.

The expected annual concentrations in the largest towns, shown in Figures RV-12 and RV-13, would be about 35 percent of the annual Federal standard of 80 μg/m^3. The 24-hour concentration would not be expected to exceed 60 μg/m^3 in any of the towns. This would be well within the Federal standard, but the Colorado standard of 15 μg/m^3 could not be maintained.

Nitrogen oxides (as nitrogen dioxide)

Nitrogen oxides are emitted primarily from power plants and vehicle exhausts. Therefore, as shown in the annual isopleth, Figures RV-14 and RV-15, there would be almost no rural impact due to the proposed action.

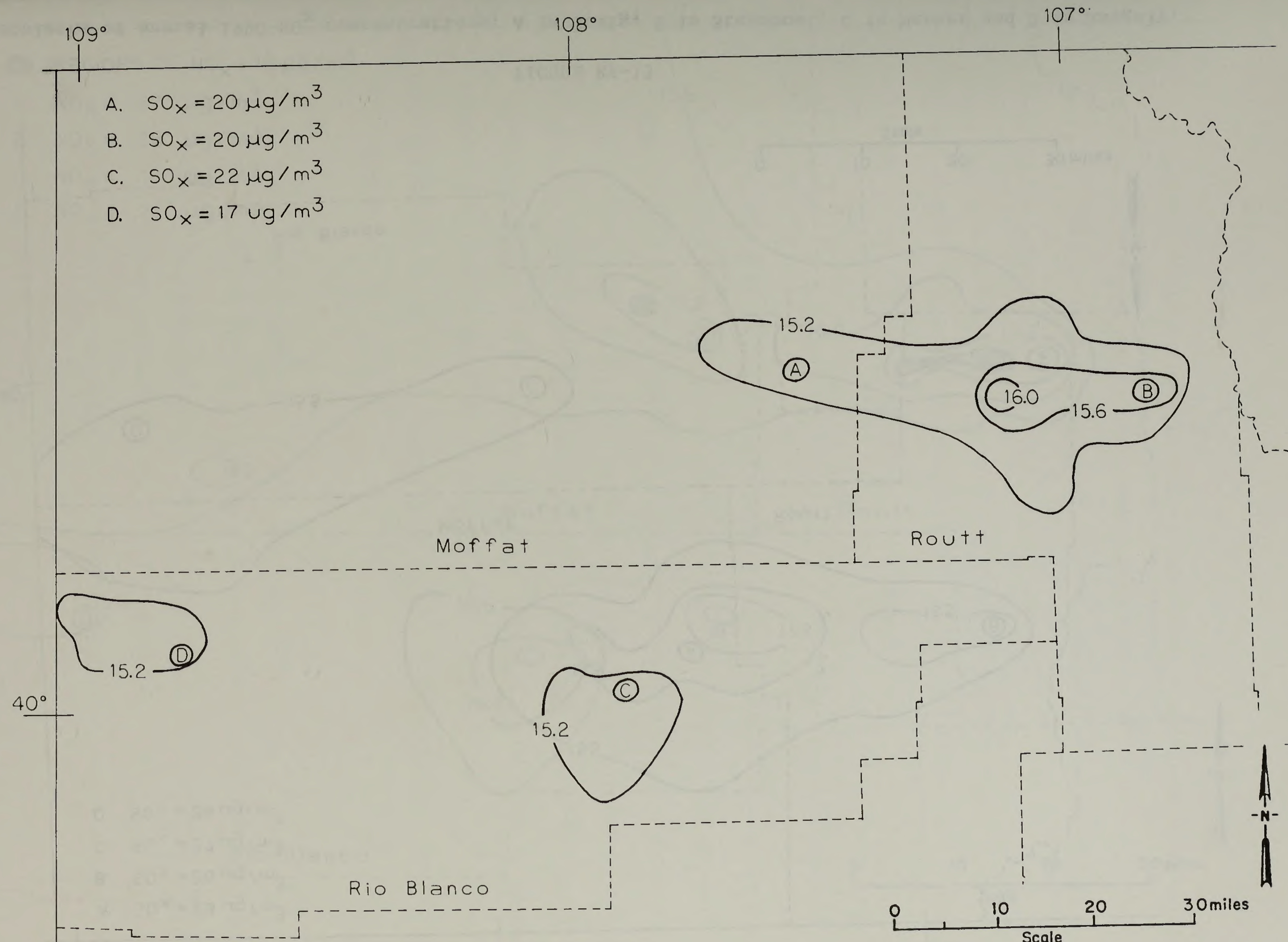

FIGURE RV-12

Isopleths of annual 1974 SO_x concentrations; A is Craig, B is Steamboat, C is Meeker and D is Rangely.

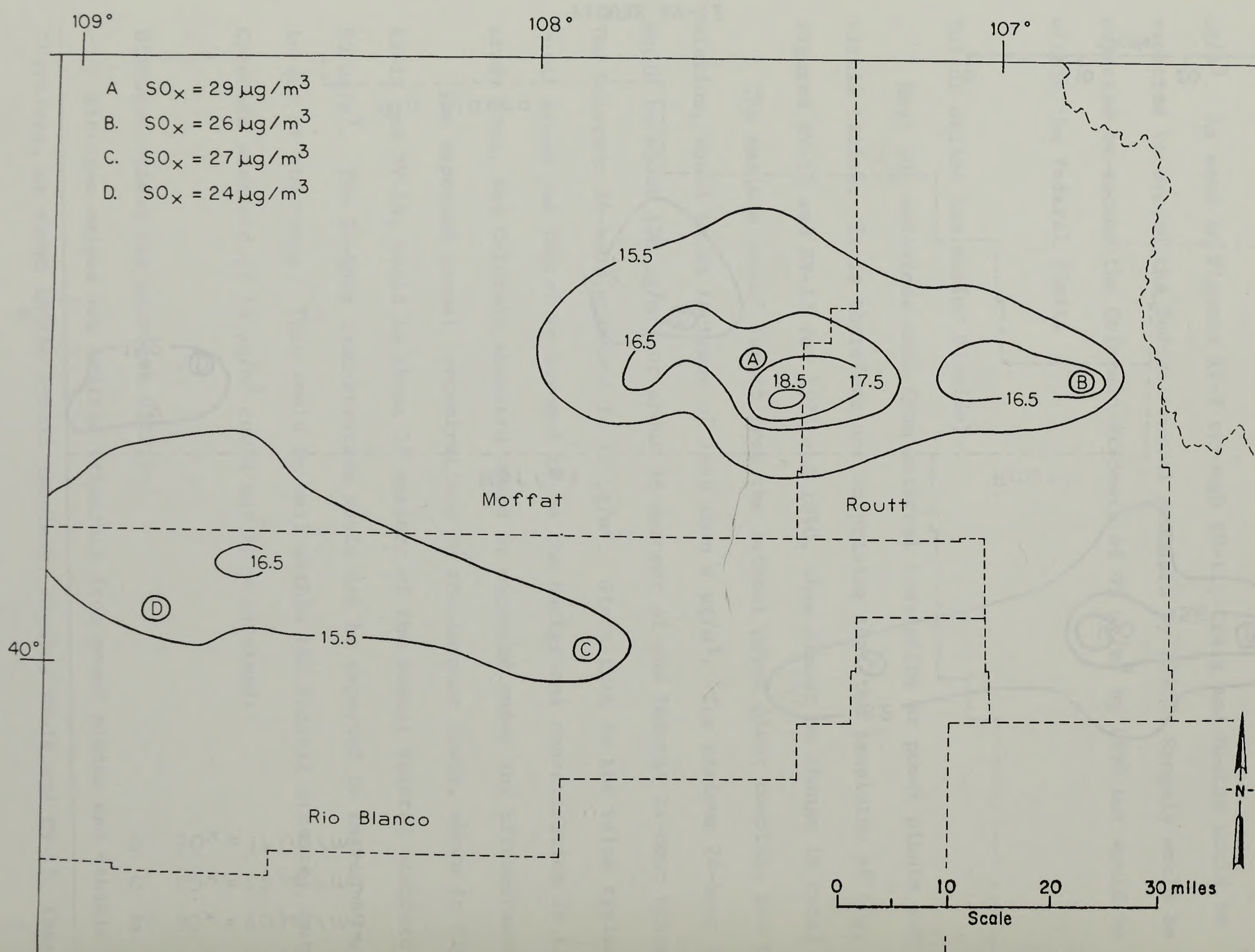

FIGURE RV-13

Isopleths of annual 1990 SO_x concentrations; A is Craig, B is Steamboat, C is Meeker and D is Rangely.

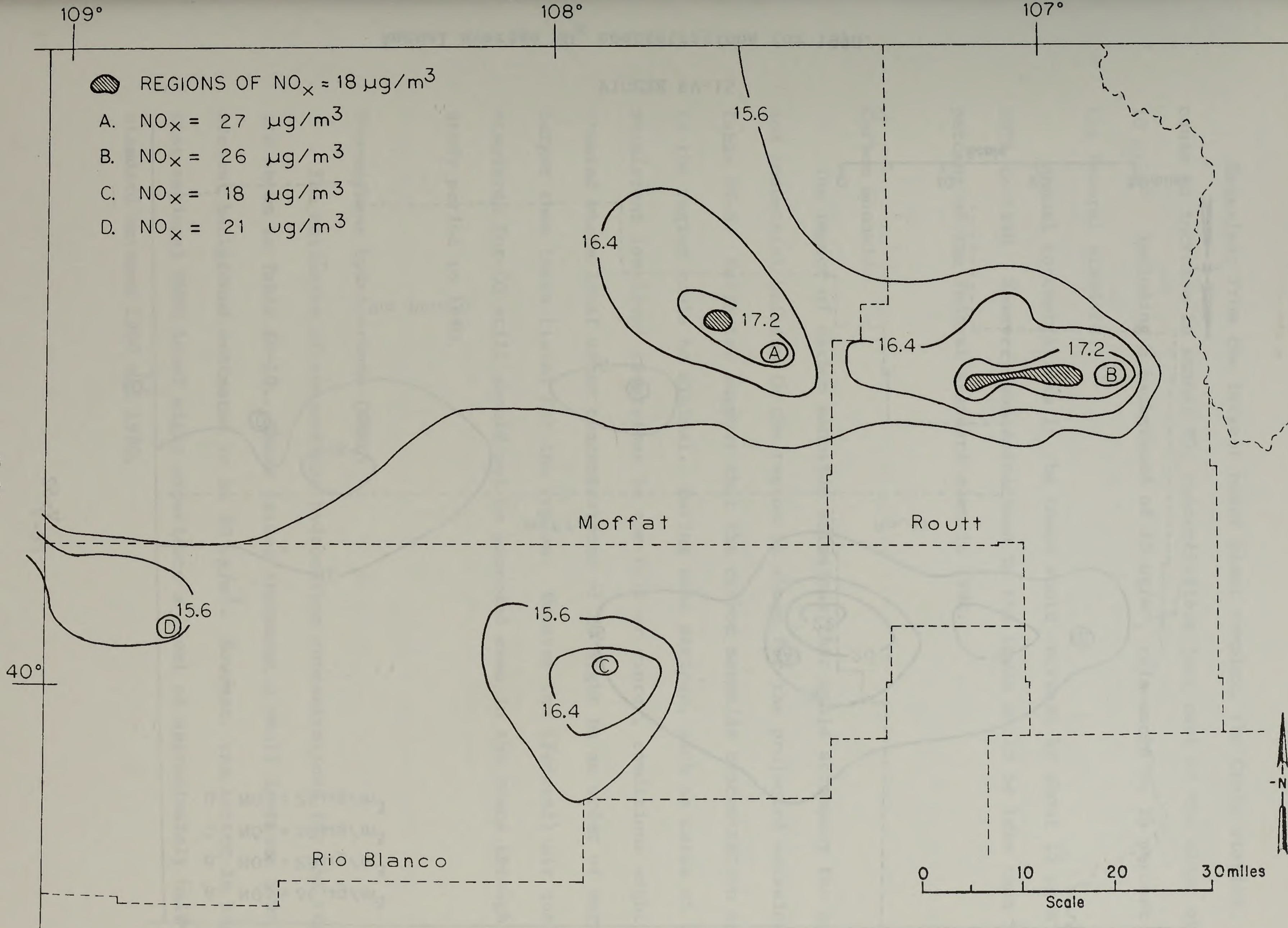

FIGURE RV-14

Annual average NO_x concentrations for 1974.

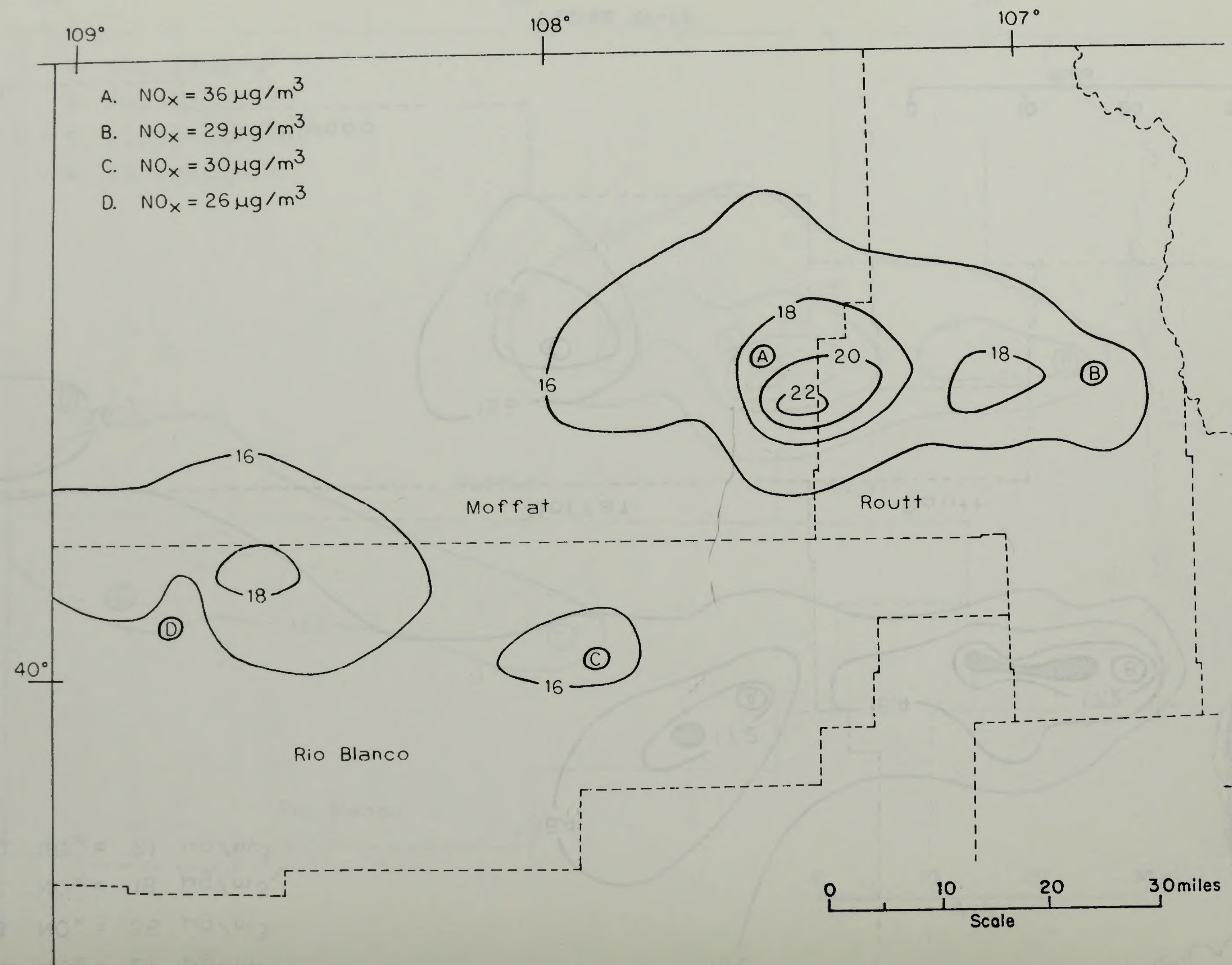

FIGURE RV-15

Annual average NO_x concentrations for 1990.

Emissions from the largest power plant complex, the Craig station, would cause an increase in annual NO_x concentrations just east of the plant of 10 $\mu g/m^3$. Including a background of 15 $\mu g/m^3$, this would be 25 percent of the Federal standard.

Annual concentrations in the towns would increase by about 15 $\mu g/m^3$ from 1974 to 1990. However, concentrations in the towns would be less than 30 percent of the Federal standard even in 1990.

Carbon monoxide

The impact of carbon monoxide emissions that would accompany the population and industrial buildup in the region is shown for the projected emissions in Table RV-9. Estimates suggest that the carbon monoxide concentration increase in the region would be minimal. During some periods, such as cases of strong persistent low-level inversions in the fall or winter, conditions might be created where local urban concentrations of CO might be an order of magnitude larger than those listed for the region. However the (Federal) air quality standards for CO still should not be exceeded even in the towns through the study period to 1990.

Non-methane hydrocarbons (NMHC)

The estimates of non-methane hydrocarbon concentrations for the region are shown in Table RV-10. These values represent a small increase over the present background estimated to be 50 $\mu g/m^3$. However, the latter is high so that regional NMHC level might experience a level of approximately half the standard between 1980 and 1990.

Estimation of the urban level concentrations from the scaling of the annual ERTAQ predictions indicates that the NMHC hydrocarbon standard might be approached on some mornings if ventilation is poor, particularly during periods prior to 1985 when motor vehicle controls would be implemented while the communities are growing.

Photochemical oxidant

In the study region and neighboring areas, the measured background or baseline oxidant is very high, already approaching the ambient standards. Therefore this area is believed to be particularly sensitive to hydrocarbon and nitrogen oxide emissions as precursors for oxidant formation. The sensitivity would be compounded by the potential for extensive increases in emissions of the precursors in neighboring areas of the Piceance Creek and Western Utah oil shale developments.

Table RV-9

Estimated Regional Incremental Carbon Monoxide Concentrations Over Background in mg/m^3 Based on Well Mixed Box Analysis and Annual Averaged Emissions.

Year	Annual	8 Hour Average	1 Hour Average
1974	9×10^{-3}	9×10^{-2}	0.2
1980	9×10^{-3}	9×10^{-2}	0.2
1985	1.2×10^{-2}	1.2×10^{-1}	.25
1990	1.1×10^{-2}	1.1×10^{-1}	.22

TABLE RV-10

Estimated Regional Incremental Non-methane Hydrocarbon Concentrations Over Background in $\mu g/m^3$ Based on Well Mixed Box Analysis and Annual Averaged Emissions

Year	Annual	3 Hour Average
1974	1.0	13
1980	1.5	19
1985	2.3	29
1990	2.1	27

With addition of the hydrocarbon background of 50 $\mu g/m^3$, the study region can be expected to realize conditions of non-methane hydrocarbon levels exceeding 80 $\mu g/m^3$ in the non-urban areas (Table RV-10), and as high as 200 $\mu g/m^3$ in the urban areas, based on the ERTAQ model analysis. For such extremes, the modified rollback approach estimates maximum one-hour averaged oxidant concentrations to range between 140 and 220 $\mu g/m^3$ assuming the analogy to Los Angeles is correct. Thus throughout the period between 1980 and 1990, it is expected that the photochemical oxidant standard would be exceeded at least once a year in the study region.

Judging from the persistent valley flow towards the west superimposed by the opposing southwest prevailing wind, it is predicted that the region of highest oxidant concentration would be encountered in the Yampa Valley on the far western side of Colorado, about 150 kilometers (100 miles) west of Craig. It is likely that elevated oxidant concentrations also would be experienced in eastern Utah near Vernal as a result of the general predicted buildup of emissions in the study area and neighboring regions.

Secondary aerosol particle formation

Accompanying the increased oxidant buildup and increases of NO_x and SO_x emissions, it is expected that there would be a contribution of sulfate and nitrate material to the TSP loading in the region. Based on the results of the California Aerosol Characterization Experiment (Hidy et al 1975) and related work, it is estimated that approximately 10 percent of the ambient SO_2 would be oxidized to sulfate in the atmosphere. Similarly approximately 1 percent of the ambient NO_x would be converted to nitrate by oxidation in the atmosphere. For such conditions, about 1 $\mu g/m^3$ sulfate (annual average) increase would be expected in the region, and approximately .27 $\mu g/m^3$ annual average nitrate would be expected, based on predicted ambient concentrations of NO_x and SO_2 in the urban areas. These increases would represent a minimal change in estimated TSP concentrations based on blowing dust and other "primary" emissions. Their contribution to visibility reduction also would be minimal in the study region.

Trace elements

It is difficult to determine the impact of trace element emissions because little is known about the levels at which they become toxic. The EPA is charged with the responsibility in Section 112 of the 1970 Clean Air Act to define hazardous air pollutants and propose emissions standards appropriately. Among the elements known to be toxic, at least in some of their chemical forms, are: lead, mercury, cadmium, chromium, nickel, selenium, arsenic, and beryillium.

The U. S. Department of Labor Occupational Safety and Health Administration (1974) has established threshold limit values (TLVs) for trace metal concentrations an employer can allow in a work room. Threshold limit values representing maximum allowed exposures for eight-hour average durations are shown in Table RV-11. Also shown are the maximum one-hour trace metal concentrations that would be expected to occur in the vicinity of the power plants during the worst case meteorological conditions. The predicted one-hour concentrations would be several orders of magnitude smaller than the TLVs in all cases.

Cooling towers

Water vapor and drift emitted from cooling towers can have environmental impact due to visibility changes associated with fogging, and to enhanced production of secondary pollutants in the presence of water vapor.

An estimate of visibility reduction around the Craig plant was made using a simple Gaussian dispersion model to predict the liquid water content in the vicinity. It is estimated that the liquid water content within the cooling tower plume at distances less than one kilometer would average 2 to 3 mg/m^3, reducing the visibility to about 10 meters (30 feet). Visibility would not be restricted outside the plume; the environmental impact in this respect would be very small. However besides restricting visibility by itself water vapor could add to the problem caused by SO_2. SO_2 and its resulting products in the atmosphere ($SO_4^=$, $(NH_4)_2SO_4$) could be the primary cause of reduced visibility; direct relationships between SO_2 to visibility have not been completely determined. Aerosols resulting from SO_2 conversion are the actual causes of visibility reduction and their formation processes are not completely understood and quantified.

When water vapor enters the problem the situation would become more complex. At high relative humidities the potential for visibility degradation by a

TABLE RV-11

Maximum 1 Hour Concentrations of Trace Elements in 1985 ($\mu g/m^3$)

Element (TLV)	Hayden 1 & 2 ($\mu g/m^3$) x 10^{-3}	Craig 1 - 4 ($\mu g/m^3$) x 10^{-3}	Moon Lake ($\mu g/m^3$) x 10^{-3}
Uranium (250) 1/	2.505	8.564	4.261
Thorium	4.525	15.470	7.697
Lead (150)	8.888	30.387	15.119
Thallium (100) 2/	0.663	2.265	1.127
Mercury (50)	0.011	0.036	0.018
Lanthanum	23.432	80.112	39.859
Barium (500)	476.718	1,629.871	810.930
Tellurium (100)	0.056	0.191	0.095
Antimony (500)	0.800	2.735	1.361
Cadmium (100)	0.137	0.470	0.234
Selenium (200)	0.291	0.994	0.495
Arsenic (500)	0.566	1.934	0.962
Zinc (5000)	36.360	124.312	61.851
Nickel (1000)	40.400	138.125	68.723
Cobalt (100)	3.232	11.050	5.498
Manganese	19.715	67.405	33.537
Chromium (1000)	10.504	35.912	17.868
Vanadium (500) 3/	26.664	91.162	45.357
Fluorine (200)	137.359	469.264	233.658
Boron (15000)	226.239	773.498	384.848
Beryllium (2)	3.798	12.984	6.460
Lithium	21.008	71.825	35.736

1/ Insoluble
2/ Soluble compounds
3/ V_2O_5 dust

certain amount of hygroscopic aerosol would be increased. Smaller particles cause the most problems due to the large surface/volume ratio.

The presence of evaporative cooling systems adjacent to a fossil fuel power plant could produce aggravated adverse health effects within a few kilometers of the plant through the direct emissions of various contaminants in the drift, and in the acceleration of the production of secondary pollutants. Although there is evidence that these pollutants have significant health effects, there is not sufficient data to determine acceptable ambient air quality levels.

Visibility

The addition of particulates into the atmosphere, either directly as suspended particulate emissions or indirectly as a result of chemical reactions of geseous pollutants, would reduce the visibility in the area. The gaseous contribution is expected to be minimal. A calculation of the degree of degradation from suspended particles depends on several parameters for which data are not available, the most important being size distribution of the particles. Total suspended particulate concentrations can be used to estimate visibility with the understanding that the relationship is not well defined, especially near a source of fugitive dust that contains a large fraction of relatively massive particles. Using the relation of visual range in kilometers equal to about 1800 divided by the average total suspended particulate concentration in $\mu g/m^3$ (Charlson 1969), the minimum visibility on an otherwise clear day would be on the order of 51 kilometers (32 miles). This was calculated using an average particulate concentration of 35 $\mu g/m^3$ as representative of the entire air mass affecting visibility during the worst case predicted 24-hour total suspended particulates. Visibility degradation of this order would be expected to occur with the same frequency as the maximum particulate concentrations, or about 10-30 days/average year. Presently the average visiblity range over a year is estimated at 25 kilometers (15 miles). This estimate includes such factors as cloud cover, humidity, and background pollutant concentrations. The proposed regional development would reduce this estimate to no less than 20 kilometers (12 miles) on an annual basis. Any incidents of coal fires in spoils could significantly reduce the above estimates of minimum visibility.

Living Components

Soils

The major impact on soils in the study region would result from actual mining operations removing 75 million tons of coal in the period 1976 to 1980, 119 million tons in the period 1981 to 1985, and 146 million tons in the period 1986 to 1990. This would result in disturbance and mixing of the soil on approximately 39,210 acres by 1990 (see Table RV-12). Disturbance would alter soil characteristics, micro-organisms, and soil climate relationships which have been established over long geologic time. The current level of soil productivity would be lost for an indefinite period. Impact on soil increases in proportion to the increased mining rate. The soil disturbance per five-year period accelerates from 9,385 acres in the 1976-1980 period, to 14,030 from 1981-1985, and increases to 15,795 from 1986-1990. This represents approximately 0.7 percent of the surface in the study region.

Mining involves removal of large volumes of overburden to reach coalbeds. Removal of overburden would result in complete alteration of soil horizons, parent material, and soil characteristics. It could result in bringing elements to the surface, such as boron, which at sufficient concentrations are toxic to plant growth. At completion of mining operations, soil structure would be completely different than prior to start of mining operations.

TABLE RV-12

Acres Disturbed and Revegetated in Study Region Based on Projected Development by Five-Year Periods

	1976-80	1981-85	1986-90	Total
Coal Mine Disturbances				
Surface mines	4,825	9,470	9,670	23,965
Surface mines revegetated	1,434	7,528	9,596	18,558
Underground mines 1/	200	300	0	500
Mine facilities 1/	400	300	500	1,200
Total Disturbed	5,425	10,070	10,170	25,665
Total Revegetated	1,434	7,528	9,596	18,558
Associated Disturbances				
Powerlines Disturbed	1,050	1,750	2,100	4,900
Powerlines Revegetated	420	1,330	1,890	3,640
Power plants 1/	1,000	1,000	1,000	3,000
Roads 1/ 2/	420	1,150	1,385	2,955
Railroads 1/	420	60	1,020	1,500
Population 1/	1,070	0	120	1,190
Total Disturbed	3,960	3,960	5,625	13,545
Total Revegetated	420	1,330	1,470	3,640
Grand Total Disturbed	9,385	14,030	15,795	39,210
Grand Total Revegetated	1,854	8,858	11,486	22,198
Grand Total Permanently Removed	3,510	2,810	4,025	10,345

1/ Acres permanently removed from production for the time frame of this report.

2/ Including coal exploration trails.

In addition to the area of soil which would be disturbed by actual mining, soil disturbance would also result from construction of railroads, roads, transmission lines, mine facilities, power plants, and new housing facilities. All of this disturbance except powerline construction would result in permanent loss of productive soil. Soil surface that would be disturbed and permanently removed by these activities is shown in Table RV-12. The impact of permanent soil surface loss would be greatest in the 1976-1980 time period when 3,510 acres would be lost due to development of associated activities.

Surface soil disturbances by the projected developments would reduce or permanently remove production on 39,210 acres by 1990. All impacts on topsoil disturbance per five year period would be 9,385 acres in the 1976-1980 period, 14,030 acres in the 1981-1985 period, and 15,795 acres in the 1986-1990 period. This would be about 61.3 square miles.

Without knowing the precise location of the disturbance on a yearly basis, it is difficult to determine which soil associations might be impacted. Since the exact locations of most of the anticipated coal related developments are not known, disturbed acreage by soil associations was not calculated.

All of these disturbances would result in the exposure of a range of soil materials, from fine to moderately coarse grained, to wind and water actions. Soil productivity, permeability and infiltration rates would be reduced, increasing runoff, soil erosion, and sedimentation. Wind action, which is variable over the area, would cause fine soil, silt and clay particles to be lifted into the atmosphere, reducing air quality and increasing soil loss. Prior to revegetation of exposed soils, erosion resulting from high intensity storms would remove fine materials, which could result in formation of gullies. Alteration of stream channels and increased velocity would accelerate erosion of stream banks and cause headcutting of the streams; this would add to soil loss and sedimentation. Greater recreation use from more population would cause additional soil losses. Increase in off-road vehicle use might cause serious impact on soils.

Terrestrial Flora

Vegetation would be disturbed to varying degrees by the following mining associated operations: roads, mine facilities, power plants, railroads, powerlines, coal removal, and associated population increases (Table RV-13).

TABLE RV-13

Acreages and Vegetation Type Disturbed by the Coal Related Development Analyzed in Site Specific Analysis at the Three Benchmark Dates.

	Vegetative Type						
	Sage-brush	Mtn. Shrub	Pinyon-Juniper	Aspen	Crop-land	Bottom-Land	Total
Energy 1 and 2	880	280	-	20	660	-	1,840
W. R. Grace	214	201	-			-	415
Peabody	338	196	-	98	50	-	682
Ruby Construction	10	-	-	-	-	-	10
W. R. Grace Railroad	151	117	28	-	72	72	440
1980 Total	1,593	794	28	118	782	72	3,387
W. R. Grace	112	89	-	-	-	-	201
Peabody	130	55	-	10	-	-	195
1985 Total	242	144	-	10	-	-	396
W. R. Grace	122	118	-	-	-	-	240
Peabody	28	11	-	54	-	-	93
1990 Total	150	129	-	54	-	-	333
2005 Total (W. R. Grace only)	489	154	-	-	-	-	643
Grand Total	2,474	2,021	28	182	782	72	4,759

The number of acres that may be disturbed by coal related activities over the next 30 year period have been projected including the site specific analysis; however it is impossible to predict the vegetative type that will be disturbed (Table RV-14).

TABLE RV-14

Cumulative Disturbed and Revegetated Acreages in the Study Area
Based on Projected Development and Acreage Requirement Units

Activity	Period 1976-80	1976-85	1976-90
Surface mines disturbed	4,825	14,295	23,965
Surface mines revegetated 1/	1,434	8,962	18,558
Underground mines 2/	200	500	500
Power lines disturbed	1,050	2,800	4,900
Power lines revegetated 1/	420	1,750	3,640
Power plants 2/	1,000	2,000	3,000
Roads 2/ 3/	420	1,570	2,955
Railroads 2/	420	480	1,500
Population 2/	1,070	1,070	1,190
Mine facilities 2/	400	700	1,200
Total Disturbed	9,385	23,415	39,210
Total Revegetated	1,854	10,712	22,198
Total Permanently Removed	3,510	6,320	10,345

1/ Assume three-year lag for revegetation.

2/ Considered to be removed from production for time frame of this report but is partially revegetated and erosion control measures taken.

3/ Including coal exploration trails.

The exact area that would be disturbed has been identified on 4,759 acres (Table RV-13), and total projected disturbance would be 39,210 acres (Table RV-14). The actual impact on the vegetation ecosystems of the region would be difficult to describe in detail since only 10 percent (4,759 acres) of the actual location of the disturbances is known. However, because of the general location of the coal, 75 percent (approximately 25,000 acres) of the area to be disturbed by the coal-related activities would probably be sagebrush and mountain shrub.

Vegetation loss would begin with the construction of roads, drainage ditches, and surface facilities. Road and drainage ditch construction would alter the surface drainage pattern. Surface water that would normally run downhill might now be diverted to areas more convenient for discharge. This might cause some downslope areas to receive somewhat less moisture; this change in available moisture might cause some minor localized alterations in vegetative patterns.

The mining operation would produce the largest vegetative impact. The first disturbance of vegetation would result from stockpiling topsoil and placing the boxcut spoils on undisturbed land. Total removal of vegetation by mining from these acreages each year would have a secondary effect on surrounding vegetation. Once the vegetation is removed from the mining areas and is unavailable to herbivors, vegetation on surrounding areas might be subjected to increased utilization. Magnitude of this impact would depend on the importance of the area as wildlife food, and the amount of overstocking of domestic livestock that takes place.

Population increases associated with employment for the mining operation would disturb approximately 1,190 acres by 1990. Vegetative types removed would be indeterminable, as the exact location of the population increases could not be determined. This figure includes areas disturbed or destroyed by development of social facilities (schools, shopping areas, etc.) to serve this increased population. Increased recreational use by the new expanded population, especially off-road vehicle use, would affect additional vegetative types and acreages within the total study area.

Disturbance of areas currently used for cropland would probably be the smallest impact to vegetation. Successful crops of shallow-rooted smallgrains would probably be easiest to re-establish on mine spoils, especially if a fertilizer program is included. Areas of native vegetation would be the most difficult to re-establish, if not impossible.

Another impact to vegetation during the mining operation would be the affects of fugitive dust and coal dust on plant life. It is difficult to predict the degree of impact produced by fugitive and coal dust, but it would probably be minor in relation to fugitive dust, and would depend upon the cleanliness of the loading operations in relation to coal dust. Dust would result from haul roads, blasting, overburden removal, and spoil shaping. Dust that falls on plants might create a decrease in plant vigor due to a lower photosynthetic rate. Dust covered vegetation might be less palatable and possibly toxic to livestock and wildlife; however this would likely constitute a very minor impact.

A secondary impact due to destruction of native vegetation would be invasion of weedy species. These weedy species such as Russian thistle (Salsola kali) would compete with revegetation attempts, thereby decreasing the chances of permanent vegetative establishment.

Most mining companies plan to use alfalfa in their revegetation programs. Alfalfa has been utilized in reclamation efforts in the area in the past and has been found to dominate the revegetated area (Berg and Barrau 1973) and thus the dominance of alfalfa would increase the time of native vegetation loss by not allowing natural invasion. In dominating, the alfalfa provides an excellent soil stabilizer; however it tends to create a vegetative stand with very little variety for a number of years (at least ten) and creates a management problem for livestock (Berg 1975). It is current theory that the stability of a plant community is a function of its species diversity, and that succession in an ecosystem is described as a progression toward higher diversity (Kormondy 1969). Diversity produces stability becasue there is less likelihood that any major shift or loss of any one component would adversely affect the system as a whole. It is evident from the increasing need for pesticides in agricultural croplands that most monocultures do not produce self-sustaining stable vegetation. Also Stewart (1974) found that micro-organism activity increased on revegetated mine spoils in southeastern Montana as species diversity increased; micro-organisms are vey important to nutrient cycling and soil development.

Length of the impact of total vegetation loss would depend upon the success of reclamation. Loss of the native vegetation would be quite long, depending upon the rate and ability of native species to invade the area, and the extent to which trees and shrubs would be transplanted from undisturbed areas to spoil areas, which are functions of most companies' reclamation programs. Because of their soil texture, toxicity, or other factors, some small areas may be impossible to revegetate, making loss of vegetation a permanent impact. Since current reclamation techniques, such as replacing topsoil, have only been utilized for a few years, sufficient information is not available to predict the amount of time needed for native species invasion or the extent of areas unable to be revegetated. In some years climatic conditions might be such that revegetation attempts would fail, extending the impacts of vegetative loss. Also the loss of existing soil geomorphologic conditions and creation of a different soil might prove difficult or native vegetation impossible to re-establish.

Young, palatable vegetation produced by revegetation efforts would attract wildlife and livestock; grazing on young plants would inhibit early growth and revegetation of disturbed areas.

The total destruction of native vegetation from an area would result in the following impacts on the vegetation ecosystem:

1. Loss of above and below ground primary productivity,
2. Loss of a diverse vegetation capable of withstanding climatic extremes and utilizing precipitation and sunlight throughout the growing season,
3. Loss of present vegetative successional stage, and a set-back to a very juvenile stage,
4. Loss of a natural seed source, necessary for ecological succession and stability,
5. Loss of nutrient cycling systems that utilize the soil, plants, micro-organisms, and physical forces to cycle nutrients from the soil to forms usable by plans. These sytems are essential for self-sustaining vegetation growth, and may be the greatest limiting factor to establishing self-sustaining plant ecosystems on mine spoils,
6. Loss of soil stability and erosion prevention by roots and shoots of vegetation.

Terrestrial Fauna

Coal development and related activities would have a significant impact on the terrestrial fauna of northwestern Colorado. Increse in coal mining activities, construction of roads, railroads, power plants, powerlines, and human population increase would each add its own characteristic impacts to form a series of cumulative regional impacts. These impacts would manifest themselves in two general categories: impacts on habitat and impacts directly on the animals.

Impacts on habitat

The region covered in this statement is expected to change from a quiet, rural setting to one bustling with human activity by 1990. By 1990, it is predicted that a minimum of 10,345 acres of wildlife habitat (approximately 0.2% of the study region) would be permanently removed from the existing productive ecosystem related directly to the activities of the proposed actions (Table RV-12). This acreage would be used by powerplants, roads, railroads, mine facilities, and urbanization (see Table RV-14, Terrestrial Flora).

The majority of these disturbed areas would be located in what is now deer winter range; this includes mountain shrub and sagebrush habitat types. A great many other species would be affected by this loss of habitat, dependent on the acres of each vegetation type disturbed (see Appendix D for animal species and habitat type preferred).

The permanent loss of 10,345 acres represents the probable loss of the annual carrying capacity for 200 mule deer, 20 pronghorns, 30 elk, 10 sage grouse, and an undetermined number of non-game birds, mammals, reptiles, and amphibians. In addition to these wildlife species, the untold numbers of invertebrates that would be lost would affect the entire ecosystem by reducing the major non-vegetative base on the region's food web. These estimates do not represent the total loss of animal lives during the 15 year period from 1975 to 1990. These figures represent only the loss of sufficient habitat to support these animals at any one point in time. Actual loss of life would be calculated from this projected loss of habitat.

In addition to the permanently lost acreage, 39,210 acres (Table RV-12) would be temporarily disturbed. These areas would be reclaimed to provide some form of wildlife habitat, even if it is not restored to the same vegetation types that exist here at the present time. Present plans indicate that 22,198 acres should be revegetated by 1990; however, none of this is expected to be totally reclaimed by this date.

The majority of the plants that will be used to revegetate the disturbed areas will be a variety of grasses and legumes; a relatively small percent of the area will be returned to a floral composition similar to what presently exists.

Based on the habitat disturbance estimates mentioned above it is expected that the temporarily lost annual carrying capacity of the region due to mining related activities would fluctuate as indicated in Table RV-15, based on data from the DOW. These losses would be spread out over the entire 15 year period. Approximately 22,198 acres of this disturbed habitat will be revegetated by 1990, so the total actual loss in deer, elk, and sage grouse may be somewhat reduced, depending on the species used and success of the revegetation work. Table RV-15 shows expected temporary loss of game species annual carrying capacities by five year increments.

Sage grouse losses would probably be permanent in most areas because few of the proposed revegetation plans call for the use of sagebrush to any significant degree.

TABLE RV-15

Probable Temporary Losses of Annual Carrying Capacity For Game Species

Year	Mule deer	Elk	Sage Grouse	Antelope
	Species			
1976-80	120	57	7	20
1981-85	230	107	10	0
1986-90	230	111	13	0

Virtually every species of terrestrial fauna listed in Appendix D would suffer from some form of lost habitat values resulting from the proposed actions covered in this statement; the degree of impact would depend on the adaptability of the species involved and/or their mobility. Because of a lack of species density and composition data for the majority of wildlife species it is impossible to adequately estimate the reduction in carrying capacity that would result from the proposed action. For these species impacts must be calculated in general terms.

Most species fit into relatively narrow habitat niches. However, some species such as the deer mouse inhabit a wide variety of habitats. These species would be least affected by the coal development although many of their kind would die from the direct actions of these developments. Generally speaking those species closely associated with mountain shrub and sagebrush habitat types would be the most severely impacted by coal development. Because of the proposed revegetation plans, species that favor grassland habitat types would be favorably impacted by the increase in available habitat (Appendix D).

Only slight impacts to animal migration patterns would be expected as a result of the proposed action; local problems related to animal movements and habitat disturbance could result from mine activities and the railroad proposed by W. R. Grace.

Impacts directly on animals

Legal and illegal hunting pressure would be expected to increase with the influx in the local human population.

Animal harassment would be expected to increase as more people spend their leisure time in the country, either on the roads or in off-road vehicles, mainly snowmobiles. The probability of vehicle-animal collision would increase on all roads within the region as people-use of these roads increases.

Many animals would be destroyed during mining, road and railroad construction and building of homes, schools, powerplants, etc. The less mobile faunal species such as many reptiles, invertebrates, and small mammals would not be able to flee and would be destroyed. The larger and more mobile species such as deer, elk, coyote, grouse, and other birds would be able to move onto adjacent lands. These displaced animals would be moving into a less suitable location or an area that is already supporting populations that are in balance with their habitat. All or most of the displaced animals would probably be eventually lost as the total population begins to adjust to the carrying capacity of the species' habitat and the interspecific and intraspecific intolerances are resolved. The animals that have been displaced would be in unfamiliar territories, and studies have indicated that most dislocated wildlife species are more vulnerable to predation than if they had been able to remain within their home ranges.

Probability of food and cover shortages as well as spread of disease and parasites would also be increased as population densities become greater.

Impacts on wildlife related to the increased noise level, especially around the mine area, could alter feeding and movement patterns for a variety of species.

Some lowering of the surface water quality would be expected within the region. This would impact terrestrial species by interrupting the food web by impacting habitat values for invertebrates, a major food item of a variety of terrestrial faunal species.

Impacts on domestic fauna

Coal development and related activities would create impacts on the livestock industry of northwestern Colorado. Some direct losses of life would probably result from vehicle-animal collisions due to increased vehicle use of the region. Accidental animal deaths would also be more likely from hunting related activities. Rustling of livestock and damage to fences and other range improvement facilities would probably result from the increase in human population and their use of the region.

In addition to the direct loss of life, 10,345 acres would be permanently lost to livestock grazing and another 28,865 acres would be temporarily lost (Table RV-12). The total impact of this habitat loss would be to reduce livestock grazing within the region by about 7,100 Animal Unit Months (AUMs). About 5,270 AUMs of this loss would be eventually replaced as mine reclamation plans begin to establish vegetative cover on mined areas. Some reclamation plans call for a revegetation program that would result in a conversion from mountain shrub and sagebrush to grasslands and cropland; these areas could possibly show a net increase in AUMs when the revegetation program is complete. This would be unlikely however because of the expected loss of soil-productivity as explained in the soils section of this chapter. A minimum permanent loss of approximately

1,825 AUMs, directly related to the proposed action covered in this statement, would be expected for the study region.

Most of the impacts from the mining operations would come on spring-summer-fall range. Power plant construction and urbanization would generally take place on livestock winter range.

Aquatic Biology

The primary regional adverse impacts to the aquatic ecosystem would involve stream sedimentation increases. Uncontrolled erosion of the disturbed surfaces in the areas of the proposed actions would lead to sedimentation increases in the local watersheds and some increases in sediment loads in some of the major streams (e.g., Yampa River) in the study region.

These increases in stream sedimentation would have some adverse impacts on the aquatic community in the Yampa River. An increase in suspended material carried by a stream raises water temperature and decreases dissolved oxygen content. The resultant increased deposition of silt could bury critical fish spawning and feeding areas and concurrently destroy benthic organisms through suffocation.

The proposed mining activities and appurtenant facilities construction could result in the elimination of a significant amount of aquatic habitat in the study region. Unmitigated sedimentation increases could destroy much of the aquatic habitat in the Trout-Fish-Middle Creek watershed (Energy Fuels mines), Wilson-Milk Creek watershed (W. R. Grace mine and railroad), Sage-Dry Creek watershed (Peabody mine), and the Yampa River (W. R. Grace Railroad, Route A). Implementation of the proposed mining plans without giving due consideration to the aquatic habitats could result in extensive encroachments into perennial streams (e.g., bridges for haul roads, dumping of spoil piles into streams) and could destroy a substantial amount of aquatic habitat in the study region.

Cultural Components

Archeological Resources

Archeological resources would be adversely impacted by: (1) disturbance of surface or sub-surface cultural remains, (2) destruction of site integrity through alteration of the adjacent landscape setting, and (3) exposure of resources to more vandalism and pothunting due to population growth and subsequent increases in visitor use.

Projected surface disturbance would total 9,385 acres by 1980, 23,415 acres by 1985, and 39,210 acres by 1990 (see Table RV-14). The potential for destruction of archeological sites would increase in direct proportion to the projected surface disturbances. Because only approximately one percent of the study region has been intensively surveyed, it is not possible to predict the number or type of sites that may be destroyed.

Required acreage disturbance for coal mining and associated development would destroy archeological sites through outright displacement. It should be noted that recently deposited alluvium (see Quaternary-aged alluvial material on geologic map, Appendix A) is often a more valuable source of cultural remains than is adjacent terrain of older geologic origin. Intensive surveys prior to surface-disturbing activities would identify surface exposures of early man's presence, but subsurface resources could not be detected prior to project construction and therefore would be destroyed.

Archeological testing and subsequent excavation are often employed to more thoroughly assess and salvage significant archeologic values prior to their destruction. Notwithstanding the beneficial nature of these actions, they are inherently destructive as they destroy the in-place value of the resource (i.e., stratification, juxtaposition, interpretive-educational values, etc.).

The significance of other sites might not warrant excavation, and they would be totally lost with their commensurate scientific, interpretive, and educational value, if they should be displaced by coal-related construction activities.

Even though vandalism and pothunting of cultural resources is presently occurring, the rate of archeological site destruction would increase in direct proportion to population increases. This increase with the proposed action compared to the normal increase without the action is projected as follows, given in average annual percent increase in population (growth rate without the proposed action is shown in parentheses): 1980-(6.9)12.61, 1985-(4.7)3.24 and 1990-(1.9)2.42. In terms of absolute numbers of residents, the population increase associated with the proposed action for the study region would total 10,759 by 1980, 9,437 by 1985, and 11,857 by 1990.

Archeological resources that are of National Register significance (i.e., eligible) would receive heavier recreation use due to the greater numbers of people in the study region. As an indicator of this projected increase, recreational four-wheel driving would be expected to increase by 29,261 activity days by 1980, 25,946 activity days by 1985, and 27,413 activity days by 1990 (see RV-23).

Historical Resources

Historical values would also be impacted by both surface disturbance and heavier visitor-use pressure. The potential for site disturbance would be proportional to acreage disturbance. The mines themselves would destroy historic sites, and linear construction and right-of-way projects would especially impact historic trails. Cumulative acreage disturbance projected for the three benchmark years are as follows (figures appearing in parentheses indicate the portion due to linear surface disturbances): 1980 - 9,385 (1,890 acres or 130 miles), 1985 - 23,415 (4,850 acres or 315 miles) and 1990 - 39,210 (9,355 acres or 525 miles). Refer to Tables RI-2 and RV-14. In relation to this acreage disturbance, perhaps the greatest impact would be measured in terms of damage to the historical setting of aesthetically attractive homestead structures, which lack special historic significance.

Though not quantifiable, an additional adverse impact would be experienced from urban development within the already-developed core of existing communities. Representative architectural styles as well as buildings of local historical significance would be either demolished to make room for new structures, or the integrity of setting could be violated by adjacent construction. For example, the present boom in Craig is resulting in replacment of older structures as new businesses, often of contrasting architectural design, are built to accommodate the expanding populace.

More local residents would be visiting other historical resources (as referenced in the Archeology section). Several old log cabins and other buildings remain standing at abandoned homesteads throughout the study region. The projected increase in four-wheel and pleasure driving would result in more use and subsequent vandalism of these sites. Collectors of artifacts and barn wood would cause some of the most significant impacts from this increase in visitor use.

National Register properities would receive more recreation use due to local population increases (as outlined above). Impacts would result from exposure to vandals and artifact hunters.

Land Use

Implementation of the proposed actions will result in changes in land use throughout the region. Probably the most drastic change would be that from grazing and farmland to intensively developed surface mines and related facilities. Since rehabilitation measures would be implemented as mining progresses, the total number of acres disturbed during the life of a mine would not be converted to a different land use at one time; it would instead be a rotation in land uses spaced over a period of 20-30 years in most cases. It is estimated that during 1976-1980, 5,425 acres would be converted to coal mines and related facilities, 10.070 acres during 1981-1985, and 10,170 acres during 1986-1990 (see Table RV-12).

More permanent changes in land use from grazing and farming to roads, railroads, powerlines, and powerplants would also occur. This conversion during the next five year period would be 2,890 acres, 3,960 acres during the second period, and 5,505 acres during the third period. This total of 12,355 acres would represent approximately 0.2 percent of the total acreage in three counties and 0.4 percent of the area being farmed and grazed. Gnerally the type and success of reclamation of surface mine areas would dictate the kind of land use that would exist after mining. Lands suitable for crop production could conceivably return to the former use one year after mining. Other lands would probably have to be excluded from grazing for three years after mining until the new vegetation could sustain continued livestock use.

In some cases, use after mining would be different than the present use. Some of the lands now in crop production would be converted to grazing, and some of the land now being grazed would be converted to farming; however considering the total acres to be disturbed, there would not be a significant net change.

Projections indicate that population directly attributable to coal development will increase by 11,900 people by 1990., Using the acreage requirements in Table RI-5, approximately 1,090 acres would be needed for residential use, shopping and other community facilities to accommodate this growth.

None of the proposed actions are in areas considered to have high potential for recreational homesites and rural subdivisions, and there are no known subdivisions outside existing communities in existence or planned that would directly be affected by the proposed actions. A slight exception might be that demands would be placed on recreation properties and areas, especially in Routt and White River National Forests, with regional growth in population and economy.

Aesthetics

Regional aesthetic impacts would be directly proportional to the amount of surface disturbance and development occurring in the proposed action areas; they would also be directly proportional to subsequent development associated with population increases. Measures of total acreage disturbed as well as linear measurements of rights-of-way would be the best indicators of cumulative aesthetic impacts on a regional basis.

Adverse aesthetic impacts would result from those actions whose inherent features do not complement the landscape(s) into which they are placed, (called the characteristic landscape). This could be quantified by analyzing the dominance elements of both the action and the environment, that is, their form, line, color, and texture. When elements of the proposal do not complement those of the landscape into which it is being placed, we say that it does not "borrow" and therefore results in a minus deviation from the characteristic landscape, or an adverse impact. This measure of impact is inherent in the proposed action and depends only on where it is to occur. These are discussed in a general sense in the Regional Analysis; more detailed quantification occurs in the site specific analyses.

However a second measure of impact can be made irrespective of the incongruous nature of proposed action elements. That is the relative visibility of the landscape units in which the proposed action occurs. With respect to this measure, the most adverse aesthetic impacts are those that: (1) can be viewed from more than one road segment, (2) can be viewed for greater distances along these segments, (3) can be viewed at varying distances, and (4) can be viewed most directly (in terms of their angle of exposure to the viewer). This second measure of aesthetic impacts can only be recognized in a general sense in the Regional Analysis. However relative numbers of viewers can be established by referencing the average daily traffic (ADT) volume maps in Chapter IV of the Regional Analysis.

Surface mine overburden removal results in creation of large areas that are strongly form, line, and color dominant. Straight lines of the active pit, edges of clearings, angular form of spoil piles, and color of exposed mineral earth create minus deviations from the characteristic natural terrain. This problem is compounded by the dumping of spoils down hillsides or over escarpments (see Figure RV-2). More significant and long-lasting impacts would occur where surface mines occur in dense aspen forest or woodland vegetative types; in these landscapes their form and color would be more incongruous. Cumulative acreage disturbed by surface mining would reach 4,825 acres by 1980, 14,295 acres by 1985, and 23,965 acres by 1990; aesthetic impacts from surface mines would increase at the same rate. However, surface mine reclamation efforts will revegetate 1,434 acres by 1980, 8,962 acres by 1985, and 18,558 acres by 1990 (see Table RV-14).

Underground mining operations would create additional aesthetic impacts. Grading for operating areas, coal stockpiling, equipment storage, and other base facilities would result in aesthetic impacts where these features do not borrow visual dominance elements from the characteristic landscape. Impacts would be proportional to the total land area disturbed: 200 acres by 1980 and 500 cumulative acres by 1985. No additional surface acreage disturbance is anticipated from 1985-1990 (see Table RV-14).

Necessary surface facilities at all new mines would cause significant visual impacts. A large array of machinery and buildings plus grading of the base area would characteristically focus attention on these facilities. Strong form and color dominance would create significant visual impacts. Mine facilities would disturb a cumulative total of 400 acres by 1980, 700 acres by 1985, and 1,200 acres by 1990 (see Table RV-14). These impacts would often be more adverse when mine facilities lie close to existing public roads; those lying in foreground landscapes would be large-scale features occupying a significant portion of the picture plane. At foreground distances (up to one mile) all visual dominance elements would be equally visible.

Road and railroad construction as well as right-of-way preparation characteristically produce strongly line, form, and color-dominant deviation, especially where they traverse steep terrain (see Figure RV-2). Half-moon shaped scars of barren earth or rock would be the most adverse aesthetic impacts these linear projects would cause. When viewed parallel to the right-of-way's alinement, the sharply angular contact of these scars with natural terrain would fail to borrow from the gently rounded form of adjacent terrain. Examples of especially adverse impacts from roads would be anticipated on the Consolidation Coal leases adjacent to Colorado 13 on Ninemile Gap or the construction of the W. R. Grace Railroad through Little Yampa Canyon. Twenty miles of new roads and 35 miles of railroad would be constructed by 1980. A cumulative 70 miles of new roads and 40 miles of new rail would be anticipated by 1985, and by 1990 there will be total of 150 miles of new roads and 125 miles of new railroad.

Because of the gentle grades necessary for construction, railroad rights-of-way often parallel major State and U.S. highways. Aesthetic impacts there would be most severe because they will be visible in foreground landscapes; they would also be visible for a greater duration than if they occupied middle-ground or background landscapes. It will be difficult for them to borrow line dominance from the existing roads because the observer views from the road itself.

Electric transmission lines are characteristically incongruous elements in the landscape. The especially strong line dominance of conductors and form dominance of support structures often create adverse aesthetic impacts, especially where they cross or parallel heavily-traveled highways at close distances. Reflective conductors and poor alinement compound their inherent structural impact. Projected transmission line construction indicates that 75 miles of new line would be built by 1980. Cumulative totals for 1985 would equal 200 miles; 250 miles of new transmission lines would be expected to be constructed by 1990.

A significant amount of acreage would also be occupied by power plants themselves: emission stacks, cooling towers, stockpile areas and the generation plant itself would create an extensive array of minus deviations that have strong line, form and color dominance. Adverse impacts from these structures as well as from stack emissions should not be confused with the beneficial impacts resulting from the human-interest values of these features. Projections indicate that a new powerplant would be built during each benchmark period; three plants would be on-the-ground in 1990 occupying a total of 3,000 acres.

Urban expansion due to population growth would result in additional losses of open space. By 1980, 1,070 acres would be consumed by housing developments and associated amenities. The cumulative total would remain at 1,070 acres by 1985 and 1,190 acres by 1990 (see Table RV-14). Aesthetic impacts wuld also result from additional fugitive dust, auto, and other related pollutant sources (see Chapter V, Air Quality).

The overall aesthetic experience in the region would also be adversely impacted. Areas that are no largely in their natural state would be altered most drastically. Feelings of isolation, solitude, or respect for nature are subjective and vary from one visitor or sightseer to another; however there would be a definite and measureable loss of natural landscape beauty, as well as a loss of its capability to create feelings of respect for nature, isolation, or solitude that would accompany development and urbanization of the natural landscape. Air quality impacts would also adversely affect mood-atmosphere values. For example, especially adverse impacts are anticipated on natural values in the Skull Creek area which lies approximately five miles due north from the proposed Moon Lake power plant site. Minus deviations would also result from increases in recreational use associated with the influx of people in the region. The impacts on natural values (identified in the recreation section) would also result in secondary impacts upon the area's aesthetic resources; these impacts would occur in the form of increased littering, more fugitive dust from additional vehicular traffic (including off-road-vehicles), and actual resource deterioration.

Although these actions would adversely impact mood atmosphere character, it would result, not aesthetically but in terms of values that challenge the mind, in beneficial human-interest impacts by revealing nature's complexity and massiveness.

Aesthetic impacts can only become beneficial when deviations from the characteristic landscape are "plus" instead of "minus", i.e., when they borrow from the natural elements in the characteristic landscape. Therefore, only when modification of the landscape enhances landscape variety, while yet maintaining visual harmony, will aesthetic impacts become beneficial. This section of the next chapter deals with ways to maintain visual harmony in the introduction of foreign elements into the natural landscape.

Recreation

The recreation user origin analysis in Chapter IV of the Regional Analysis can be combined with population projections for the study area to obtain estimates of future recreation participation rates within as well as adjacent to the study area. Tables RIV-31 and RIV-32 in Chapter IV provide a 1974 data base that indicates the type of recreation activities in which Region 11 and Region 12 residents participate, as well as the region in which the activity takes place. Assuming that per capita recreation participation rates would remain constant as population increases, recreation use projections can be made. Table RV-16 indicates population projections with the proposed action for 1980, 1985, and 1990 for both planning regions encompassed by the study area (see Figure RIV-35).

By combining the 1974 base tables and population projections, Tables RV-17, RV-18, and RV-19 were derived to indicate projected recreation use from Region 11 residents; Tables RV-20, RV-21, and RV-22 indicate projected recreation accruing to Region 12 residents. Though these projections are made only for a unit as small as the State planning region, they are valuable indicators of the amount and type (i.e., what recreation activities) of impacts that would be caused by additional recreation users in Routt, Moffat, and northern Rio Blanco Counties.

Approximately eighty-five percent of all Colorado recreation use from Region 11 residents occurs within the region. Regions 10 and 12 supply 6.8 and 4.0 percent respectively of total Region 11 recreation demands; other regions in the State receive only small amounts of recreation use from Region 11 residents. Using the methodology outlined above, the greatest impacts from increasing population in Moffat and Rio Blanco Counties will be experienced in Region 11, and to a much smaller degree in Regions 10 and 12 (see Table RIV-31, Chapter IV, Regional Analysis).

Approximately ninety-three percent of all Region 12 residents participate in Colorado recreation activities within the region; significant in-state recreation participation outside Region 12 occurs in Regions 13 (3.9 percent) and three (2.0 percent). These also serve as valuable indicators for anticipating the area of impact due to population growth in Routt County (see Table RIV-32, Chapter IV, Regional Analysis).

Tables RV-17, RV-18, RV-19, RV-20, RV-21, and RV-22 only depict the cumulative impact of increased recreation use due to the proposed action; for Planning Regions 11 and 12 the actual impact due to the proposed action can be obtained by subtracting the projected recreation participation rates without the proposed action (see Chapter IV, Regional Analysis; Tables RIV-44, RIV-45, RIV-46, RIV-47, RIV-48, and RIV-49) from those participation rates found in the six tables referenced above showing cumulative impact.

TABLE RV-16

Population Projections for Colorado Planning Regions 11 and 12; 1980, 1985 and 1990 with the Proposed Action

Colorado State Planning Region	1974	1980	Average* annual growth rate(%) 1974-1980	1985	Average* annual growth rate(%) 1980-1985	1990	Average* annual growth rate(%) 1985-1990
11	89,374	123,781	5.58	145,253	3.25	168,231	2.98
12	46,347	63,067	5.27	75,821	3.75	88,923	3.24

*Compounded Annually

SOURCES: Colorado Regional and County Population Estimates - 1970-1980: Methods and Results. Volume I, July 1974.

Regional Analysis, Chapter V, Impact of Proposed Action on Social Environment.

TABLE RV-17

Number of Recreation Users from Region 11

Using Recreational Facilities in Other Planning Regions in 1980 (Activity Days)

Activity / State Planning Region:	1	2	3	4	5	6	7	8	9	10	11	12	13
Hiking										433,595	3,094,968	299,031	59,806
Horseback Riding											284,079		
Bicycling											5,606,824		
Motorcycling		29,903								89,709	822,334		
Driving for Fun		59,806	239,224	269,128						433,595	1,300,784	149,515	59,806
Four-Wheeling									59,806		328,933	29,903	
Mountain Climbing													
Swimming										89,709	1,569,911	59,667	
Picnicking		59,806								29,903	816,793	209,322	
Camping		104,660							59,806	299,031	418,643		
Boating										29,903	493,401		
Game Playing				29,903			59,807				1,868,942		
Tennis											269,127	44,855	
Golf											493,401		
Fishing										299,031	2,392,249	194,369	
Shooting/Hunting									59,806	59,806	598,062	29,903	
Skiing/Snowshoeing											343,886	14,951	
Snowmobiling											209,322		
Sledding/Tobogganing/Tubing											493,401		
Ice Skating											74,758		
Other		89,709		29,903							613,013		

TABLE RV-18

Number of Recreation Users from Region 11

Using Recreational Facilities in Other Planning Regions
in 1985
(Activity Days)

Activity / State Planning Region:	1	2	3	4	5	6	7	8	9	10	11	12	13
Hiking										508,785	3,631,671	350,886	70,177
Horseback Riding											333,342		
Bicylcling											6,579,111		
Motorcycling		35,088								105,266	964,936		
Driving for Fun		70,177	280,708	315,798						508,785	1,526,354	175,443	70,177
Four-Wheeling									70,177		385,973	35,089	
Mountain Climbing													
Swimming										105,266	1,842,151	70,013	
Picnicking		70,177								35,089	958,434	245,621	
Camping		122,809							70,177	350,886	491,240		
Boating										35,089	578,962		
Game Playing				35,089			70,178				2,193,038		
Tennis											315,797	52,633	
Golf											578,962		
Fishing										350,886	2,807,092	228,075	
Shooting/Hunting									70,177	70,177	701,773	35,089	
Skiing/Snowshoeing											403,520	17,544	
Snowmobiling											245,621		
Sledding/Tobogganning/Tubing											578,962		
Ice Skating											87,721		
Other		105,266		35,089							719,316		

TABLE RV-19

Number of Recreation Users from Region 11

Using Recreational Facilities in Other Planning Regions

in 1990

(Activity Days)

Activity	State Planning Region: 1	2	3	4	5	6	7	8	9	10	11	12	13
Hiking										589,249	4,206,016	406,378	81,275
Horseback Riding											386,060		
Bicycling											7,619,591		
Motorcycling		40,637								121,914	1,117,540		
Driving for Fun		81,275	325,102	365,741						589,249	1,767,745	203,189	81,275
Four-Wheeling									81,275		447,014	40,638	
Mountain Climbing													
Swimming										121,914	2,133,485	81,085	
Picnicking		81,275								40,638	1,110,009	284,466	
Camping		142,231							81,275	406,378	568,929		
Boating										40,638	670,524		
Game Playing				40,638			81,277				2,539,864		
Tennis											365,740	60,957	
Golf											670,524		
Fishing										406,378	3,251,031	264,145	
Shooting/Hunting									81,275	81,275	812,758	40,638	
Skiing/Snowshoeing											467,336	20,319	
Snowmobiling											284,466		
Sledding/Tobogganning/Tubing											670,524		
Ice Skating											101,594		
Other		121,914		40,638							833,075		

TABLE RV-20

Number of Recreation Users from Region 12
in 1980
(Activity Days)

Activity	State Planning Region: 1	2	3	4	5	6	7	8	9	10	11	12	13
Hiking			117,520									4,275,887	
Horseback Riding												822,644	
Bicycling												3,114,292	367,252
Motorcycling												235,041	
Driving for Fun			73,449				88,140				29,381	249,731	249,731
Four-Wheeling												190,970	
Mountain Climbing			14,690							14,690			29,381
Swimming			58,760								29,381	793,263	
Picnicking												205,660	
Camping											117,521	205,661	29,381
Boating												367,251	
Game Playing												411,323	
Tennis												279,111	
Golf												73,451	
Fishing												631,672	29,381
Shooting/Hunting												146,900	
Skiing/Snowshoeing			58,760									5,229,116	73,451
Snowmobiling												249,731	
Sledding/Tobogganning/Tubing												323,181	
Ice Skating												661,053	
Other			73,451									161,591	

TABLE RV-21

Number of Recreation Users from Region 12

Using Recreational Facilities in Other Planning Regions
in 1985
(Activity Days)

Activity	State Planning Region: 1	2	3	4	5	6	7	8	9	10	11	12	13
Hiking			141,271									5,140,043	
Horseback Riding												988,900	
Bicycling												3,743,690	441,474
Motorcycling												282,543	
Driving for Fun			88,293				165,953				35,319	300,202	300,202
Four-Wheeling												229,565	
Mountain Climbing			17,659							17,659			35,319
Swimming			70,635								35,319	953,581	
Picnicking												247,224	
Camping											141,272	247,225	35,319
Boating												441,472	
Game Playing												494,451	
Tennis												335,519	
Golf												88,295	
Fishing												759,333	35,319
Shooting/Hunting												176,588	
Skiing/Snowshoeing			70,635									6,285,919	88,295
Snowmobiling												300,202	
Sledding/Tobogganning/Tubing												388,496	
Ice Skating												794,652	
Other			88,295									194,249	

TABLE RV-22

Number of Recreation Users from Region 12

Using Recreational Facilities in Other Planning Regions in 1990 (Activity Days)

Activity / State Planning Region:	1	2	3	4	5	6	7	8	9	10	11	12	13
Hiking			165,689									6,028,465	
Horseback Riding												1,159,825	
Bicycling												4,390,762	517,780
Motorcycling												331,379	
Driving for Fun			103,354				124,266				41,424	352,090	352,090
Four-Wheeling												269,244	
Mountain Climbing			20,711							20,711			41,424
Swimming			82,844								41,424	1,118,401	
Picnicking												289,955	
Camping											165,690	289,956	41,424
Boating												517,777	
Game Playing												579,914	
Tennis												393,511	
Golf												103,556	
Fishing												890,579	41,424
Shooting/Hunting												207,110	
Skiing/Snowshoeing			82,844									7,372,398	103,556
Snowmobiling												352,090	
Sledding/Tobogganing/Tubing												455,645	
Ice Skating												932,002	
Other			103,556									227,824	

Table RV-23 shows incremental recreation growth for each benchmark year (Impact projections minus projections for Future Environment Without the Proposals) in State Planning Regions 11 and 12. This quantification of impacts identifies region-wide incremental growth that results from increasing population due to coal development in Routt, Moffat, and Rio Blanco Counties; it assumes that recreation user composition is uniform throughout each region. This region-wide incremental growth can be anticipated largely within the study area boundaries by using the gravity model concept (discussed in the Regional Analysis, Chapter IV -- Future Social Environment Without the Proposed Action).

Impacts to recreational resources accrue at the same rate as population increases that result from the proposed action (Table RV-16). Impacts outlined in the Regional Analysis, Chapter IV -- Future Environment Without the Proposals, will be increased by the incremental amounts shown in Table RV-23; incremental impacts of the proposed action would create larger deficits of recreation resources already in scarce supply (see Regional Analysis, Chapter IV).

An absolute quantification of needs created by the proposed action must be compared to the future supply-demand situation to determine which activities would be in short supply. However available data do not permit a determination of the future recreation supply-demand picture by counties; this is because Chapter IV's analysis of future recreation demand without the proposals is based on population growth and user-origin data, specific only to State planning regions.

TABLE RV-23

Cumulative Recreation Impacts
(Increased Use Due to Population Growth in Study Area in Terms of Activity Days of Absolute Growth for Each Benchmark Year)

	State Planning Region 11			State Planning Region 12		
	1980	1985	1990	1980	1985	1990
Hiking	221,626	182,738	188,311	114,349	130,222	147,037
Horseback Riding	20,352	16,774	17,286	24,540	28,111	31,878
Bicycling	401,676	331,045	341,141	92,901	106,423	120,684
Motorcycling	58,913	48,554	50,035	7,012	8,033	9,110
Driving for Fun	93,190	76,803	79,185	7,449	9,932	11,319
Four-Wheeling	23,565	19,421	20,013	5,696	6,525	7,400
Mountain Climbing						
Swimming	112,469	92,692	95,518	23,663	27,107	30,739
Picnicking	53,271	41,931	42,363	6,135	7,028	7,970
Camping	29,992	24,718	22,472	6,135	7,028	7,970
Boating	35,348	29,132	30,020	10,955	12,549	14,230
Game Playing	133,892	110,349	113,714	12,270	14,056	15,940
Tennis	19,280	15,890	16,375	8,326	9,538	10,816
Golf	35,348	29,132	30,020	2,191	2,509	2,845
Fishing	171,382	141,246	145,554	18,843	21,586	24,479
Shooting/Hunting	42,845	35,311	36,388	4,382	5,019	5,691
Skiing/Snowshoeing	24,636	20,305	20,924	155,392	177,973	201,793
Snowmobiling	14,996	12,359	12,736	7,449	8,534	9,678
Sledding/Tobog-ganning	54,148	51,699	56,309	9,641	11,044	12,524
Ice Skating	5,356	4,413	4,547	19,720	22,590	25,617
Other	43,916	36,193	37,296	4,820	5,522	6,262
Totals	1,596,301	1,320,705	1,360,207	541,869	621,329	703,982

The next best approach is to compare regional increases in recreation use that will be caused only by the proposed action to the existing supply-demand picture of the county(s) causing the increase. The result is shown in Table RV-24, which quantifies the projected need for activities whose supply would be depleted if only the proposed action were to occur (i.e.: no normal population growth without the proposed action).

An amendment to the base data for Table RV-24 (contained in the 1976 Statewide Comprehensive Outdoor Recreation Plan), based on community planners' input, indicates existing resource needs for other activities as well. If these estimates are valid, then additional needs for these same recreation activities would also be created; however, these estimates are unquantifiable (see Chapter IV, Description of the Existing Environment, Recreation Supply-Demand Analysis).

The foregoing analysis considers only allocatable population increases. The unallocatable population increase (1,800 from 1985-1990) applies to the entire study region and is over and above the rates shown in Table RV-16; the increased demand stemming from the unallocatable population increase therefore cannot be compared to existing county recreation supplies. Table RV-25 shows the unallocatable increase in regional recreation demand due to anticipated popualtion growth over and above that shown in Table RV-24. A projected 1990 regional demand for 33 million tons of coal is based on the Project Independence Blueprint. However, only 26.22 million tons of 1990 production can be accounted for in specific industry plans; the remaining 6.78 million tons of coal production results from applying the acceptable acceleration rates found in the Project Independence Blueprint. This production would be expected to generate a regional population increase of 1,800 people from 1985-1990. Assuming a uniform distribution over the study

TABLE RV-24

Recreation Needs Resulting from Population
Growth due Only to the Proposed Action (Activity Days)

Activity	1980 Region 11	1980 Region 12	1985 Region 11	1985 Region 12	1990 Region 11	1990 Region 12
Bicycling	401,676	92,901	331,045	106,423	341,141	120,684
Swimming	-	23,663	-	27,107	-	30,739
Tennis	9,280	8,326	5,890	9,538	6,375	10,816
Golf	35,348	-	29,132	-	30,020	-
Shooting/Hunting	-	4,382	-	5,019	-	5,691
Ice Skating	5,356	17,720	4,413	20,590	4,547	23,617

This table is a comparison of Table RV-23, Cumulative Recreation Impacts, and Table RIV-30, Recreation Supply-Demand-Need Analysis. Increased demand for Region 11 was compared to the existing supply for Rio Blanco and Moffat Counties combined; demand for Region 12 was compared to Routt County's supply.

area, this would increase recreation demand in the three-county area by the following amounts in 1990:

TABLE RV-25

Unallocatable Three-County Increase in Recreation Demand
In Both State Planning Region 11 and 12.
(growth due to Project Independence Blueprint acceleration rates)

Activity	Activity Days
Hiking	69,512
Horseback Riding	10,500
Bicycling	81,574
Motorcycling	9,841
Driving for Fun	14,398
Four-Wheeling	4,865
Mountain Climbing	—
Swimming	22,087
Picnicking	9,509
Camping	5,834
Boating	8,071
Game Playing	21,190
Tennis	5,157
Golf	5,258
Fishing	28,130
Shooting/Hunting	6,927
Skiing/Snowshoeing	53,247
Snowmobiling	4,323
Sledding/Tobogganning	7,649
Ice Skating	7,020
Other	7,206

In reality the proposed action would also cause resource deficits in other activities, and those listed in Table RV-24 would be somewhat larger. These other resource deficits would happen because population growth without the proposed action would deplete the present surplus of recreation activities (see Table RIV-30). This cannot be absolutely quantified as mentioned above, but rates of increase in recreation demand without the proposed action can be compared to increases in demand with the proposed action for each State Planning Region in the study area:

Average Annual	Region 11			Region 12		
Rate of Increase:	1980	1985	1990	1980	1985	1990
Without Proposals(%)	3.39	3.16	3.80	2.46	2.33	2.26
With Proposals(%)	4.21	2.86	3.43	2.60	2.50	2.43

This comparison of rates at which recreation demand would increase illustrates the effect of impacts due to the proposed action relative to impacts expected to occur without the action.

Additional recreation use pressures would also result from increased non-resident use if a "destination" recreation area is built as a result of coal-related development, however this also is unquantifiable.

Resource deficits for bicycling, swimming, tennis, hunting-shooting, and ice skating would grow larger for Routt County. Similar resource deficits for bicycling, ice skating, golf, tennis, and sledding would increase in Moffat County. In Rio Blanco County the shortage of bicycling, ice skating, and tennis would continue to grow larger. In addition, resource deficits in Routt County for golf would be reached by 1980 even though a 15,000 activity-day supply was available in 1974.

Adverse impacts resulting from the proposed action cannot be viewed in terms of numbers of recreation trips foregone. Indeed population increases in the three-county study area would increase recreation-visitation (as outlined above), and it would also limit the capabilities of the recreation resource to sustain this use. Therefore, adverse recreation impacts can be measured in terms of visitation which would be directly proportional to population growth, and in terms of recreation satisfaction or achievement attainable which would be inversely proportional to population growth.

Implementation of the proposed action would add the following numbers of people to the study area: 10,756 by 1980, 9,437 by 1985, and another 11,587 by 1990 (Table RV-28).

Wildlife for hunting and viewing would be directly displaced by the increased urbanization of open space; more human activity in these areas would indirectly displace intolerant species from their habitats. Acreage disturbance would result in permanent and temporary annual losses of wildlife carrying capacity and subsequent recreation opportunities (temporary shown in parentheses): 200 (580) mule deer, 30 (275) elk, 20 antelope and 10 (30) sagegrouse by 1990 (Table RV-15).

The increased fishing pressure outlined above would reduce fisheries' present capability to attract and sustain fishing use. Using standard fishing success rates for cold and warm water fisheries, 3.9 and 2.2 fish/day respectively, the need for additional cold and warm water catchable fish can be determined (warm shown in parentheses): 677,334 (36,410) fish/year by 1980, 579,796 (31,165) additional fish by 1985 and 605,437 (32,545) additional fish by 1990 (DOW, The Strategy of Today For Wildlife Tomorrow, 1974).

These impacts to both hunting and fishing would be experienced by users who live throughout the State, as well as by non-resident sportmen; user-origin data in Chapter IV indicate the relative amount of use that comes from each State Planning Region as well as from other states.

Mining operations and attendant rights-of-way proposed in too close proximity to perennial streams would result in damage to downstream fishing capabilities if adequate erosion control measures are not implemented.

Cultural resources, collectable rocks, and fossils would be more rapidly depleted; this increase in use would be directly proportional to population increase rates. Surface disturbance would also result in cultural resource destruction, and a subsequent loss in their inherent capability to attract and sustain recreation use an an interpretive resource.

Capabilities of open-space lands to sustain a variety of dispersed recreation use would also be diminished where off-road-vehicle (ORV) use, or other intensive site use such as camping, removes vegetative cover or promotes soil erosion. These impacts can be expected with the increased recreational demand.

Increased sewage discharge rates would result from rapid population growth of the region's communities lying along the Yampa and White Rivers. This would result in a decrease in water quality adjacent to the Yampa's Little Snake and Maybell monitoring stations, perhaps to the point of becoming unsafe for body-contact sports. Recreational capabilities of the Yampa Canyon portion of Dinosaur National Monument would be subsequently limited; this segment's eligibility for inclusion in the National Wild and Scenic Rivers System might also be impaired. Section 2 of Public Law 90-542 (1968) states that Wild Rivers must be "unpolluted". Guidelines for evaluating Wild, Scenic, and Recreational Rivers were adopted by the Departments of Interior and Agriculture in 1970; using the Federal Water Pollution Control Administration's Water Quality Criteria, April 1, 1968, the guidelines state that "Wild River areas can be included in the national system only if they also meet the minimum criteria for primary contact recreation, except as these criteria might be exceeded by natural background conditions" (see Environmental Impacts of the Proposed Action Surface Water Resources).

Natural, primitive, and mood atmosphere values would also be impacted by increased people pressures, by the loss of open space associated with surface disturbance resulting in resource deterioration. Roads, railroads, underground mines, surface mine facilities, powerplants, and developments to accommodate the increased population will permanently remove the following amounts of open space: 3,510 acres by 1980, an additional 2,810 acres by 1985, and another 4,025 acres by 1990 (Table RV-12). The loss of open space caused by surface coal mines and electric transmission lines is of a semi-temporary nature because revegetation would return part of it to open-space conditions; acreage disturbed by these actions but not yet revegetated would equal 4,021 acres by 1980. The difference between disturbed and revegetated acres would grow to 6,383 by 1985, and to 6,667 by 1990. Because revegetation efforts will not completely return all disturbances to an open space condition, total acreage disturbance is also a valuable indicator of regional impacts: 9,385 acres by 1980, 23,415 acres by 1985, and 39,210 acres by 1990 (Table RV-12).

Greater numbers of recreation users resulting from population increases would impact all developed recreation areas and sites irrespective of subsequent surpluses or deficits. Greater use pressure would increase maintenance and overhead costs to maintain visitor safety and protect the recreation resource. National Forest campgrounds and picnic-grounds would experience heavier use, although residents of the study area constitute an unknown fraction of total National Forest visitation. Reliable use projections specific to the National Forest cannot be made. Similiar situations apply to impacts anticipated from visitation increases at Dinosaur National Monument, Browns Park National Wildlife Refuge, Colorado State recreation sites administered by the Divisions of Parks, Wildlife, and Highways, at municipal recreation areas, and at private and quasi-public areas. However increased use in these areas can be directly related to projected increases by kinds of activity, rather than by facility ownership; these projections are presented earlier in this section.

Beneficial recreational impacts would also result from the proposed action. Additional roads, trails, and barren slopes would increase disturbed land units' capability to attract and sustain off-road-vehicle (ORV) use, but inadequate or poor topsoil quality on reclaimed surface mines would limit ORV capabilities.

Increased rockhounding capabilities would also result on surface mine spoils; overburden removal would expose interesting rocks and collectible fossils (see also Chapter V, History and Archeology).

Greater capabilities for geologic and industrial interpretation are additional beneficial impacts. Existing public access viewpoints have potential for informing visitors of the physical and economic conditions conducive to coal mine development, as well as how the operation functions, where the coal is marketed, etc. This could be accomplished by erecting interpretive signs, by developing interpretive-educational brochures, and also by guided tours.

Successful reclamation efforts on all land disturbances may increase wildlife viewing opportunities; especially significant winter season big game viewing opportunities would occur adjacent to rights-of-way where snowfall is regularly removed.

Social Environment

Methodology for determining impacts of the proposed action on the social welfare of the study region is essentially the same as that outlined in the section dealing with the future social environment without the proposed action. The only difference is that data for direct employment at each of the proposed projects involving Federal action were added to the input base used to generate the base scenario population and employment projections. Representative direct employment data for each of the projects considered are shown in Table RV-26. Complete input data are presented in Appendix D.

<u>Demographic features</u>

The expected total population in the study region is presented in Table RV-27. These estimates represent the total population including that of the base scenario plus the incremental effects of all coal-related developments; this total is hereafter referred to as the cumulative scenario. Note that Table RV-27

TABLE RV-26

Representative Input Data
for Gravity-Employment Multiplier Model

	Construction/Permanent		
	1980	1985	1990
Energy Fuels Corp.	-/137	-/306	-/418
Colowyo Mine	-/244	-/244	-/244
W. R. Grace Railraod	-/29	-/29	-/29
Seneca 2-W Mine	-/44	-/44	-/44
Ruby Construction Mine	-/65	-/65	-/65
Woodward, Merchants Petroleum 1/	-/75	-/75	-/75
Paul Coupey	-/75	-/75	-/75
American Electric Power	-/210	-/275	-/275
Coal Fuels Corp.	-/290	-/290	-/290
Moon Lake Electric Association 2/	1,400/-	800/480	-/746
Other coal-related development	811/101	-/648	-/648

1/ Treated as one project due to proximity of properties. No implication of actual joint venture development is intended.

2/ Includes Midland Coal due to proximity of properties. No implication of actual joint venture development is intended.

"-" indicates zero.

TABLE RV-27

Cumulative Scenario Population Projection

	1980	1985	1990
Moffat County	15,182	15,124	17,675
Craig	13,721	13,036	15,375
Dinosaur	660	1,121	1,101
Rio Blanco County	14,974	20,370	21,882
Meeker	7,279	9,097	9,727
Rangely	5,551	8,762	9,191
Routt County	16,366	19,160	20,162
Hayden	2,939	3,346	3,429
Oak Creek	2,040	2,496	2,634
Steamboat Springs	9,013	10,602	10,992
Yampa	459	585	708
Other unallocatable growth 1/	--	--	1,800
Study Region Total	46,522	54,654	61,519
Increases Outside Study Region 2/	1,600	1,400	1,100

1/ Growth due to coal production in the study region where specific project sites could not be identified.

2/ Incremental growth in Garfield County, Colorado and Uintah County, Utah.

indicates some coal-related population growth in Garfield County, Colorado and Uintah County, Utah. Communities in these counties are within the maximum travel time to coal projects on the fringe of the study region; therefore portions of the direct employment at fringe-area projects were allocated to these counties through the mechanisms of the gravity-employment multiplier model. Because no reliable estimate of a base scenario population for these counties could be prepared, population impacts from coal development on these counties are shown only as increments; no total population for the two counties was estimated. Note also that an additional 1,800 people have been assigned to the study region in 1990, but not allocated to any specific communities. This portion of the total population growth is the population impact associated with the 6.78 million tons of 1990 annual projected coal production that could not be assigned to any specific project listed in Table RI-2.

Figure RV-16 is a graphic depiction of both the base scenario (expected population without the proposed action) and the cumulative scenario (expected population with the action) on an annual basis through 1990. The difference between the two curves represents that portion of population growth associated with the proposed action. Note the peak and decline in the 1978-1985 period. As noted previously, the peak in the base scenario is the result of temporary construction forces associated with oil shale development. The accentuation of this peak in the cumulative scenario represents the additional temporary construction employment associated with projected units three and four at Colorado Ute Electric Association's Yampa project and at Moon Lake Electric Association's projected power plant northeast of Rangely. Note also that neither population projection includes any temporary population that would be seeking winter recreation opportunities in the Steamboat Springs area.

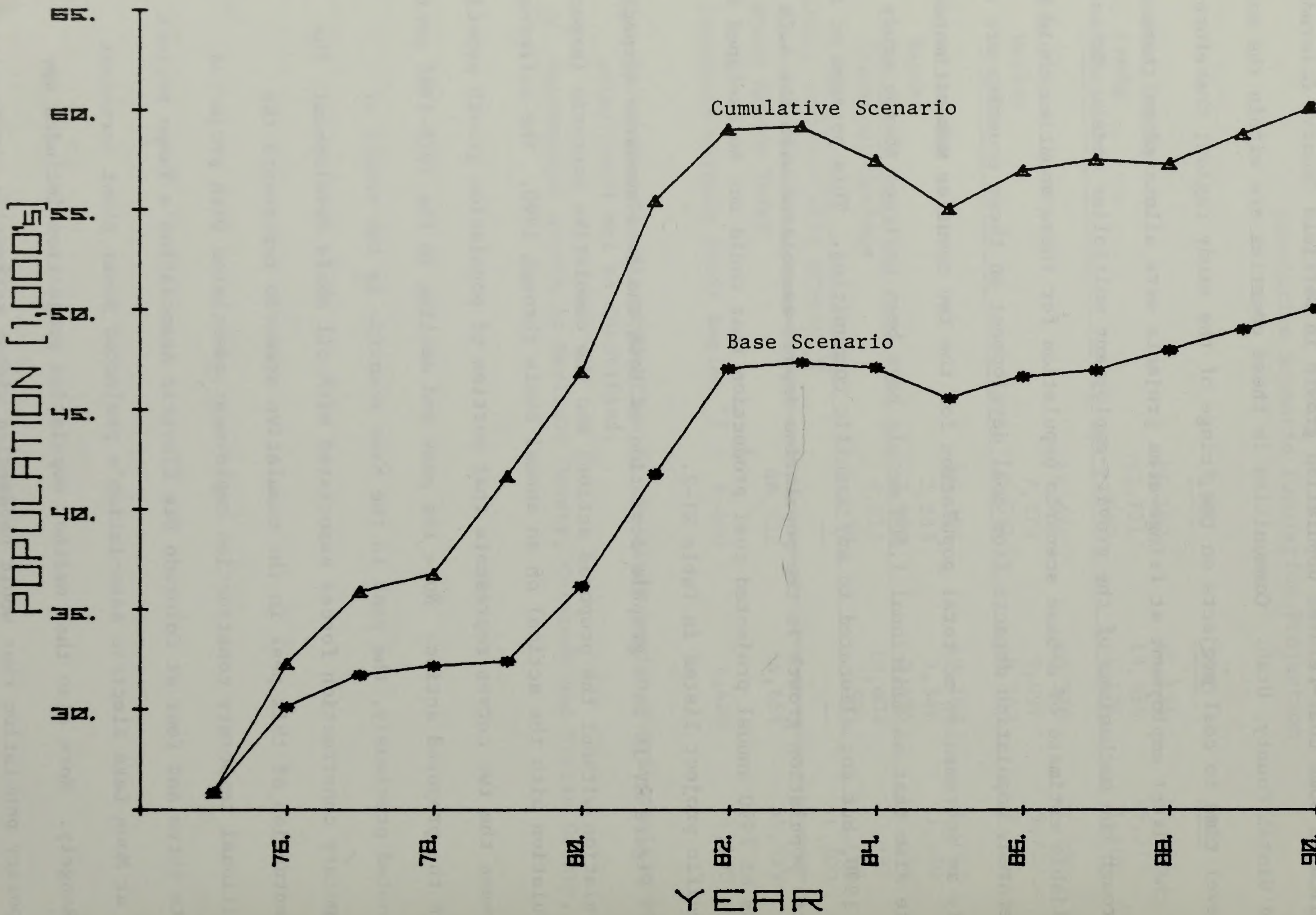

FIGURE RV-16

Base and cumulative population projections for the study region.

Historically, winter recreation facilities in this area have attracted close to 7,000 people during the peak holiday season.

The complete base and cumulative data set for each of the communities for each of the fiteeen projection years is presented in Appendix D.

Table RV-28 shows the population difference between the cumulative scenario and the base scenario. These data represent population impact of coal development resulting from proposed Federal actions. In each of the benchmark years Moffat county would draw the largest proportion of the total, followed by Rio Blanco, Routt, and growth outside the study region. The drop in population impact in Moffat, Rio Blanco, and Uintah counties between 1980 and 1985 is the result of the temporary nature of construction employment.

Social support facilities

It is expected that the population growth associated with the base scenario would place demands on existing social support facilities (Table RIV-36 through 38) that would exceed their current capacities and capabilities. Therefore the additional population growth that would result from the implementation of the proposed action would require additions to these facilities.

To assess these new demands, it was necessary to determine standards for these facilities that could be related to number of people requiring the services of social support facilities. These standards are presented in Table RV-29. Note that these standards reflect physical capacity requirements only; quality of the service cannot be described with these simple ratios. A high quality of service provided by all social support facilities is nevertheless required; this is especially true in water and sewage treatment where quality of effluents must meet increasingly stringent standards (see Chapter IV, Surface Water Quality). In the design of sewage treatment plants, flow requirements

TABLE RV-28

Difference in Cumulative Scenario from Base Scenario

	1980	1985	1990
Moffat County	5,028	3,890	4,128
Craig	4,776	3,716	4,002
Dinosaur	252	174	126
Rio Blanco County	3,803	3,392	3,471
Meeker	1,607	2,468	2,374
Rangely	2,195	924	1,097
Routt County	1,874	2,155	2,458
Hayden	727	826	896
Oak Creek	172	272	348
Steamboat Springs	924	971	1,107
Yampa	51	87	108
Other unallocatable growth	--	--	1,800
Study Region Total	10,759	9,437	11,857
Increases outside study region	1,600	1,400	1,100

TABLE RV-29

Standards for Social Support Facilities

Facility	Standard
Housing (1)	One dwelling unit/family unit
Medical and allied health care (2)	One doctor/1,000 county population 245 hospital beds/1,000 county population. 14 hospital professional and non-health staff, excluding physicians, per 1,000 population. 1.2 non-hospital nurses per 1,000 population. .47 dentists per 1,000 population. 1 optometrist per 10,000 population increase. 7 beds per 1,000 population for long-term health care.
Education (3)	One teacher and classroom/25 school age (5-17) people in county. 60 sq.ft./pupil including both classroom and cafeteria, gymnasium, library and other support space.
Water treatment (4)	450 gallons/day/person (applied to communities only)
Sewage treatment (5)	360 gallons/day/person (applied to communities only)
Fire protection (6)	$G = 1,020 \sqrt{P} (1-0.1 \sqrt{P})$ where G - gallons per minute pumping capacity P = county population in thousands
Law enforcement (7)	Two officers/1,000 county population One vehicle/three officers

SOURCE: (1) Professional judgement
(2) Doctors: VTN Colorado, Socioeconomic and Environmental Land Use Survey, 1975, p. A-90.
Hospital Beds: Colorado Dept. of Health, Colorado State Plan for Construction for Hospitals and Health Facilities, 1975, p. A-57.

TABLE RV-29

(Continued)

Staff, non-hospital nurses, and optometrists: Ratio of 1970 national employment in these fields to national population from Tables 1 and 116, 1974 Statistical Abstract of the U.S., U. S. Dept. of Commerce, Bureau of the Census.

Dentists: Table 107, 1974 Statistical Abstract.

Long-term health care beds: Ratio of 1973 Colorado beds to 1973 Colorado population, Tables 11 and 126, 1974 Statistical Abstract.

(3) Teacher and classrooms: VTN Colorado, op. cit., p. A-88-a.

Space requirements: Dr. Cal Anderson, Colorado Department of Education.

(4) Colorado Department of Natural Resources, Office of the State Water Engineer. This standard represents peak daily use and therefore can be used for capacity of new treatment plants.

(5) 80 percent of water treatment standard

(6) Joseph de Chiava, Lee Kippelman, Planning Design Criteria, 1969, p. 10-11.

(7) VTN Colorado, op. cit., p. A-85.

only give the scale of the plant; the required quality of effluents determines the nature of the various components of the plant. Therefore the application of the ratio standards for social support facilities must be viewed as only an initial assessment of new requirements. Additional planning and design efforts would be necessary to determine the precise nature of new facilities.

Note also that the water and sewage treatment standards are based on an average for the State. Individual communities within the study region have experienced peak loads two to three times the 450 gal/capita/day water treatment standard, and similar peak loads on sewage plants. Three factors account for these high peaks: flat rate billing systems for water which causes high lawn-watering use in the summer, bleeding of water lines during cold winter periods to keep these poorly insulated lines from freezing, and inadequate sewage collection systems which allow extensive infiltration of ground water to sewer pipes. Although these are recognized existing problems, for the purposes of assessment of future water and sewer needs it is assumed that new water taps will be metered, new water lines will be adequately insulated, and new sewer lines will be watertight.

Table RV-30 and 31 present the applications of the standards from Tables RV-29 to the counties and communities of the study region. The standards are applied to the largest annual difference between the base scenario population projection and the cumulative projection; in this fashion the tables show the maximum demands for social support facilities resulting from the proposed Federal action. These maximum differences were determined from the data set in Appendix D; for each county and community the year corresponding with the maximum difference is noted on Table RV-30 and 31.

TABLE RV-30

New Demands for Social Support Facilities by County
resulting from the Proposed Federal Action

	Moffat	Rio Blanco	Routt
Maximum Population Difference between Base and Cumulative Scenarios	5,217	6,947	2,458
Year of Maximum Difference	1979	1981	1990
New Housing Demands: 1/	1,840	2,420	790
New Medical and Allied Health Care Demands:			
Number of doctors	5	7	2
Number of hospital beds	13	17	6
Number of hospital professional and non-health staff	73	97	34
Number of non-hospital nurses	6	8	3
Number of dentists	2	3	1
Number of optometrists	1	1	--
Beds for long-term care facilities	37	49	17
New Education Demands:			
New school-age children	1,166	1,534	501
Number of classrooms and teachers	47	61	20
New space requirements (thousand sq. ft)	69.96	92.04	30.06
New Fire Protection Demands:			
Pumping capacity (gal/min)	2,300	2,600	1,600
new Law Enforcement Demands:			
Number of officers	10	11	5
Number of vehicles	3	4	2

1/ 70 percent of total new employment.

TABLE RV-31

New Demands for Social Support Facilities by Community resulting from the Proposed Federal Action

	Craig	Dinosaur	Meeker	Rangely	Hayden	Oak Creek	Steamboat Springs	Yampa
Maximum population difference between base and cumulative scenarios	5,098	368	3,180	3,767	896	348	1,107	108
Year of maximum difference	1979	1981	1981	1981	1990	1990	1990	1990
New water treatment demands treatment capacity (1,000/gal/day)	2,290	170	1,430	1,700	400	160	500	50
New sewage treatment demands treatment capacity (1,000/gal/day)	1,840	130	1,140	1,360	320	130	400	40

The impact to communities and counties in the study region is the cost of providing those new social support facilities that are public goods and services, including education, public health services, police and fire protection, water and sewer treatment, administration, and other items. While the preferred method for estimating the cost of these items is calculating capital and operating expenses for each item, data are sparse for itemized prices. Additionally, Tables RV-30 and 31, while highlighting physical needs for major expense items, do not show the entire universe of required goods and services. For example, public administration and road construction and maintenance needs could not be identified.

However, using per capita county and community expenditures published by the U.S. Bureau of the Census in the 1967 Census of Governments (Vol. 7, No. 6, Table 32), an estimate of the operating expenses of all locally administered public goods and services can be made. The 1966-67 weighted average per capita expenditure for these goods and services in the study region was $480.81, excluding interest on debt and capital outlays. Assuming that the 1966 to 1975 change in the implicit price deflator for State and local government's purchases of goods and services (1976 Economic Report of the President, Table B-3) reflects the change in prices of goods and services purchased by local governments in the study region, then the 1975 per capita operating expenditures were approximately $846.

Applying this figure to the maximum population difference between the base and cumulative scenarios shown in Table RV-30, the annual operating cost impact on local governments that would result from the implementation of the proposed actions would be: Moffat County, 4.4 million dollars; Rio Blanco County, 5.9 million dollars; and Routt County, 2.1 million dollars.

Note that this cost analysis assumes that 1975 prices will not change and that the 1966-67 mixture of expenditures for public goods and services in the study region will remain constant. Note further that the above costs do not include any capital outlays for the required facilities. These capital outlays would be significant. For example, assuming the cost of educational space is $40/sq. ft., the total capital expenditure for schools would be 7.7 million dollars.

<u>Community attitudes and life styles</u>

In response to concerns about regional population growth resulting from natural resource development in western Colorado, several opinion surveys have been conducted to assess the attitudes of current residents toward the impacts associated with this potential growth. Three of these surveys covered residents in the study region. The Meeker opinion survey, the Craig opinion survey, and the oil shale development survey indicated that people are generally aware that some growth would take place and that there would be both social costs and benefits associated with it.

The Meeker survey, conducted by the Rio Blanco County Planning Department, covered approximately one thousand community households and had 350 responses. The questionnaire, reproduced in Section XI of Appendix D, was mailed to the households and self-administered by the respondents. Because of misinterpretation of and no response to some questions, the results are not as reliable as those from the other two surveys. Although the results are not finally tabulated, some significant data are available on a preliminary basis. With respect to population growth: 18 percent of the respondents desired no further increase in the population of Meeker; 60 percent would like to see a population of 3,000-5,000; 18 percent wanted growth to the 6,000-10,000 level, and 5 percent thought a population greater than 10 thousand would be satisfactory. In view of the cumulative scenario projection--1990 Meeker population of approximately 9,700 (Table RV-27), it appears that more than three-quarters of the current Meeker population would be dissatisfied with the expected population growth. It is significant to note that the same portion of the population would be dissatified with the expected base scenario 1990 population of about 7,400 (Table RIV-51).

The Craig opinion survey, conducted by Social Change Systems, Inc. for the W. R. Grace Corporation, indicated similar attitudes toward community growth. The survey was conducted by Social Change Systems, Inc. for VTN's socioeconomic study of the effects of W. R. Grace and Company's proposed Colowyo mine development. The questionnaire, shown in Section XI of Appendix D, was administered by two interviewers, one a Craig resident, to every twentieth household drawn from the records of the Moffat County Assessor's office. Only 25 percent of the 87 respondents desired a community population greater than 10,000. The cumulative scenario projection indicates a 1990 Craig population of about 15,400; therefore three-quarters of the current residents would be dissatified with the expected population growth. The same portion would rather see a population less than the 11,400 level projected in the base scenario (Table RIV-51).

The Craig survey also solicited attitudes toward cyclical peaks and troughs in population growth. Of the 87 respondents, 80 percent would rather see steady growth rates. The cumulative scenario indicates rapid growth in Craig to 1980, a relatively stable level in 1985, and additional growth by 1990. Although the trend of the cumulative population scenario does not show a significant trough, the two distinct periods of growth are nevertheless cyclical in nature. This pattern would thus be unsatisfactory to 80 percent of the current residents.

The report Attitudes and Opinions Related to the Development of an Oil Shale Industry (Bickert, Brown, and Coddington and Associates, Inc., July 1973) was principally concerned with assessing the opinions of Mesa, Garfield, and Rio Blanco county residents toward oil shale development; however a portion of the survey provides information regarding the views of Meeker residents toward population growth in general. A 22-page questionnaire was administered by a team of professional market research interviewers to 592 randomly selected households, 192 of which were in Rio Blanco county. The average maximum desirable population indicated by Meeker respondents was about 3,500. Both the base and cumulative scenarios project that Meeker population would be substantially higher than this level in each of the benchmark years; therefore these projected levels of growth would be undesirable to a majority of Meeker residents.

The Craig survey investigated the benefits and costs of population growth. Benefits most often cited by respondents were increased employment opportunities, increased income, and a greater variety of shopping facilities. The most frequently identified costs were overcrowded schools, loss of small town atmosphere, and increased levels of criminal offenses. Forty-five percent of the respondents thought that the potential benefits would be greater than the costs; twenty-three percent thought the opposite was true; 19 percent thought benefits would equal costs; and 13 percent were unsure on the balancing of the two.

The Craig survey further analyzed cost and benefits by identifying the subgroups of the existing population that showed differing opinions toward growth.

> . . .people found to be more pro-growth tend to be those in positions to gain most, in economic terms, from growth. They are the merchants, business people, professionals (physicians, attorneys, etc.), land owners, and so on. Growth does usually bring more money into the community, and some people are more likely than others to receive a goodly share of that money. People in lower income categories (who tend to be younger, less educated, renters, in less prestigious jobs, etc.) seem to sense instinctively that the benefits of growth do not trickle down to them, that they do not share significantly in the community's increased wealth, and that, in many cases, they may hurt most by growth (e.g., the higher cost of living or higher taxes that many respondents cited).
> (Social Change Systems, Inc., 1974)

Because the existing unemployment rate in the study region is low (Table RIV-39), it is expected that the vast majority of population increase would involve people new to the study region. This influx of new residents would bring about changes in existing lifestyles. Seventy percent of the respondents to the Craig survey thought that social conflicts would not be lessened and fifty-two percent thought that newcomers would experience adjustment problems, although 65 percent thought that the community would welcome these newcomers. The oil shale survey indicated that most residents would resent any drastic change in the overall casual lifestyle and friendliness as they are satisfied with their immediate surroundings and quality of life; additionally, the oil shale survey indicated that because of real or imagined social conflicts, newcomers could easily feel isolated and alienated from the established community, while long-time residents might feel that their values and way of life are threatened by the newcomers.

The population growth rate associated with the cumulative scenario would be almost 13 percent/year in the three-county study area between 1975 and 1980. Rio Blanco county would grow at almost twice that rate over the same period, while Moffat and Routt counties would exhibit somewhat lower rates, 11 and 8 percent respectively. Without proper planning serious adverse impacts on lifestyles could be expected; these have already been experienced in Sweetwater County, Wyoming (Gilmore and Duff 1974). That area experienced a 19 percent growth rate between 1970 and 1974; as a result of this boom the mental health clinic caseload increased ninefold while the population was only doubling. Crime rates increased in a one year period by 60 percent, three times the population growth rate. Housing shortages resulted in home prices and rents that were beyond the reach of many people, and many new residents located in trailer and tent cities on the unincorporated fringes of existing communities. Demands on social support facilities, such as health care, education, and water and sewage treatment were beyond the capabilities of these facilities, leading to a general decline in the quality of life in the area. Without substantial planning efforts, these same social afflictions would adversely impact the study area.

Economic Conditions

Tables RV-32 and RV-33 present sectoral employment and earnings, respectively. Employment estimates were generaged by the gravity-employment multiplier model, utilizing the input data from Tables RIV-50 and RV-26, with the exception of the mining sector. Earnings data were calculated by multiplying the projected national sectoral earnings/employee (U.S. Department of Commerce 1974) times the appropriate sectoral employment levels. Earnings in the mining sector

TABLE RV-32

Cumulative Scenario Regional Employment

	1980	1985	1990
Agriculture	911	867	824
Mining	2886	5888	7061
Contract Construction	4789	2906	2350
Manufacturing	385	465	561
Transportation, Communications, and Utilities	1435	1729	2014
Wholesale and Retail Trade	3241	3782	4433
Finance, Insurance and Real Estate	445	518	579
All Other Private Services	6509	7910	8398
Public Administration	901	1076	1265
Total Employment	21502	25141	27485

TABLE RV-33

Cumulative Scenario Regional Earnings

(Thousands of 1974 constant dollars)

	1980	1985	1990
Agriculture	10,923	11,765	12,681
Mining	56,649	136,252	182,605
Contract Construction	63,167	43,241	39,574
Manufacturing	5,429	7,384	10,048
Transportation, Communications, and Utilities	19,573	26,454	34,540
Wholesale and Retail Trade	31,729	41,110	53,551
Finance, Insurance and Real Estate	5,843	7,641	9,623
All Other Private Services	50,054	69,924	85,324
Public Administration	13,740	18,507	24,566
Total Earnings	257,107	362,278	452,512
Total Personal Income (2)	329,097	463,716	583,740
Per Capita Personal Income (3)	7.021	8.431	9.711

(1) Based on projected national sectoral earnings per employee from U.S. Dept. of Commerce, Bureau of Economic Analysis, OBERS Projections, 1974.

(2) Based on the ratio of projected national personal income to national earnings from U.S. Dept. of Commerce, Bureau of Economic Analysis, OBERS Projections, 1974.

(3) Based on population estimtes from Table RV-27

are the sum of two calculations: one is the product of coal mining employment times the average earnings per employee, where this latter item is based on applicants' estimates; the second is the product of employment in non-coal mining operations times the appropriate national average from the work cited above.

Incremental economic impacts resulting from the proposed action are summarized for the study region in Table RV-34. These data represent the difference between the cumulative and base scenarios for employment, earnings, and per capita personal income. With the exception of agriculture, all sectors show increases in employment and earnings and are therefore beneficial impacts. In 1980 contract construction and mining sectors show the greatest increase over base scenario levels; this would be the result of direct employment associated with the proposed action. By 1985 construction employment and earnings would have declined, and mining would be the leading sector. Induced employment effects fall principally in the other private services sector. This same pattern would be continued in 1990, with mining and services being the dominant employing and income-producing sectors. Increases in total earnings resulting from the proposed action would also be reflected in increases in per capita personal income in each of the benchmark years.

The gravity-employment multiplier model assumes there would be no surplus or deficit in the labor force, i.e., all new jobs would be filled, and no unreasonabl unemployment rate would occur. To the extent that this assumption would not be fulfilled, some adverse economic impacts could be expected. In the deficit situation, output from the proposed mines and powerplants would not reach expected levels and the induced employment and earnings effects would be diminished. In the surplus situation, excessive financial requirements would be placed on government-financed unemployment and welfare services.

TABLE RV-34

Difference Between Cumulative and Base Scenario:
Employment, Earnings, and Per Capita Personal Income

	1980		1985		1990	
	Employment	Earnings (1)	Employment	Earnings (1)	Employment	Earnings (1)
Agriculture	---	---	---	---	---	---
Mining	1,143	25,580	2,151	53,797	2,469	69,225
Contract Construction	2,130	28,095	522	7,767	289	4,867
Manufacturing	16	227	15	238	16	287
Transportation, Communications and Utilities	186	2,538	211	3,228	218	3,739
Wholesale and Retail Trade	554	5,424	490	5,325	525	6,342
Finance, Insurance, and Real Estate	105	1,379	95	1,402	101	1,679
All Other Private Services	1,036	3,503	890	7,868	953	9,683
Public Administration	135	2,058	15	1,976	121	2,348
Totals	5,305	68,804	4,389	81,601	4,692	98,200
Per Capita Personal Income		.357		.547		.579

(1) Thousands of 1974 constant dollars.

There are other adverse economic impacts that are not easily quantifiable, but are nevertheless identifiable, based on experiences in other rapid-growth areas. Gilmore and Duff (1974) noted several adverse economic conditions in their analysis of the impacts of rapid population growth associated with natural resource development in Sweetwater County, Wyoming. In that area rapid increase in both employment and earnings caused substantial increases in the cost of living, as too many dollars sought too few goods and services; this had severe impact on people with fixed incomes. Disparity between high wage levels of mine and construction workers and lower pay scales for employees in more established sectors caused serious turnover and productivity problems in established sectors as workers shifted from lower to higher paying jobs. A shortage of skilled construction and mine employees brought an influx of inexperienced personnel, resulting in additional turnover and productivity problems. County and municipal governments had considerable difficulty financing new social support facilities because assessed valuations and mill levies did not increase as rapidly as the need for additional bonding capacity. In the study region Rio Blanco and Moffat Counties would be expected to grow at rates approaching the boom-growth rate in Sweetwater County; therefore the same adverse economic impacts could be expected.

Transportation Networks

Impact on transportation networks would be caused by: (1) increased mining of coal and expanding construction of utilization and transportation facilities, (2) transportation of coal out of the study area, and (3) increased employment and population with its attendant increase in vehicles and miles-travelled.

The actual impacts on transportation networks resulting from population increases would be primarily on highway commuting and airports. The Yampa Valley airport near Hayden, Colorado would probably receive the major airport impact from increased use.

Based on a 1974 population in Routt, Moffat, and Rio Blanco counties of 21,700 and a combined vehicle registration for 1974 of 26,892 in the three counties, population increase projections can be used to calculate increases in vehicle registration. Using the coal associated population increases shown in Table RV-28 and assuming the 1974 value of 1.24 vehicles per person will remain constant, the change in vehicle registrations would be 13.341 in 1980, 11,702 in 1985, and 14,703 in 1990. These data are over and above new vehicle registrations that would be associated with base scenario population increases. Increases in road maintenance and vehicle accidents are statistically predictable from any significant increase in traffic volume. The Colorado State Highway Department estimates the substantial improvement and upgrading of all State highway segments in this area would be required to accommodate increases in coal traffic and non-commercial traffic. This upgrading and improvement would create minor environmental impacts on soils, vegetation, and wildlife. Present accident rates for rural, non-interstate, non-controlled access highways is 2.66 per million vehicle-miles travelled. The State Highway Department predicts that even if traffic flow doubles or triples the rate would not change, but absolute numbers of accidents would increase as the number of miles travelled increases.

At this time, no rerouting of any State highways is planned to accommodate mining activities. Some mining activity of the W. R. Grace mine near Axial would be near Colorado State Highway 13, but a buffer zone was established between the mine and the highway to prevent any unfavorable interactions. A limited number of minor graded dirt roads and gravel roads lie within mining lease areas but they are generally lightly traveled and could be rerouted if necessary without much disturbance to traffic. The State Highway Department foresees no difficulty with these roads.

Heavy additions of loaded diesel coal truck traffic is a definite potential problem in this area. These highways are designed for light vehicle use, and although paved, would deteriorate rapidly if used for repeated heavy coal trucks of 25 to 30 net tons/load. Planned hauling over these roads is discussed in the site specific analyses.

Construction of the W. R. Grace coal-haul rail line as well as increased traffic over all the rail lines in the area would increase railroad-highway interactions. The W. R. Grace line would cross several unimproved and graded dirt roads, and lesser roads which are all generally lightly used for local access (e.g. to ranches). Grade crossings or detours would be provided during construction which would cause an inconvenience impact on the traveller. Impacts due to increased rail traffic on designated highways would be negligible inasmuch as the highways would be crossed by an overpass and the flow of vehicular traffic would not be impeded.

Although the crossings of numerous lesser roads would be by well-marked or (when necessary) improved grade crossings, train traffic to the extent of trains/day on the Denver and Rio Grande Western (D&RGW) branch line would restrict freedom of travel across the tracks. An increased potential for train-auto accidents would be likely.

The immediately foreseeable construction impacts associated with expansion of the transportation network would be those resulting from construction of the D&RGW RR spur to the Colowyo mine at Axial, improving some sections of Colorado State Highway 13 between Hamilton and Meeker, including strengthening at least three bridges, and upgrading Routt County Road 53 between the Energy Fuels mine sites and the Hayden power plant. This latter effort would primarily be one of widening and strengthening the roadbed by the addition of scoria. Construction of this spur and improvement of these roads should not adversely affect other transportation systems other than temporarily.

Impact from the transportation of coal, its derivatives and service supplies would be expected to manifest only on highways and railroads. The actual transportation of electricity by powerlines, coal by slurry pipeline, synthetic gas by pipeline, and water by aqueduct would not impact other systems. Shipment of service supplies by highway would increase traffic between Laramie-Casper-Sinclair, Wyoming, and Craig, Colorado, and between Steamboat Springs and Hayden and mine sites. Increased traffic would induce incremental road wear and higher maintenance costs. U. S. Highway 40 between Craig and Steamboat Springs is of high standard and appears able to withstand the increase in traffic with already planned modifications. Colorado State Highway 13 between Craig and Meeker would require considerable upgrading to accommodate increases in coal-haul traffic, and north of Craig to accommodate service supplies traffic.

The existing D&RGW branch line from Dotsero to Steamboat Springs to Craig is single line track in excellent condition, capable of handling the projected increases in coal hauling traffic. The centralized traffic control being installed by D&RGW is upgrading this line to main line capacity. Where this line crosses highways or roads, minor delays might be caused by increased frequency of train passage.

Chapter VI

Mitigating Measures

THE FOLLOWING CHAPTER DISCUSSES THE MEASURES THAT WOULD BE UTILIZED TO REDUCE OR ELIMINATE ADVERSE IMPACTS RESULTING FROM THE PROPOSED ACTIONS. EACH MITIGATING MEASURE IS PRESENTED AS IT RELATES TO A PARTICULAR RESOURCE OR ENVIRONMENTAL COMPONENT. BECAUSE SOME MEASURES REDUCE IMPACTS TO MORE THAN ONE RESOURCE, SOME REPETITION OF MITIGATIONS IS UNAVOIDABLE. ALL MEASURES ARE ASSESSED AS TO THEIR PROBABILITY OF IMPLEMENTATION AND/OR SUCCESS. MITIGATING MEASURES ARE PRESENTED AND ANALYZED AS PROCEDURES THAT WOULD BE REQUIRED IF THE PROPOSED ACTION IS APPROVED.

CHAPTER VI

MITIGATING MEASURES

Measures Required by Law or Regulation

The mitigating measures presented in this section will be implemented and enforced in order to reduce or eliminate specific impacts. The measures are necessarily general and are meant to apply in a broad sense to all of the site specific analyses. Wording in this section such as "should, could, may, etc." imply that when the final statement is developed, these measures will be characterized by the use of wording such as "will" and "would." Should the proposal be approved, the mandatory mitigating measures and/or procedures will be initiated and monitored.

Geologic and Geographic Setting - Paleontology

Protection for fossils receives legislative backing through the 1906 Antiquities Act. Fossils were specifically withdrawn from the provisions of locatable mineral law and designated saleable under 44 LD 325 (Land Decisions), 1915.

An early memoranda, January 19, 1959, from the Assistant Solicitor for National Parks held "that fossils were covered by the Antiquities Act." This opinion recited the long history of the Interior Department in interpreting the Antiquities Act to include fossils; "Long continued interpretation should be given great weight" (Associate Solicitor, Division of Public Lands, October 13, 1971).

On July 10, 1963, the Regional Solicitor at Salt Lake held "that fossils are covered by the Antiquities Act but such coverage extends only to such fossils which are of an actual and real, historic or scientific interest and/or are of some unusual significance" (Associate Solicitor, Division of Public Lands, October 13, 1971).

Significant fossils covered under the Antiquities Act can, however, be collected by a competent paleontologist having a valid antiquities permit. Federal antiquities permits are granted only by the Interior Consulting Archeologist in Washington D. C. for collecting on national resource lands; the Office of the Colorado State Archeologist grants State permits for collecting on lands owned by the State of Colorado.

Title 43 CFR 6010.2(a)(1) permits the collection of common invertebrate fossils. Section 6010.2(b)(2) prevents removal of "object of antiquity, historic, or scientific interest..." However, Section 6010.2(a) does allow for collection of common invertebrate fossils, rocks, and gem stones for personal use, consumption, or hobby collecting. Section 36 22.4 sets forth petrified wood collecting rules prohibiting excessive collecting and use of mechanical equipment, and also prohibiting commercial use of the wood.

Water Resources

Surface water quality and aquatic biology

The agency that has primary responsibility for water-pollution control in the study region is the Colorado Department of Health (McKee and Wolf 1963). The Department of Health (1974) published a booklet describing water quality standards for Colorado as defined in the Water Quality Control Act of 1973. The standards contained therein are intended to be consistent with the goals and policies of the Federal Water Pollution Control Act amendments of 1972. The basic water quality standards applicable to all State waters are (Colorado Department of Health 1974):

(1) All state waters shall be:

a. free from substances attributable to municipal, industrial or other discharges or agricultural practices, which will settle to form objectionable sludge deposits;

b. free from floating debris, scum, and other floating materials attributable to municipal, industrial, or other discharges or agricultural practices, which are present in amounts sufficient to be unsightly or deleterious;

c. free from materials attributable to municipal, industrial, or other discharges or agricultural practices, which produce color, odor, or other conditions in such a degree as to create a nuisance or impart any undesirable taste to fish flesh or in any way make fish inedible;

d. free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to human, animal, plant, or aquatic life;

e. free from substances and conditions or combinations thereof attributable to municipal, industrial, or other discharges or agricultural practices in concentrations which produce undesirable aquatic life;

f. free from residues attributable to wastewater or visible film oils or globules of grease, which are present in concentrations which cause a film or other discoloration of the surface, or which cause an emulsion to be deposited beneath the surface of the water or upon adjoining shorelines or which prevent classified uses of such waters.

(2) The radioactivity of surface waters shall be maintained at the lowest practical level and shall in no case, except when due to natural causes, exceed the latest Federal Drinking Water Standard as established by the United States Public Health Service, the Environmental Protection Agency or their successor.

(3) The Commission presently has not adopted a standard regarding salinity, but has reserved this section for such criteria. Since Colorado has been collecting and analyzing stream samples for a relatively short period of time, it is felt that insufficient data are available to set numerical standards at this time. In addition, technological know-how has not advanced to the point where all sources of salinity (irrigation return flows, for example) can be resolved. Therefore, Colorado proposes where possible to maintain salinity concentrations at or below present levels while gathering additional data so that meaningful numerical salinity standards can be established at some future date. In the meantime Colorado will continue to take action against known discharges contributing to the salinity problem where present technology allows for such control, continue with demonstration projects, such as the Grand Valley Project, and through whatever means available, strive to educate the irrigator in proper water management and irrigation practices.

With regard to the Colorado River system and its tributaries, the State of Colorado will cooperate with other Colorado River Basin states and the Federal Government to support and implement conclusions and recommendations adopted April 27, 1972, by the reconvened 7th Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and its tributaries.

The following rules became effective August 21, 1975. The rules were adopted by the Colorado Department of Health, Water Quality Control Commission.

REGULATIONS
FOR
EFFLUENT LIMITATIONS

100. AUTHORITY. The Water Quality Control Commission is directed by C.R.S. 25-8-205, as amended, to promulgate control regulations,

to describe prohibitions, standards, concentrations, and effluent limitations on the extent of specifically identified pollutants that any person may discharge into any specified class of state waters.

200. REGULATIONS.

(1) These effluent limitations for the discharge of wastewaters shall pertain to all wastewater discharges, except storm runoff waters and agricultural return flows, into any state waters. "State waters" means any and all surface or subsurface waters which are contained in or flow in or through this state, except waters in sewage systems, water in treatment works of disposal systems, water in potable water distribution systems, and all water withdrawn for use until use and treatment have been completed.

(2) No person (except as provided in subparagraph (3) below) shall discharge any wastewaters into any state waters if such wastewaters violate any of the specific limitations contained in paragraph 300 below, applicable to such wastewaters, unless the discharge is covered by a discharge permit containing a compliance schedule which will bring the discharge into compliance with the effluent limitations, according to a planned schedule.

(3) At such time as effluent limitation guidelines are promulgated by the Commission for an industry pursuant to Section 25-8-205(2)(d), C.R.S., as amended, such industry shall be subject to those guidelines and shall not be subject to effluent limitations set forth below in paragraph 300. If the Commission has not so promulgated effluent limitation guidelines for any particular industry but that industry is subject to effluent limitation guidelines promulgated by the United States Environmental Protection Agency pursuant to the Federal Water Pollution Control Act of 1972, an effluent from these industries shall be subject to the applicable EPA guidelines and shall not be subject to the effluent limitations of paragraph 300 below.

(4) The effluent limitations set forth below, or promulgated according to subparagraph (3) above, are also subject to being superseded or augmented when it is found that stricter limitations are required in order to maintain water quality or to bring a receiving water up to its prescribed water quality standards.

300. SPECIFIC LIMITATIONS FOR THE DISCHARGE OF WASTES.

PARAMETERS	PARAMETER LIMITATIONS 7-Day Average	PARAMETER LIMITATIONS 30-Day Average
BOD_5	45 mg/l*	30 mg/l*
Suspended Solids	45 mg/l*	30 mg/l*
Fecal Coliform	As determined by the Division of Administration of the State Health Department to protect public health in the stream classification to which the discharge is made	
Residual Chlorine	Less than 0.5 mg/l**	
pH	6.0 - 9.0**	
Oil and Grease	10 mg/l and there shall be no visible sheen**	

*Analyses of wastewater discharges for BOD_5 and suspended solids shall be based on the following:

(a) Samples: If samples are taken at the outfall of a final quiescent pond, with at least 48 hours detention, the sample may be a grab sample. In all other plants, samples shall be a composite sample, comprised of a minimum of four grab samples taken approximately two hours apart.

(b) 7-Day Average: The arithmetic mean of a minimum of three samples taken on separate days in a 7-day period.

(c) 30-Day Average: The arithmetic mean of a minimum of three or more samples collected in separate calendar weeks during a 30-consecutive-day period with a minimum of 20 days occurring between the first and last sample days.

(d) In addition to the above effluent limitations, the arithmetic mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 15 percent of the arithmetic mean of the values for influent samples collected at approximately the same time during the same period (85 percent removal).

(e) These numerical limits and sampling requirements have been set with the inherent variability of the analytical procedures taken into consideration.

**A single grab sample shall be used for residual chlorine, pH, and oil and grease.

400. TECHNICAL DATA.

(1) Analytical and sampling methods utilized by the discharger shall conform to those designated in one of the following references or equivalent methods approved by the Director, Water Quality Control Division, Colorado Department of Health.

(a) Standard Methods for the Examination of Water and Wastewater. Latest edition, American Public Health Association (New York, New York 10019).

(b) A.S.T.M. Standards, part 23, water: Atmospheric Analysis. American Society for Testing and Materials (Philadelphia, Pennsylvania 19103), 1970.

(c) Methods for Chemical Analysis of Water and Wastes. U.S. Environmental Protection Agency, Office of Technology Transfer (Washington, D.C. 20460), 1974.

The permittee must be able to show proof at the request of the Director, Water Quality Control Division, Colorado Department of Health, of the accuracy of any flow-measuring device used in obtaining data submitted in the monitoring report. The flow-measuring device must indicate values within ten percent of the actual flow being measured.

(2) In no case will wastewaters be held to be in compliance with any of the limitations set forth in paragraph 300, above, where those wastewaters are diluted with other waters, unless such compliance would exist without such dilution.

(3) For the purposes of enforcement of the effluent limitations for the discharge wastes set forth in paragraph 300, above, sampling of waste discharges shall be made prior to any admixture of waste discharges with receiving water. All new discharges,

constructed after the effective date of this regulation, shall be so designed or modified that a sample of the effluent can be obtained at a point after the final treatment process and before discharge to state waters. All existing discharges shall be similarly designed or modified by July 1, 1975.

(4) If wastewater is returned to the source from which it was obtained, the parameter limitations specified in paragraph 300, above, are in addition to the measured values of the same parameters in the incoming water.

(5) Any person discharging wastewater into any waters of the state shall have the option of establishing to the continuing satisfaction of the Commission, a BOD/COD (chemical oxygen demand), BOD/TOC (total organic carbon, BOD/TOD (total oxygen/ demand) relationship with respect to such effluent, and the COD, TOC, or TOD values so established shall govern that person's effluent under this limitation. The Commission has the same option.

REGULATIONS PROHIBITING THE OPERATION OF A SEWAGE TREATMENT WORKS FOR WHICH A SITE APPROVAL HAS NOT BEEN OBTAINED

100. AUTHORITY. Sections 25-8-202(2); 25-8-205; 25-8-207(1); 25-8-704, C.R.S., 1973.

200. DEFINITIONS.

(1) "Sewage treatment works" means a system or facility for neutralizing, stabilizing, or disposing of sewage, which system or facility has a designed capacity to receive more than 2,000 gallons of sewage per day. The term sewage treatment works includes appurtenances such as outfall and outlet sewers, pumping stations, interceptors, collection lines and related equipment.

300. REGULATIONS. No person shall operate a sewage treatment works which has been constructed or expanded in violation of 25-8-704, C.R.S., 1973 (quoted below), unless and until a site approval from the Water Quality Control Commission and any necessary discharge permits have been obtained and plans have been reviewed by the Commission.

25-8-704:

"(1) No person shall commence the construction or expansion of any sewage treatment work intended to serve more than twenty persons unless:

(a) Site location and the construction or expansion has been approved and designs therefor reviewed by the Commission; and

(b) A permit for the discharge therefrom has been issued pursuant to Section 25-8-501(6).

(2) In determining the suitability of a site location for any sewage treatment works, the Commission shall consider the long-range comprehensive planning for the area and the consolidation of sewage treatment works to avoid proliferation of small sewage treatment works."

REGULATIONS
PROHIBITING THE DISCHARGE OF CERTAIN WASTEWATERS TO STORM SEWERS AND PROHIBITING CERTAIN CONNECTIONS TO STORM SEWERS

100. AUTHORITY. Section 25-8-205, C.R.S., 1973.

200. REGULATIONS.

(1) No person shall discharge waste from industrial, commercial, or sanitary sources to a storm sewer unless a discharge permit has been obtained therefor.

(2) No person shall connect a waste drainage system for wastewater other than sotrm water runoff to a storm sewer.

(3) All such connections between industrial, commercial, or sanitary waste sewers and storm sewers which are not the subject of a discharge permit shall be disconnected on or before January 1, 1976, even though the connection is unused.

Air Quality

Impact on air quality as a result of the proposed Federal action is affected by the following laws, regulations and guidelines dealing with air pollution (see Appendix D):

1. National ambient air quality promulgated by EPA for suspended particulates, hydrocarbons, nitrogen oxides, sulfur dioxide, carbon monoxide, and oxidants (EPA 1971);

2. Ambient Air Standards for the State of Colorado, sulfur dioxide and suspended particulates. (Colorado 1970);
3. Regulation No. 1, Emission Control Regulations for Particulates, Smokes, and Sulfur Oxides for the State of Colorado, Section II.D. Fugitive Dust. (Colorado 1971);
4. Clean Air Act, 1970, Section 110, State Implementation Plans, Prevention of Significant Air Quality Deterioration. (EPA 1974b);
5. Clean Air Act, 1970, Section 110, State Implementation Plans, Air Quality Maintenance Areas and Plans (EPA 1973b).

Of these, the first three are existing regulations governing air quality and emissions; the last two are EPA requirements and guidelines that will probably lead to emission regulations in the next several years.

Under the State of Colorado Implementation Plan for achieving air quality standards, the State has enforcement responsibility for all five listed existing or future regulations.

The State Ambient Air Quality Standards are more restrictive than the Federal standards promulgated by EPA for suspended particulates and sulfur dioxide. These and the Federal standards for the other gaseous pollutants will apply to all areas in the region.

Emissions of particulate matter, as well as ambient air concentrations of suspended particulates, are controlled by Colorado law. Ambient air standards are not specific to a source, while emission standards apply directly to each individual emission point and may be different for each source. Enforcement of emission regulations is independent of ambient air pollutant concentrations and thus does not necessitate distinguishing between contributions of several sources. The fugitive dust regulations referenced above in Number 3 prohibit mining operations without a permit that specifies fugitive dust control measures. The following excerpt from page 1.19 of Regulation No. 1, Section 9, indicates some of the control measures that may be required.

9. List of Abatement and Preventive Measures.

b. Demolition, Wrecking and Explosive Detonation Activities; Earth and Construction Material Moving, Mining and Excavation Activities.

b-1 Abatement and preventive fugitive dust control measures shall be approved by the Division and may include, but shall not be limited to:

. wetting down, including pre-watering;
. landscaping and replanting with native vegetation;
. covering, shielding or enclosing the area;
. paving, temporary or permanent;
. treating, the use of dust palliatives and chemical stabilization;
. detouring;
. restriction of the speed of vehicles on sites;
. prevention of the deposit of dirt and mud on improved streets and roads and other such effective means of dust control as the Division may deem necessary;
. disturbing less topsoil and reclaiming as soon as possible.

b-2 Sequential blasting shall be employed whenever or wherever feasible to reduce the amounts of unconfined particulate matter.

b-3 Such dust control strategies as re-vegetation, delay of surface compaction and sealing, shall be applied.

b-4 Haulage equipment shall be washed or wetted down, treated, or covered when necessary to minimize the amount of dust emitted in transit and in loading.

The proposed action would constitute a new source of emissions of all the regulated air pollutants and would therefore be subject to analysis of significant deterioration of air quality (Number 4) and air quality maintenance planning (Number 5). At the present time, the significant deterioration regulations are under development by the State according to guidelines from EPA. The final regulations will place limitations on ambient air quality degradation in the area of the mine that may include limits more restrictive than the ambient air quality standards. The regulations will probably be written as specific emission limitations, based on expected impact on air quality. But since fugitive emissions are not easily measured, as exemplified by the Colorado fugitive dust regulation which does not refer to the quantity of dust, it is not clear what form the new regulations will take.

The purpose of air quality maintenance planning is to assure that ambient air quality standards once achieved are not exceeded at a later date due to new sources. Baseline air quality in the region is presently better than the Federal standards except for Steamboat Springs which is exceeding the annual total suspended particulate standard. The air quality maintenance plan now being developed by the State and EPA will address the impact of mines and any other new or expanding sources in the area. Significant deterioration regulations, if promulgated, will become part of the plan.

Soils and Terrestrial Flora

Regulations governing the prospecting for and leasing or contracting for coal that could reduce the impact of coal development on soils and terrestrial flora are found in Title 43, Code of Federal Regulations (CFR) 3041 and 30 CFR 211.

Subpart 3041 requires that a plan 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 the USGS. This part concentrates on insuring the orderly development of the publicly owned coal lands, accounting of coal produced, and rent and royalty payments. These regulations are now in the final stages of revision, and in addition to the above they cover surface protection requirements to the other resources and reclamation.

The Endangered Species Act of 1973 provides for the conservation to the extent possible of plant species facing extinction. The Smithsonian Institution has prepared a report (Report on Endangered and Threatened Plant Species of the United States, 1975) that identifies plants which it considers candidate endangered or threatened species. Should the Smithsonian list of endangered plants be formally adopted by the U.S. Fish and Wildlife, and any of these species be found on the areas preposed for mining, their protection would be provided for by the enforcement of this act. None of the species considered threatened or endangered for Colorado (Table RIV-0) have been located on any specific mining areas; however, the areas have not been examined in detail.

The Colorado Land Use Act of 1974 (House Bill 1041) provides for the protection of the utility, value, and future of all lands within the State, including the public domain as well as privately-owned land, in a matter of the public interest. Local governments have the duty to identify, designate, and administer such areas and activities of State interest and establish minimum criteria for the administration of such areas and activities. The control of surface disturbance on sites designated as mineral resource areas would be provided for in Part 2, Section 106-7-202 of this act:

TABLE RVI-0

Plant Species of Colorado Considered Endangered or Threatened by the Smithsonian Institute. 1/

Status	Family	Species
Endangered	Apiaceae	Neoparrya lithophila
Endangered	Asteraceae	Haplopappus femontii spp. monocephalus
Endangered	Asteraceae	Senecio porteri
Endangered	Boraginaceae	Cryptantha weberi
Endangered	Brassicaceae	Arabis oxylobula
Endangered	Brassicaceae	Draya humilis spp. ventosa
Endangered	Brassicaceae	Eutrems penlandii
Endangered	Brassicacae	Lesquerella pruinosa
Endangered	Cactaceae	Sclerocactus glaucus
Endangered	Caryophyllaceae	Stellaria irrigua
Endangered	Fabaceae	Astragalus deterior
Endangered	Fabaceae	Astragalus detritalis
Endangered	Fabaceae	Astragalus lutosus
Endangered	Fabaceae	Astragalus microcymbus
Endangered	Fabaceae	Astragalus naturitensis
Endangered	Fabaceae	Astragalus osterhoutii
Endangered	Fabaceae	Astragalus schmollae
Endangered	Fabaceae	Oxytropis obnapiformis
Endangered	Fabaceae	Trifolium lemmonii
Endangered	Hydrophyllaceae	Phacelia formosula
Endangered	Onagraceae	Gaura neomexicana spp. coloradensis
Endangered	Polygonaceae	Eriogonum ephedroides
Endangered	Ranunculaceae	Aquilegia micrantha var. mancusana
Threatened	Boraginaceae	Cryptantha elata
Threatened	Boraginaceae	Crypthantha stricta
Threatened	Boraginaceae	Mertensia viridis var. cana
Threatened	Brassicaceae	Arabis gunnisoniana
Threatened	Brassicaceae	Draba exunguiculata
Threatened	Brassicaceae	Parrya nudicaulis
Threatened	Brassicaceae	Rorippa coloradensis
Threatened	Cactaceae	Sclerocactus mesae-verdae
Threatened	Cyperaceae	Carex microptera var. crassinervia
Threatened	Fabaceae	Astragalus wetherillii
Threatened	Fumariaceae	Corydalis caseana spp. caseana
Threatened	Poaceae	Phippsia algida
Threatened	Polygonaceae	Eriogonum brandegei
Threatened	Polygonaceae	Eriogonum saurinum
Threatened	Polygonaceae	Eriogonum viridulum
Threatened	Ranunculaceae	Aquilegia chrysantha var. ryobergii
Threatened	Saxifragaceae	Sullivantia purpusii

1/ Report on Endangered or Threatened Plant Species of the United States, 1975.

(1)(c) The extraction and exploration of minerals from any area shall be accomplished in a manner which causes the least practicable environmental disturbance, and surface areas disturbed thereby shall be reclaimed...

Emissions of particulate matter, as well as ambient air concentrations of suspended particulates are controlled by Colorado law. The following excerpt from page 1.19 of Regulation No. 1, Emission Control Regulations for Particulates, Smokes, and Sulfur Oxides for the State of Colorado, Section 9, indicates some of the control measures that may be required.

9. List of Abatement and Preventive Measures.

b. Demolition, Wrecking and Explosive Detonation Activities; Earth and Construction Material Moving, Mining and Excavation Activities.

b-1 Abatement and preventive fugitive dust control measures shall be approved by the Division and may include, but shall not be limited to:

- wetting down, including pre-watering;
- landscaping and replanting with native vegetation;
- covering, shielding or enclosing the area;
- paving, temporary or permanent;
- treating, the use of dust palliatives and chemical stabilization;
- detouring;
- restriction of the speed of vehicles on sites;
- prevention of the deposit of dirt and mud on improved streets and roads and other such effective means of dust control as the Division may deem necessary;
- disturbing less topsoil and reclaiming as soon as possible.

The requirement and enforcement of these measures would minimize the impact of fugitive dust on soils and vegetation.

A summary of the requirements of the Colorado Open Mining Land Reclamation act follows: (The Rules and Regulations of the Land Reclamation Board are in Appendix D).

The Colorado Open Mining Land Reclamation Act of 1973 (Colorado Revised Statutes, 1973 Supplement) amended the Colorado Open Cut Reclamation Act of 1969. Minerals regulated by this act include ". . .natural deposits of limestone used for construction purposes, coal, sand, gravel, and quarry aggregates. . ." (§ 92-13-2(2)).

The State policy is ". . .for the reclamation of land subjected to surface disturbance by open mining and thereby conserve natural resources, aid in the protection of wildlife and aquatic resources and establish recreational, home and industrial sites to protect and perpetuate the taxable value of property. . ." to be provided for both during and after mining operation (§ 92-13-2).

A Land Reclamation Board was created as part of the Division of Mines in the Department of Natural Resources (§ 92-13-14(1)). The Board consists of five members, including the director of the Department of Natural Resources, the Executive Commissioner of Mines, the chief inspector of Coal Mines, the State Geologist, and a member of the State Soil Conservation Board (§ 92-13-14(2)). The Board as part of the Department of Natural Resources has the duty of administering this Act (§ 92-13-11), and also of adopting and promulgating rules and regulations regarding this Act (§ 92-13-12). The Board is also to continually review open mining and reclamation problems in the State, develop standards for reclamation plans and administer a land reclamation fund (§ 92-13-15), and initiate studies and programs concerning surface mining and reclamation (§ 92-13-16).

Permits are required from the Land Reclamation Board for open mining operations. A permit is good through June 30 of the fifth year of operations. An application for a permit is required to be filed with the board and must include details of the operation, maps, present condition of the land, etc. (§ 92-13-5). A fee of $50 plus $15 for each acre or fraction of acre that will be affected by the operation is required (§ 92-13-5(4)). A bond is also required and is discussed in the following paragraph. Any changes in the open mining operation or permit renewal must be approved by the Board in an application filed by the operator as an amendment to the original application. Accompanying this new application will be a fee of $10, plus $15 for each acre as well as a supplemental bond (§ 92-13-5(6)).

A bond is required by the Board to insure the performance of the operator under this law. The amount of the bond is determined by the Land Reclamation Board. In certain cases, proof of other properly reclaimed areas by the operator may substitute for the bond (§ 92-13-8).

The Reclamation requirements of this law are summarized as follows:

> "Reclamation" means the employment during and after an open mining operation of procedures reasonably designed to minimize as much as practicable the disruption from the open mining operation and to provide for the rehabilitation of any such surface resources adversely affected by such open mining operations through the rehabilitation of plant cover, soil stability, water resources and other measures appropriate to the subsequent beneficial use of such mined and reclaimed lands (§ 92-13-2(12)).

Reclamation of the mined area must be completed prior to the expiration of three years after the date on which the operator begins his reclamation work, except for those areas of affected land still being utilized in the operation. In special cases where chemical and physical characteristics of the surface serve to inhibit plant growth and cannot be feasibly remedied, a 10 year period is allowed for natural factors to act upon the site to improve its characteristics for plant growth. If during or after the 10 year period the Board decides it is still unplantable, the Board may discharge the obligations of the operator, if the operator reclaims an equal number of acres of land previously mined by the operator, not otherwise subject to reclamation under this law (§ 92-13-6(1)(n)).

The permit application must include details of the operation (§ 92-13-5(2)) and a detailed map of the area (§ 92-13-5(3)). Every July 1st the operator is required to submit a reclamation plan and map showing the details of the affected area and the reclamation accomplished (§ 92-13-6(1)(b)).

The operator, subject to Board approval, is required to determine reclaimed land uses of affected areas, including such uses as "forest, range, crop, horticultural homesite, recreational, industrial or other uses, including food, shelter and ground cover for wildlife." The Board is required to confer with local county commissioners and soil conservationists regarding suitable reclamation (§ 92-13-6(1)(g)). If the operator, on approval, decides to plant trees, he may select the species to be planted but is required to plant approximately 435 trees per acre (§ 92-13-7(1)(h)). The operator is required to keep up fire lanes and access roads for planting supervision and inspection (§ 92-13-7-1)(i)). The operator may also permit public use of the area for recreational purposes (§ 92-13-7(1)(j)). If the operator decides to reclaim the area for rangeland uses, he is required to strike peaks and ridges to widths of not less than 15 feet before seeding. He is required to restore slopes to a degree suitable for the proposed use by livestock. Seeding will be conducted in a proper technical manner and no grazing shall be permitted until the planting is firmly established (§ 92-13-7(1)(k)). If the operator chooses to reclaim the area for agricultural or horticultural crops, proper grading and site preparation will be required (§ 92-13-6-(1)(1)). Minimum basic requirements will be agreed upon by the operator and the board if the area is to be reclaimed for other land uses (§ 92-13-691)(m).

Where practical, the operator is required to construct dams in final cuts to impound water, if those impoundments will not interfere with mining operations or damage adjoining property (§ 92-13-6(L)(d)). Exposed acid-forming materials must be covered to a depth adequate to protect the drainage system (§ 92-13-6(1)(e)). Water from the mining operation must be diverted to control siltation, erosion, or other damage to streams and natural water courses (§ 92-13-6(1)(f)).

Ridges are required to be of a width not less than 15 feet. "In all cases an even or gently undulating skyline will be a major objective" (§ 92-13-6(1)(c)). Other grading and backfilling requirements depend upon the land use of the affected areas.

Refuse must be disposed of to prevent ". . .stream pollution, unsightliness, or deleterious affects. . ." (§ 92-13-6(1)(f)).

This law is enforced as follows:

If the Land Reclamation Board determines an operator has failed to comply with the law and all endeavors to remedy the violation have failed, the Board may bring formal charges and require the operator to appear at a hearing. Witnesses may be called to present testimony at such a hearing. After the hearing, as appropriate, the Board will submit such order be reviewed in the courts (§ 92-13-9). If the operator fails to comply with the Board's order and further action is not stayed by further court review, then the operator may be required to forfeit his bond. After the notice of such forfeiture, the operator has the right to appear before the Board within 30 days. After that hearing, the Board may withdraw the notice of violation or continue to institute proceedings (§ 92-13-13(1)). Any person indulging in open mining without first securing a permit as required by this law is guilty of a misdemeanor and subject to a fine of not less than $50 nor more than $1,000 for each day of the violation (§ 92-13-13(2)).

Regarding the extraction of sand, gravel, and quarry aggregates, the operator is required to complete such extraction and commence reclamation within five years after the issuance of the initial permit. Reclamation is required to be completed within three years after the commencement of reclamation work (§ 92-13-5(5)(d)).

Terrestrial Fauna

To comply with the Endangered Species Act of 1973, any action that alters existing habitat would require in-depth research to insure that no endangered species are harassed in any way (see Appendix D for species list). Endangered species using an area would have to be identified and the purpose of their use of the area determined. Full compliance with the intentions of this act would help mitigate potential impacts to endangered species.

The Fish and Wildlife Coordination Act of 1958, states that whenever waters of any stream or other body of water are "...controlled or modified for any purpose whatever...by any department or agency of the United States, adequate provisions...shall be made...for the conservation, maintenance and management of wildlife resources, thereof and its habitat, thereon..." This indicates that no permits or other forms of permission could be granted by any Federal agency unless potential impacts on aquatic related wildlife have been adequately mitigated.

In the Federal coal lease (Form 3130-1 October, 1967) Section 5, "The lessor agrees to take such reasonable steps as may be needed to prevent operations...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." Adherence to this lease stipulation wuld help mitigate impacts on wildlife and domestic faunal habitat and food sources.

"All abandoned shafts, drifts or portals are required to be sealed or caved in to prevent people, wildlife or domestic animals from entering an unsafe situation" (30 CFR 211).

In accordance with 30 CFR 211:16, all core holes would be filled with a mud or cement substance to mitigate loss or damage to wild or domestic animals.

Archeological Resources

Legislative backing for protection of archeological resources comes from a variety of legislation. The following excerpts are from existing Federal and State antiquities legislative enactments:

The Federal Antiquities Act of June 8, 1906 (P.L. 59-209; 34 Stat. 225)

That any person who shall appropriate, excavate, injure or destroy any historic or prehistoric ruin or monument, or any object of antiquity, situated on lands owned or controlled by the Government of the United States, without the permission of the Secretary of the Department of the Government having jurisdiction over the lands on which said antiquities are situated, shall upon conviction be fined in a sum of not more than five hundred dollars or be imprisoned for a period of not more than ninety days, or shall suffer both fine and imprisonment, in the discretion of the court.

That permits for the examination of ruins, the excavation of archaeological sites, and the gathering of objects of antiquity upon the lands under their prospective jurisdictions may be granted by the Secretaries of the Interior, Agriculture, and War to institutions which they may deem properly qualified to contact such examinations, excavations, or gathering, subject to such rules and regulations as they may prescribe; Provided, that the examinations, excavations, and gatherings are undertaken for the benefit of reputable museums, universities, colleges or other recognized scientific or educational institutions, with a view to increasing the knowledge of such objects, and that the gatherings shall be made for permanent preservation in public museums.

The Historic Sites Act of 1935 (P.L. 74-292; 49 Stat. 666)

...it is hereby declared that it is a national policy to preserve for public use historic sites, buildings and objects of national significance for the inspiration and benefit of the people of the United States.

Among the numerous duties assigned the Secretary of the Interior and delegated to the National Park Service by this Act are the following:

Make a survey of historic and archaeologic sites, buildings and objects for the purpose of determining which possesses exceptional value as commemorating or illustrating the history of the United States.

Restore, reconstruct, rehabilitate, preserve, and maintain historic or prehistoric sites, buildings, objects, and properties of national historical or archaeological significance and where deemed desirable establish and maintain museums in connection therewith.

The Historic Preservation Act of October 15, 1966 (P.L. 89-665, 80 Stat. 915

SEC. 101(a)(1). The Secretary of the Interior is authorized to expand and maintain a national register of districts, sites, buildings, structures, and objects significant in American history, architecture, archeology, and culture, hereinafter referred to as the National Register, and to grant funds to States for the purpose of preparing comprehensive statewide historic surveys and plans, in accordance with criteria established by the Secretary, for the preservation, acquisition, and development of such properties.

SEC. 106. The head of any Federal agency having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking in any State and the head of any Federal department or independent agency having authority to license any undertaking shall, prior to the approval of the expenditure of any Federal funds on the undertaking or prior to the issuance of any license, as the case may be, take into account the effect of the undertaking on any district, site, building, structure, or object that is included in the National Register. The head of any such Federal agency shall afford the Advisory Council on Historic Preservation established under title II of this Act a reasonable opportunity to comment with regard to such undertaking.

Executive Order 11593 -- Protection and Enhancement of the Cultural Environment, March 5, 1970 (36 F.R. 8921)

SEC. 1. Policy. The Federal Government shall provide leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation. Agencies of the executive branch of the Government (hereinafter referred to as "Federal agencies") shall (1) administer the cultural properties under their control in a spirit of stewardship and trusteeship for future generations, (2) initiate measures necessary to direct their policies, plans and programs in such a way that federally owned sites, structures, and objects of historical, architectural or archaeological significance are preserved, restored and maintained for the inspiration and benefit of the people, and (3), in consultation with the Advisory Council on Historic Preservation (16 U.S.C. 470i), institute procedures to assure that Federal plans and programs contribute to the preservation and enhancement of non-federally owned sites, structures and objects of historical, architectural or archaeological significance.

SEC. 2. Responsibilities of Federal agencies. Consonant with the provisions of the acts cited in the first paragraph of this order, the heads of Federal agencies shall:

(a) no later than July 1, 1973, with the advice of the Secretary of the Interior, and in cooperation with the liaison officer for historic preservation for the State or territory involved, locate, inventory, and nominate to the Secretary of the Interior all sites, buildings, districts, and objects under their jurisdiction or control that appear to qualify for listing on the National Register of Historic Places.

(b) exercise caution during the interim period until inventories and evaluations required by subsection (a) are completed to assure that any federally owned property that might qualify for nomination is not inadvertently transferred, sold, demolished or substantially altered. The agency head shall refer any questionable actions to the Secretary of the Interior for an opinion respecting the property's eligibility for inclusion on the National Register of Historic Places. The Secretary shall consult with the liaison officer for historic preservation for the State or territory involved in arriving at his opinion. Where, after a reasonable period in which to review and evaluate the property, the Secretary determines that the property is likely to meet the criteria prescribed for listing on the National Register of Historic Places, the Federal agency head shall reconsider the proposal in light of national environmental and preservation policy. Where, after such reconsideration, the Federal agency head proposes to transfer, sell, demolish or substantially alter the property he shall not act with respect to the property until the Advisory Council on Historic Preservation shall have been provided an opportunity to comment on the proposal.

(c) initiate measures to assure that where as a result of Federal action or assistance a property listed on the National Register of Historic Places is to be substantially altered or demolished, timely steps be taken to make or have made records, including measured drawings, photographs and maps, of the property, and that copy of such records then be deposited in the Library of Congress as part of the Historic American Buildings Survey or Historic American Engineering record for future use and reference. Agencies may call on the Department of the Interior for advice and technical assistance in the completion of the above records.

Colorado State Antiquities Act, 1973 (House Bill 1569)

Sec. 131-12-1. Title to historical, prehistorical, and archaeological resources. (1) The state of Colorado reserves to itself title to all historical, prehistorical, and archaeological resources in all lands, rivers, lakes, reservoirs, and other areas owned by the state or any of its political subdivisions. Historical, prehistorical, and archaeological resources shall include all deposits, structures, or objects which provide information pertaining to the historical or prehistorical culture of people within the boundaries of the state of Colorado, as well as fossils and other remains of animals, plants, insects, and other objects of natural history within such boundaries.

Sec. 131-12-6. Permits. (1) (a) The society shall issue or deny permits for the investigation, excavation, gathering, or removal from the natural state of any historical, prehistorical, and archaeological resources within the state and determine whether or not the applicants for such permits are duly qualified to conduct investigations in the field for which the permit is requested.

Sec. 131-12-8. Properties not owned by the state. Upon the request of any municipality, county, governmental agency, corporation, or private individual, the society may undertake the powers provided for in sections 131-12-5 to 131-12-7 with respect to historical, prehistorical, or archaeological resources on private or public lands, owned by the person so requesting, within the boundaries of Colorado. The state archaeologist may adopt rules and regulations governing the extent of responsibility he will assume and the conditions pertaining thereto.

The Colorado Land Use Act of 1974 (House Bill 1041)

The protection of the utility, value, and future of all lands within the state, including the public domain as well as privately owned land, is a matter of the public interest.

Local governments have the duty to identify, designate, and administer such areas and activities of state interest and establish minimum criteria for the administration of such areas and activities.

Historical or archaeological resources of regional or statewide importance means resources which have been officially included in the National Register of Historic Places designated by statue, or included in an established list of places compiled by the State Historical Society.

Areas containing, or having a significant impact upon historical, natural, or archaeological resources of regional or statewide importance shall be administered in a manner that will allow man to function in harmony with, rather than be destructive to these resources... Development in areas of historic, educational, archaeological or natural value shall be conducted in a manner which will minimize depletion of those resources for future use.

The Archeological and Historical Data Conservation Act of 1974, May 24, 1974 (P.L. 93-291)

Sec. 1. That it is the purpose of this Act to further the policy set forth in the Act entitled "An Act to provide for the preservation of historic American sites, buildings, objects, and antiquities of national significance, and for other purposes", approved August 21, 1935 (16 U.S.C. 461-467), by specifically providing for the preservation of historical and archeological data (including relics and specimens) which might otherwise be irreparably lost or destroyed as the result of (1) flooding, the building of access roads, the erection of workmen's communities, the relocation of railroads and highways, and other alterations of the terrain caused by the construction of a dam by any agency of the United States, or by any private person or corporation holding a licence issued by any such agency or (2) any alteration of the terrain caused as a result of any Federal construction project or Federally licenced project, activity or program.

Sec. 4. (a) The Secretary, upon notification, in writing by any Federal or State agency or appropriate historical or archeological authority that scientific, prehistorical, historical or archeological data is being or may be irrevocably lost or destroyed by any Federal or federally assisted or licensed project, activity, or program, shall, if he determines that such data is significant and is being or may be irrevocably lost or destroyed and after reasonable notice to the agency responsible for funding or licensing such project, activity, or program, conduct or cause to be conducted a survey and other investigation of the areas which are or may be affected and recover and preserve such data (including analysis and publication) which, in his opinion, are not being, but should be recovered and preserved in the public interest.

To clarify the application of Executive Order 11593 to privately-owned surface acreage that is underlain by Federal-owned minerals, the Assistant Solicitor for Parks and Recreation, U.S. Department of the Interior, issued an opinion on September 10, 1974. The opinion reads as follows:

This is in response to your request for our opinion concerning whether section 2(a) of Executive Order 11593 applies to reserved Federal mineral and coal lands administered by the Bureau of Land Management, where the surface is privately owned but the sub-surface resources are federally owned.

In our view, the inventory and nomination responsibilities of Executive Order 11593 would be applicable to these lands pursuant to section 1(3) of Executive Order 11593 and the procedures adopted by the Advisory Council on Historic Preservation thereto. We also agree that BLM would be required to comply with the provisions of section 106 of the National Historic Preservation Act of 1966, 16 U.S.C. section 470 et seq. (1970 ed.); and, additionally that BLM would have a NEPA responsibility to identify and consider the effects of its programs on cultural resources. In this regard, a copy of the Department's guidelines for the preparation of environmental impact statements with regard to cultural resources is enclosed.

In our opinion, the scope of section 2(a) of Executive Order 11593 can best be understood in light of the Secretary's decision, after the passage of the National Historic Preservation Act of 1966, to work through the various states to have them inventory and nominate non-federal holdings in order to expand the National Register of Historic Places. In our view, Executive Order 11593 was designed to primarily work within this framework. Accordingly, it is our opinion that the general inventory of land holdings for National Register nomination purposes where the surface is privately owned but the sub-surface resources are federally owned is initially a responsibility of the state within which the land is located. Indeed, the completion of these inventories would appear to be a necessary step in the development of a comprehensive statewide historic preservation plan required by the 1966 Act.

In addition, however, section 1(3) of the Executive Order has been implemented by the Advisory Council on Historic Preservation through consultation and adoption of procedures 39 Fed. Reg. 3366 (Jan. 25, 1974). These procedures provide in section 800.4(a) that "the Agency Official shall identify properties located within the area of the undertaking's potential environmental impact that are included in or eligible for inclusion in the National Register". Accordingly, while it is our view that there is no general inventory responsibility under section 2(a) of Executive Order 11593 applicable to the reserved Federal mineral and coal lands in issue, it is also our opinion that there is such a responsibility at the point that a proposed BLM undertaking may have a potential environmental impact on such lands.

Professional archeological surveys must be required prior to mine plan approval. This is substantiated by an opinion from the Regional Solicitor, Department of the Interior, April 16, 1974. That opinion follows:

In your memorandum of April 2, 1974, you ask, in substance, whether BLM can require a professional historical and archeological survey of the surface of lands to be strip mined by withholding approval of plans that do not provide for such surveys. Your question is based on the assumption that a lease has been issued without stipulations requiring such surveys.

To our knowledge the question of whether the Bureau of Land Management can, by the above-described procedure, require a coal lessee to make an intensive survey has not been previously decided by the Department or judicial proceedings. We are of the opinion that the Bureau of Land Management should take the position that professional surveys must be made a part of a mining plan. We believe that the Bureau's position should be the same whether the surface be in private or public ownership.

In order to comply with the provisions of Section 106 of the Historic Preservation Act, the necessary archeological survey must be at least an intensive survey; reconnaissance surveys are inadequate for assessment of cultural site potential on proposed action areas. A Federal antiquities permit is required for surveys of national resource lands (BLM) and a State antiquities permit is required for surveys of State lands. Federal permits are granted only by the Interior Consulting Archeologist in Washington, D. C.; the Office of the Colorado State Archeologist grants State permits.

Procedures required by Section 106 of the 1966 Act (36 CFR Part 800) require impacted areas must first be surveyed. After survey completion, BLM must determine in consultation with the Colorado State Historic Preservation Officer(SHPO), whether the proposed action will have an adverse effect upon either existing or eligible National Register properties; if so, then the Advisory Council on Historic Preservation must be given opportunity to comment through the SHPO. Also these procedures require that this statement must document whether an existing or eligible National

Register property will be affected by the proposed action; if so, then the statement must document the steps taken in compliance with Section 106 and a comprehensive discussion of the contemplated effects on the National Register property (Advisory Council on Historic Preservation, 1975).

Exaction of the aforementioned laws will mitigate losses to archeological resources by ensuring that they are located and evaluated prior to initiating any potentially damaging actions. It will also allow a determination of more suitable alternatives to prevent destruction of cultural resources.

However, for all practical purposes, not all archeological sites having surface evidence will be identified in the required survey. In addition, other sites may be buried by alluvium and hidden from view. The regulations themselves will also do little to curb theft and vandalism of archeological values due to increased visitor-use pressure.

Historical Resources

Historical resources receive the same degree of legal protection as archeological resources. All laws and required procedures contained in the foregoing section are also applicable herein.

Enforcement of these regulations would be very successful in mitigating impacts caused by surface-disturbing actions themselves, but they would do little to curb increasing vandalism and theft of historical features caused by increased population pressure.

Land Use

Impacts from changes in land use can be mitigated by enforcement and implementation of county zoning and subdivision regulations and various county ordinances. To restrict changes in land use to residential and other uses needed to accommodate population growth, county officials can exercise their powers to reject subdivision proposals and applications for building permits, etc. This tool can be implemented to keep expected growth dispersed throughout the rural, agricultural areas.

The Colorado Open Mining Land Reclamation Act of 1973 could mitigate impacts by insuring that disturbed areas are reclaimed and made suitable for certain uses after mining.

In addition, there are specific laws and regulations governing railroad rights-of-way that provide for certain mitigating measures. Section 1(18) of the Interstate Commerce Act requires prior approval from the Interstate Commerce Commission for extension or new construction of a line of railroad or abandonment of the operation of a line of railroad. The general right-of-way principles and procedures in Title 43, CFR 2800 sets forth certain terms and conditions that the applicant, by accepting a right-of-way, agrees and consents to comply with.

Aesthetics

Regulation No. 1, Emission Control Regulations for Particulates, Smokes, and Sulphur Oxides for the State of Colorado, Section II-D, Fugitive Dust, (Colorado, 1971) prohibits mining operations from occurring without a permit that specifies fugitive dust control measures. These measures can be implemented to reduce atmospheric haze that results from airborne pollutants and particulates.

The Colorado Department of Health's water quality standards (1974) provide regulations consistent with the provisions of the Federal Water Pollution Control Act amendments of 1972. All State waters are thereby required to be free from the aesthetically damaging effects of floating debris, scum, and discoloration.

Colorado's Open Mining Land Reclamation Act of 1973 directs the mine operator to assume several duties in Section 92-13-6 of the act. Part 1-c dictates that spoil pile peaks and ridges be graded to a width of not less than 15 feet and that a gently undulating skyline be maintained. This regulation would help mitigate the strong line and form-dominant minus deviations of surface mine spoils.

Part 1-f of the same section in the above act also directs refuse disposal in a manner that will control stream pollution and unsightliness. The mining operations themselves can hereby be constrained to maintain a litter-free environment by providing for an unobtrusive sanitary landfill and by maintaining an overall litter-free landscape.

Part 1-a, Section 92-13-6, of Colorado's Opening Mining Land Reclamation Act provides for consultation between the State Land Reclamation Board, the County Commissioners, and the local board of supervisors of the Soil Conservation District. This required consultation process provides opportunities for the reclamation board to learn of aesthetically sensitive areas and to take appropriate action to mitigate impacts to visual resources.

Impacts to mood-atmosphere values that will be caused by increased noise levels can be partially mitigated by implementing the provisions of Colorado Senate Bill 197 (1971) which establishes maximum permissible noise levels and abatement procedures. Federal noise pollution guidelines are outlined in P.L. 92-604, the Clean Air Act, Section 401 -- Noise Pollution and Abatement Act of 1970. The Office of Noise Abatement and Control, established by this Act, provides for enforcement of the guidelines contained in the Act. Enforcement of these laws will achieve the lowering of noise levels adjacent to coal mining operations.

The above legislative acts will be effective only to the extent that they are enforceable, that the standards set forth are enforced, and that these minimum standards are indeed effective in reducing impact. The probability of all of these actually being enforced, on the ground, is something less than 100 percent, as evidenced by impacts presently occurring from similar ongoing operations.

Recreation

Water Quality standards established by the Colorado Department of Health (1974) provide regulations that can be used to mitigate impacts to recreation resources. All State waters should be free of substances or conditions that are toxic to plant, animal or aquatic life, that produce undesirable aquatic life, and that import any undesirable taste to fish flesh, or make fish inedible. These regulations prohibit mine-caused damage to the recreational potential of downstream fisheries.

The Colorado Open Mining Land Reclamation Act of 1973 contains several provisions for mitigating recreation impacts. Section 92-13-6 describes the duties of mine operators. Part 1-f directs the disposal of refuse in a manner that will control stream pollution, siltation and other damage to streams and water courses. This regulation prohibits actions which would indirectly impact recreational fisheries potential.

Part 1-g of the same act directs the operator to determine the reclaimed use of the mine, and it provides for this determination in consultation with the local board of county commissioners as well as with the board of supervisors of the soil conservation district. This would provide input from other land-use decision makers who could determine and direct reclamation efforts to respond to the growing demand for recreational facilities.

The recreational value of archeological and historical resources will be protected by enforcement of the provisions of current Federal and State antiquities legislation. These include The Federal Antiquities Act (S. 4698, June 8, 1906) which makes it illegal to appropriate, excavate, injure or destroy any object of antiquity; this act also requires issuance of permits to qualified applicants for survey or excavation on Federal lands. The Historic Preservation Act (P.L. 89-665, October 15, 1966) established the National Register of Historic Places; it also requires a review of all Federal actions affecting existing National Register entries by the President's Advisory Council on Historic Preservation. Executive Order 11593 (May 13, 1971) expanded P.L. 89-665 to provide a review of any Federal action affecting properties eligible for inclusion in the National Register of Historic Places. Section 101(b)(4) of the National Environmental Policy Act of 1969 (P.L. 91190, January 1, 1970) directs the preservation of "important historic, cultural and natural aspects of our national heritage. . ." The Archeological and Historical Data Conservation Act of 1974 (P.L. 93-291, May 24, 1974) provides for the preservation of antiquities "which might otherwise be irreparably lost or destroyed as a result of any alteration of terrain caused as a result of any Federal construction project or federally licensed project, activity or program".

The Colorado Antiquities Act (H.B. 1569) reserves all antiquities on State-owned lands to the State of Colorado and prohibits the destruction, excavation or excavation thereof; permits are also required for qualified applicants to conduct surveys.

The degree to which these legislative enactments will be successful in mitigating impacts will be dependent upon their enforceability and actual on-the-ground enforcement. Based upon past observations of similar coal mining operations, enforcement of current laws has not been completely effective in mitigating applicable impacts.

Social Environment

Section 35 of the Mineral Leasing Act of 1920 provides that 37.5 percent of all rentals, royalties and bonuses from leased minerals including coal, be returned to the State in which the mineral was produced to be used for roads and schools. Based on coal production projections in the Proposed Action section (Figure RI-2), the present value, discounted at six percent, of the State's share of 15 years of rents and royalties from Federal coal is about 10 million dollars, assuming 17.5 cents/ton royalty, one dollar/acre rental, and 67 percent of production would be Federal coal. State enabling legislation for disbursement of the 37.5 percent share of rents, royalties, and bonuses limits disbursement to counties from which the revenues are derived to no more than $200,000 per year.

Of amounts disbursed to counties at least 25 percent must be spent on either roads or schools. Assuming that in each year through 1990 the State allocates the maximum allowable to each of the three counties in the study region, about eight million dollars could be disbursed (present value at six percent: 4.3 million dollars). These disbursements could help mitigate new demands for roads and schools, but would be insufficient to meet total capital and operating cost requirements of new social support facilities because of the 200 thousand dollar/county/year limitation.

Transportation Networks

All transportation nets involving railroads and highways used to transport coal on an interstate basis are regulated by the Interstate Commerce Commission (ICC). The ICC authority extends to regulation of rates, franchises, and issuance of miscellaneous permits but does not include provisions for maintenance of transportation facilities.

Safety provisions are regulated under CFR 49, parts 390-397, and hazardous materials are regulated under CFR 49, parts 100-199. Railroad safety is regulated under the Safety Act of 1970.

The Colorado Department of Highways maintains standards and specifications for construction of new highways and further regulates load size and configuration on those highways. Transportation systems and motor carrier safety are also regulated by Colorado Public Utilities Laws. Railroad safety is regulated by laws under the authority of the Public Utilities Commission, Chapter 115.

County governments regulate load specifications in relationship to weather and road conditions.

Other Measures

The mitigating measures presented in this section are measures that will be utilized in specific instances to reduce or eliminate specific impacts. These measures will be utilized and enforced as terms and conditions of leases, licenses, and permits. It is not meant to imply that every measure discussed in this section will be implemented and enforced in the case of every site specific proposal discussed in this report. Instead, measures will be utilized on a case by case basis to mitigate known impacts. Wording in this section such as "should, could, may, etc." imply that when the final statement is developed, these measures will be characterized by the use of wording such as "will" and "would." Should the proposal be approved, the mandatory mitigating measures and/or procedures will be initiated and monitored.

Geologic and Geographic Setting

Wherever proposed coal-related surface disturbances involve formations that are potentially vertebrate fossil-bearing (see Figure RIV-1a), the area should be examined for such evidence by a qualified vertebrate paleontologist prior to approval of the mine plan. Should any vertebrate fossil remains be found, either the mine plan should be modified or the fossils excavated prior to initiating any surface-disturbing activities.

Water Resources

Ground water

The water sources that are destroyed can readily be replaced by wells that extend below the disturbed material at the mine. At each of the mines the mined area is underlain by at least 1,000 feet of sandstone, shale, and coal of the Mesa Verde Group, and there will be no difficulty in obtaining a supply of water equivalent to that which is lost.

Hydrologic conditions are favorable for the development of flowing wells to replace the destroyed springs and flowing wells. In places where wells did not flow prior to mining, it may be possible to develop deeper wells that will flow.

The cost of replacing lost water sources would be borne by the mining company; however the replacement of old water sources or development of new water sources must be worked out on a site by site basis with the surface owner. The water supply for the reclaimed area should not be based solely on the localities of destroyed water sources, but on the needs for managing the reclaimed area; this development needs to be a part of the long term reclamation plan.

Surface water and aquatic biology

The potential increases in stream sedimentation resulting from implementation of the proposed actions would be mitigated by the employment of certain environmental safeguards on the part of the companies involved. All road cuts and fills should be revegetated as soon as possible after construction to minimize erosion. Extra care should be exerted by the companies to minimize the amount of surface disturbed for road cuts, as this is probably the greatest single source of sedimentation from strip mining areas. The encroachment of overburden materials and heavy equipment into streams on the mining property should be avoided. A minimum bugger zone (i.e., area in which all mining and mining related activity is prohibited) of at least 100 feet should be established on all perennial streams flowing through the proposed mining areas. Special caution should be exercised to minimize the possibility of accidental spills of toxic materials into perennial streams. The removal of materials from the beds of perennial streams for any purpose (e.g., fill material for construction of the proposed coal haul railroad) should be prohibited. All fill materials deposited into perennial stream beds in conjunction with road and railroad construction should be permanently stabilized with riprap to minimize erosion.

The implementation of the Environmental Protection Agency's <u>201-Regional Sewage Treatment Plant Study</u> would mitigate the impacts of increased water utilization by new population in the study region. However the time frame for EPA's program would not provide for the updating of the region's sewage treatment plants until 1977-78 when the studies are completed and funds allocated.

Adverse impacts to the surface water resource could be mitigated on a regional basis by the establishment of water quality-aquatic organism monitoring stations below disturbed areas throughout the study region. Complete water quality analyses, as well as comprehensive inventories of the benthic communities, should be conducted on a monthly basis, and sediment sampled on a daily basis at each of these stations. This monitoring would detect problems that could then be corrected. Such monitoring stations have been or are being established on the Yampa River and on most of the affected streams. These stations are or will be operated by the USGS.

Mitigation is neither necessary for the dissolved solid load in the study area nor recommended for the small downstream effects of pumping from the mine pits.

If the mitigating measures mentioned in the other sections are successful, then a corresponding decrease in sedimentation would occur as shown in Tables RVI-1, 2, and 3.

Mitigating measures would include revegetation for all activities, settling ponds, drainage ditches, water bars on roads, and hard surfacing of roads and streets. See Appendix D for computation methods for the following tables.

Air Quality

Fugitive dust from process operations should be controlled by watering at transfer points, such as conveyor ends or loading stations. The placement of hoods connected to a ventilation and dust collection system over sources such as crushers and sorters limits emissions from mechanical treatment of coal. General cleanliness and the prevention of spills help to reduce the amount of fugitive dust.

TABLE RVI - 1

Decrease in Sediment Yield due to Mitigation

1976-1980

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	4,825	22,100	90	19,900	2,200
Surface mines, revegetated	1,434	770	50	380	390
Underground mines	200	430	90	390	40
Power plants	1,000	2,150	80	1,730	430
Roads, new	420	1,930	80	1,540	390
Roads, revegetated	250	270	50	140	130
Railroads, new	420	4,000	80	3,200	800
Railroads, revegetated	420	1,150	50	580	580
Population	1,070	2,310	60	1,390	920
Mine facilities	400	1,840	90	1,660	180

TABLE RVI - 2

Decrease in Sediment Yield due to Mitigation

1981-1985

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	9,470	43,500	90	39,200	4,300
Surface mines, revegetated	7,528	6,000	50	3,000	3,000
Underground mines	300	650	90	580	70
Power plants	1,000	2,160	80	1,730	430
Roads, new	1,150	5,280	80	4,220	1,060
Roads, revegetated	850	1,590	50	800	790
Railroads, new	60	320	80	260	60
Railroads, revegetated	480	10,400	50	5,200	5,200
Population	0	0	60	0	0
Mine facilities	300	1,380	90	1,240	140

TABLE RVI - 3

Decrease in Sediment Yield due to Mitigation

1986-1990

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	9,670	44,400	90	40,000	4,400
Surface mines, revegetated	9,596	17,300	50	8,650	8,650
Underground mines	0	0	90	0	0
Power plants	1,000	2,160	80	1,730	430
Roads, new	1,385	6,360	80	5,090	1,270
Roads, revegetated	1,130	4,190	50	2,100	2,090
Railroads, new	1,020	5,510	80	4,410	1,100
Railroads, revegetated	1,500	34,600	50	17,300	17,300
Population	120	260	60	160	100
Mine facilities	500	2,300	90	2,070	230

Particulate matter will be forced into the atmosphere in the blasting operations, but the amount that remains airborne can be controlled sufficiently if care is taken in the blast design. The function of blasting, the break-up of material so that it can be moved, can be accomplished without the production of a large fraction of very small particles by proper sequencing and control of amounts of explosive.

Coal fires as a source of pollutants can be minimized by careful design of overburden piles and preventive action. Once a fire starts, only prompt, thorough fire fighting can prevent a major air pollution problem.

A major mitigating measure for the control of fugitive dust is the reclamation of the mine surfaces. As mining proceeds, reclaimed areas are expected to cease to be sources of fugitive dust. Reclamation includes grading, vegetation planting and other landscaping.

Major stationary sources of total suspended particulates (TSP) other than fugitive dust should be controlled by the best available scrubber or precipitator technology.

Since transportation sources and solid waste disposal are responsible for most of the non-methane hydrocarbon (NMHC) emissions, open burning should be minimized and an inspection program for maintenance of light-duty vehicle emission control devices is advisable. In addition, consideration should be given to requiring hydrocarbon (HC) emission control devices on heavy-duty vehicles, railroad locomotives, and off-the-road vehicles. The major stationary sources such as the power plants should minimize their NMHC output by an intensive operational and maintenance program on their boilers.

Because of its link with atmospheric processes and background sources, control of oxidant will be difficult in the area. Since the region appears to be sensitive to this pollution problem, nitrogen oxides (NO_x) and NMHC emissions should be minimized by the application of the best available technology for control of both stationary and motor vehicle sources.

The sensitivity to oxidant buildup in this region is sufficiently great that it is recommended that at least two oxidant (ozone) monitoring stations be established in the Yampa Valley to better document the current conditions and trends expected during the next five years.

Baseline sulfur dioxide concentrations are already equal to or greater than the Colorado State short-term standard. Therefore, either a condition of "no development" must be imposed or the standard revised.

Soils

To mitigate the impacts on soils identified in Chapter V, four distinct actions would be required: (1) removal and stockpiling topsoil; (2) shaping and grading of the spoil; (3) replacement of topsoil, and (4) revegetation with native or other adapted species. In addition the following documentation from the applicants to support the implementation of these actions should be provided to optimize the success of reclamation:

1. A map showing the detailed location and extent of the existing soils,
2. Appropriate soil descriptions and associated chemical and physical data,

3. Diagrams or figures and maps showing depth from surface and extent of overburden (geologic strata) that are suitable for establishing, supporting, and maintaining vegetation with appropriate supporting chemical data; (this is necessary when existing natural soil qualities and quantities at the present surface are deficient in the to-be mined area),

4. Climatic data,

5. Planned land use (range, cropland, etc.),

6. Topsoil stockpiling procedure and management,

7. Identification, location, and plan for disposal of toxic layers with supporting chemical data,

8. Procedures for grading and shaping of the spoil that includes a plan for the reduction in compaction of the soil material and actions to be taken to increase slope stability before topsoil placement,

9. Procedures for replacement of topsoil and reduction of compaction,

10. Detailed topsoil map after placement with supporting chemical and physical data to a depth of 60 inches,

11. Surface manipulations (mulches, etc., including seedbed preparation),

12. Soil amendments and/or fertilizers and rates (gypsum, nitrogen, phosphate, potash, etc.).

By 1990 the implementation of these mitigations would assure about 90 percent of the original total vegetative production on 23,965 acres disturbed by coal development activities (see Table RV-12).

Terrestrial Flora

To best mitigate the loss of existing vegetation, a reclamation plan should be developed before the mining operation begins. Baseline climatic, soils, vegetation, wildlife, and current land use information should be collected and utilized to determine the best land use or uses after mining, and the best ways of achieving the chosen use or uses.

The first physical step in the reclamation process should be topsoil removal. After mining proceeds every effort should be made to remove topsoil from areas to be mined and replace it directly on reshaped spoils. Immediate replacement of topsoil is most desirable where grazing land is proposed, because some native plant species and microorganisms will be transplanted live to speed reclamation of the mined area. If topsoil is replaced at a time other than optimum seeding dates, spring or fall, it should be seeded with a quick-growing annual to guard against erosion and compete with invading weed species. If topsoil cannot be replaced immediately and is stockpiled for more than a few months it should also be seeded with a quick growing annual to control erosion, or if it is to be left for periods longer than a year, it should be seeded to a mixture of perennial grasses and/or legumes. Topsoil stockpiles should be placed on areas to be mined, or areas already mined if possible, so additional vegetation is not destroyed.

Topsoil should be replaced to the maximum depth possible, with a minimum of approximately eight inches on areas to be returned to grazing land, and 18 inches for cropland, to insure vegetative establishment and production. In areas where topsoil is found in large quantities it should all be removed and stockpiled so it can be replaced on areas where topsoil is lacking prior to mining.

During the overburden removal, the fragmented material below the topsoil should be placed on top of the spoil piles. This material has proven usable for plant growth in the area, and would provide a usable growth media for deep rooting plants, plus speed the soil building process because of its fragmentation.

Spoil shaping should begin as soon as possible to reduce vegetative loss. It should be performed in accordance with the planned land use to produce cropland areas as flat as possible and grazing lands approximating original contours. Areas to be returned to wildlife habitat should be shaped to create various micro-climatic conditions that are characteristic of the differences in soils and exposure that produce the diversity in native vegetation.

After spoils have been shaped, the area should be ripped or deep chiseled, if shaping by heavy equipment has resulted in compaction that would inhibit moisture or root penetration. This is especially important where overburden is removed and replaced totally by scrapers.

After topsoil is replaced a seed bed should be prepared by discing or a comparable process, and revegetation programs implemented. Seeding of perennial vegetation should be confined to fall or spring to insure best possible seedling establishment. Where topography permits, seeding should be done with a rangeland drill, or a suitable drill with depth bands; on areas where seed is broadcast the soil surface should be roughened to allow seed penetration. On areas returned to wildlife habitat, seed mixtures should be varied according to micro-climatic conditions produced by the shaping process.

Transplanting of native trees and shrubs from unmined areas to reshaped areas would decrease the impact of loss of native vegetation, and return the area to wildlife habitat. This program should be utilized to the maximum extent possible to mitigate the loss of existing shrub and tree vegetation. Trees and shrubs, especially aspens, should be transplanted to areas of most favorable soil moisture conditions produced by the shaping and topsoil replacement operations.

The BLM, through the Energy Minerals Resource Inventory Analysis program is implementing a study to test the usefulness of a Vermeer tree spade for transplanting trees and shrubs onto mined lands (Figure RVI-1).

Impact of native vegetation loss could be lessened by collecting seed from native vegetation before mining and using it in revegetation efforts.

Plant growth media produced by the mining operation is very different from native conditions, and may not be suited for reseeding native vegetation. Removal and replacement of present soil profiles may increase the success of reclamation attempts. If water is available for irrigation, it would also increase reclamation success, especially in years when precipitation following seedings and transplantings is low. When climatic conditions are such that seedlings fail, reseeding should be implemented

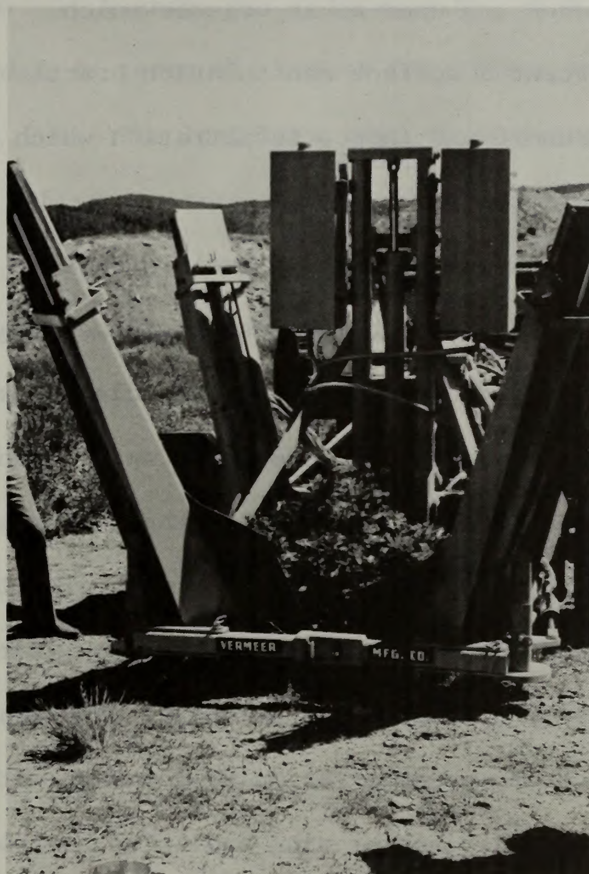

Figure RVI-1

A Vermeer tree spade being tested for use in transplanting shrubs and trees on mined lands.

until vegetation is established. If localized adverse soil conditions are such that vegetation will not establish, the area should be covered with at least 18 inches of suitable material and revegetated.

In areas of extremely adverse soil moisture conditions or very steep slopes, a mulching practice, such as straw or hydromulch, should be utilized to increase revegetation potential. Vegetation on areas to be mined could be shredded and used as an organic mulch. Where slopes are greater than 33 percent a surface manipulation practice should be implemented to impede runoff and induce infiltration which will increase success of revegetation attempts.

After replacement, topsoil fertility levels should be determined, and fertilizer applied with rates and composition depending upon requirements of plant species being seeded. If fertility levels are too low for seedling establishment, fertilizer should be applied shortly after seedling emergence, unless seeded in the fall; then it should be applied in early spring following seeding. If soil fertility levels are adequate for seeding establishment but not for sustained growth, fertilizer should be applied in early spring of the second growing season.

Berg (1975) found that the application of adequate nitrogen (N) for good initial ground cover on sandy uranium spoils in northwestern Colorado had a short-lived effect on very N-deficient spoil material, and that considerably more N would have to be applied before a self-maintaining system can be expected. This N can possibly be supplied after a few years by planting N-fixing species such as alfalfa, but this would create bloating and monoculture problems as described in Chapter III. Where soil fertility rates are very low and plant growth is deficient, a maintenance fertilizer program should be implemented until the soil system is self-maintaining.

Berg (1975) felt that the most important reason to replace topsoil is to supply N. He stated that an acre of soil one foot deep containing 0.1 percent N (a fair average for Colorado) has an N content of about 4,000 pounds, which in terms of current fertilizer prices would be worth approximately $1,000. The long-term cost of adequate fertilizer N where not supplied by N-fixing plants might well exceed the cost of topsoil replacement.

An intensive management program that includes fencing should be implemented to allow successful revegetation following mining.

The establishment of the Upper Colorado Plant Materials Center at Meeker, Colorado, through the efforts of the local Soil Conservation Districts assisted by Federal, State, and local governments will eventually provide native seeds to mining companies for use in reclamation. Other measures will be provided by on-going reclamation studies by private companies and State agencies in to-be mined areas in the study region.

Terrestrial Fauna

Cutting of vegetation during exploration should be avoided for off-road vehicle (ORV) access if possible. All disturbed areas should be revegetated as soon as exploration in the immediate area is concluded.

All deer and antelope fauning areas, elk calving areas, grouse and greater sandhill crane dancing and nesting areas, and waterfowl nesting areas should be avoided during critical periods in these species life cycles. Identification of these time periods should be coordinated with the DOW.

During drilling of core holes, some vegetation, even if only the lower growing forms such as the grasses and forbs, should be left on the site to provide some degree of wildlife habitat.

Where surface disturbance would destroy or render unusable large acreages of big game winter range, the impact could be mitigated only to the extent that this habitat could be avoided or rehabilitated (W. R. Grace and Company has begun big game habitat improvement projects even before beginning mining operations, in an effort to absorb those animals that would be displaced when mining begins).

In order to mitigate the impacts of increased human pressure on game animals, more restrictive hunting regulations and more Wildlife Conservation Officers may be needed within the region.

Restricting the timing of some operations like exploration could reduce adverse impacts during critical periods, like the breeding and nesting seasons.

Fences should be kept to a minimum. When necessary, they should be built incorporating features to allow passage and reduce hazards to such species as antelope, deer, and elk.

All mine related vehicular use should be restricted to daylight hours whenever possible to reduce the probability of vehicle-animal collisions.

All sources of surface water that would be lost should be replaced by a source that could be used by large and small wildlife species as well as domestic livestock. These new sources of water should be located to insure maximum utilization of the surrounding areas.

Archeological Resources

Arecheological resources' primary value lies in being preserved in-place as a cultural data bank; their secondary value occurs as the site is expended to yield scientific data. No archeological excavation stemming from intensive surveys on proposed action areas should be permitted unless the site is in imminent danger of destruction. This would prevent destruction of the primary in-place value of archeological resources, perhaps at the expense of their on-site interpretive and educational value. It would also allow utilization of improved archeological survey and analysis techniques if the site might be excavated at a future date; more information about the culture could then be obtained. For all practical purposes, this guideline would not always be followed; secondary impacts of the proposed action would occur in the form of archeological excavations that stem from intensive surveys.

Impacts to subsurface archeologic values could be partially mitigated by requiring that an archeologist accompany construction crews working in recently-deposited alluvium, suspected of containing subsurface values. This is usually done at the recommendation of the surveying archeologist. Not all subsurface resources could be found in this manner, for there is no foolproof method for determination of subsurface archeological potential.

Impacts to sensitive existing and potential National Register archeological properties could be largely mitigated by withholding legal description of the site location from the register; solicitor's opinion legally allows this action to be taken for fragile cultural resources endangered by potential vandalism and pothunting. Sites of National Register significance or National Register properties could be further protected by appropriate interpretive-protective signing and fencing.

Historical Resources

For each proposed action area a thorough literature search should be conducted, prior to project initiation and mine plan approval, to determine the potential for significant historical resources on a site specific basis.

Impacts to sensitive existing and potential National Register historical properties could be largely mitigated by withholding legal description of site location from the register; a solicitor's opinion legally allows this action to be taken to protect fragile resources endangered by potential vandalism. Sites of National Register significance or National Register properties themselves could be further protected by appropriate interpretive-protective signing and fencing.

Land Use

Changes in land use from grazing and farming to mining and related operations could be mitigated by stockpiling the topsoil on the stripped areas, and then reclaiming the surface to its original condition immediately after mining is completed. This would offer an opportunity to the surface landowner to return the land to grazing or farming, whichever is determined appropriate.

Total reclamation should include removal of all improvements established for mining and related purposes after mining is completed.

Aesthetics

Where vegetative removal is necessary, clearings should conform to an irregular pattern to simulate natural openings as nearly as possible;

disturbance of vegetation should be minimized, as breaks in ground cover tend to dominate the view. When trees or shrubs are removed, they should either be buried or chipped and returned to the reclamation site as a mulch.

All spoil piles should be leveled to a gently rolling landscape that complements adjacent topography as soon as safely feasible after each pit is mined. No spoils should be dumped over ridges or escarpments onto adjacent undisturbed terrain. To retain characteristic form, line, and texture, surface mining operations should be restricted from ridgetops and escarpments. This restriction should begin at a line where stripping operations become silhouetted or where danger of overspill or slumping occurs.

All cut-and-fill slopes should be backsloped in a rounding grade that intersects adjacent terrain at a low angle. Successful revegetation of these slopes should be accomplished by reseeding indigenous species that are present on immediately adjacent terrain.

Buildings and equipment structures built to a low profile can more easily borrow from adjacent landscape's form. Careful attention to architectural design can avoid the creation of strong vertical lines in these structures.

Road, railroad, and right-of-way alinements should borrow from already existing lines in the characteristic landscape. Where agricultural patterns occur, these linear features might parallel edges of fields. In areas of natural terrain, the integrity of the natural landscape visual units can best be protected by placing alinements along natural transitions between hills and valleys or at edges of forest and woodland types. Rights-of-way and roads should also be routed obliquely to viewshed sequences and to promontories. Roads and rights-of-way should also be restricted from steep hillsides to avoid large line and form-dominant minus deviations which they create. Rights-of-way and access roads should not parallel public roadways unless separated from them by effective vegetative or topographic buffers or adequate distance (i.e., middleground or background). The benefits of vegetative screening adjacent to facility developments should be utilized to screen incongruous lines. Earth mounding should also be used to help screen minus deviations.

Electric transmission line alinements should be located at a sufficient distance (out of foreground) from any roads, and if possible against a backdrop of trees or topography. Vegetative removal along rights-of-way should be minimized, and medium-sized trees and shrubbery retained within the rights-of-way to prevent strong line, color, and texture-dominant minus deviations. Any necessary clearings should selectively thin existing vegetation at its edges to reduce the tunnel effect. When transmission lines enter heavily wooded areas, vegetation removal sould be avoided as much as possible. To prevent an unobstructed view down rights-of-way, their alinement in wooded areas should change after crossing highways. Some transmission lines could also be buried to mitigate minus deviations, especially where they must traverse foreground landscape visual units, and where they occur adjacent to and within housing developments. Non-reflective conductors should be used on all transmission lines that can be viewed from public roads, regardless of how distant they may be. Helicopter construction should be used where sensitive land units or steep slopes are encountered.

Reclamation efforts on coal surface mines should concentrate on re-establishing plant communities having native colors and textures. Alternately they could center on the creation of an agricultural landscape whose color, though different from the adjacent landscape, would provide an attractive visual focal point (e.g., pastoral landscapes). Both are visually acceptable alternatives as long as their form and line elements complement those of the characteristic landscape (e.g., an undulating surface and irregular edges).

All coal facility developments (e.g., buildings and tipples) should be painted a non-reflective warm green to brown color to blend their usual silver form with the characteristic landscape. Transmission line supporting structures should also be painted or stained, especially where they occupy foreground landscapes. Unless transmission lines will not be viewed against the sky, their color should be chosen on the basis of its ability to blend with both sky and immediate landscape.

All surface disturbing activities should be restricted from flood plains and active drainage courses to reduce siltation in adjacent streams. Stream diversions should not be allowed to run uncontained over alluvial nor over colluvial areas.

On coal haul roads and mine access roads regular sprinkling with water or oiling should be required to control road dust. Roads built for new housing developments should receive the same treatment or be surfaced to reduce fugitive dust levels in urban areas. However, dust control by wetting roads is only about 30 percent efficient.

All coal-related developments should maintain a litter-free landscape by regularly disposing of accumulated litter, building materials, and discarded equipment.

Wherever possible, incongruous elements of the proposed action could be moved from foreground landscapes to reduce their scale, visibility and ultimate impact; alternate routes may be determined for rights-of-way, roads, and other features, that will make them less visible or completely screen them.

Other elements of the proposed action that contain inherent minus deviations can also be relocated on areas that are viewed more obliquely; then they will be less visible.

However, transmission lines and other features with significant vertical dimensions are best routed against a backdrop to screen their strongly line-dominant form and avoid silhouetting.

Within each proposed action area there are landscape visual units that are less visible than others, in terms of the number of times viewed and length of time each view lasts. These units, as well as those that can be viewed at varying distances, identify sensitive areas from which inherently incongruous elements could be moved, to mitigate their adverse aesthetic impacts by reducing their relative visibility.

Economic considerations and a lack of awareness have generally precluded the imposition of government controls over private industry for aesthetic considerations that return unknown or questionable economic gains: therefore companies proposing any coal-related development may not be required to adopt all these aesthetic mitigations. Internal economic considerations by these companies may also preclude their desire to employ these mitigating measures, as their major objective will be either coal production or construction, and development to meet coal-related needs.

Recreation

To mitigate the impacts of increased recreational demand, additional activities or facilities must be supplied. To meet the deficits expected in Routt, Moffat, and Rio Blanco Counties, the following standards quantify the resources needed for each additional 1,000 activity days of recreational demand per year, based on the season length shown:

TABLE RVI-4

Recreation Facility/Resource Standards

Activity	Standards/ 1,000 Activity Days/Year	Season Length (Days)
Bicycling, trails	0.04 mile	316
Tennis	0.47 court	246
Golf	0.44 acre	250
Swimming	0.0027 acre	140
Ice skating, rink	0.05 acre	88
Snow sledding	54.17 acres	92.3
Shooting-hunting	4,000.00 acres	-

These standards are based on the season lengths shown; they are statewide standards developed in the 1974 Interim Colorado Statewide

Comprehensive Outdoor Recreation Plan (SCORP). Season length may need adjustment for the various communities within the study area; subsequent changes in the standards will result.

Impacts of the proposed action might also create deficits in other activities but the above activities would be in short supply in several portions of the study area, given the normal population projections without the proposed action (see Chapter IV).

Irrespective of additional deficits that will be caused by population growth without the proposals, the proposed action would create recreational demands that are greater than existing supplies for certain activities; these can be mitigated by increasing the supply as shown in Table RVI-5 by using the above standards.

The Colorado Interim SCORP for 1974 failed to identify any supply of skating facilities in Moffat County. Currently an ice skating rink is operated each winter which supplies an unknown amount of skating; this may modify the projected needs for ice skating in Table RVI-5.

The Recreation and Public Purposes Act of June 14, 1926, as amended (43 U.S.C. 869; 869-4), authorizes the leasing or selling of public lands by the Department of Interior for recreational and public purposes. This act would help to provide for recreation acreage needed to meet increasing demands; national resource lands adjacent to communities can meet some of these demands.

Section six of the Land and Water Conservation Fund Act of 1965 (Public Law 88-578) as amended, provides financial assistance to states

TABLE RVI-5

Recreation Resources Needed to Meet Demands Caused by the Proposed Action*

Activity	1980 Moffat and Rio Blanco County	1980 Routt County	1985 Moffat and Rio Blanco County	1985 Routt County	1990 Moffat and Rio Blanco County	1990 Routt County
Bicycling1/	16.07	3.72	13.24	4.26	13.65	4.83
Swimming2/	—	0.06	—	0.07	—	0.08
Tennis3/	4.36	3.91	2.77	4.48	3.00	5.08
Golf4/	15.55	—	12.82	—	13.21	—
Shooting/Hunting5/	—	17,528.0	—	20,076.0	—	22,764.00
Ice skating6/	0.27	0.89	0.22	1.03	0.23	1.18

1/ miles of trails.

2/,4/,5/,6/ acres.

3/ courts.

* In terms of absolute need (not incremental) for each benchmark year.

This table assumes that the existing recreating supply-demand picture remains static (regional population increases without the proposed action will also increase recreation demand quantifiable only by Planning Region -- see Chapter IV).

and local political subdivisions. Financing for up to 50 percent of planning, acquisition and development costs is provided; project proposals are submitted to the Bureau of Outdoor Recreation's Mid-continent Regional Office through the State Liason Officer. Demonstrated need for such recreation development projects must conform to the Interim SCORP upon which this analysis is based.

Mine reclamation plan objectives could be altered to increase recreation supplies with developments based upon a regional park concept; this is an especially viable option for mining operations in close proximity to the region's population centers.

Public Law 88-578 also provides financial assistance up to 50 percent, to State and local political subdivisions for mined land reclamation projects that are suitable for outdoor recreation and that are in conformity with the Interim Colorado SCORP.

The mine operator is permitted to allow the public to use lands owned by him for recreational purposes except in areas where he determines such use to be hazardous or objectionable; Section 92-13-6, Part 1-j, of the 1973 Colorado Open Mining Land Reclamation Act contains these provisions in accordance with Article four of Chapter 62, Colorado Revised Statutes, 1963. This act can be used to allow the public to use surface mine areas for off-road-vehicle use, rockhounding, and as geologic-industrial interpretive areas. Beneficial impacts of the mines could thereby be realized, and the additional supply of recreation lands would help meet the increased demand.

All surface mining, road building, and right-of-way construction should be restricted from floodplains to avoid siltation and subsequent deterioration in the capability of downstream fisheries. Construction activities on steep slopes adjacent to perennial streams should be avoided for the same reason.

Impacts upon the inherent recreational capabilities of cultural resources should be mitigated as outlined in Chapter VI, History and Archeology.

The DOW could increase stocking of catchable fish throughout the study area to maintain existing capabilities to attract and sustain fishing use. Annual stocking for cold and warm water fish (figures for warm water stocking in parentheses) would have to reach 677,334 (36,410) fish by 1980, 579,796 (31,165) by 1985, and 605,437 (32,545) by 1990.

Social Environment

New demands for social support facilities are a significant adverse impact that would result from the implementation of the proposed action. This impact would bear principally upon county and city government's capabilities to generate monies to pay for these new facilities. The traditional source of revenue are taxes based on property values, but it is expected that increases in property values would lag the new demands for tax revenues. This is known as the tax lead time problem.

The resolution of this problem has been addressed in depth in the Tax Lead Time Study (Lamont et al 1974). The study was directed principally toward the mitigation of oil shale impacts, but the analysis is equally applicable to coal-related developments. The study presents detailed analyses of several revenue and fiscal management alternatives available to local governments in Colorado. These alternatives are summarized in Tables RVI-6 and RVI-7. Selection of the exact combination of these mitigating measures that would best resolve the tax lead time problem is properly the function of local governments; however the Tax Lead Time Study provides the following general guidelines for local officials:

1. Communities should predetermine the manner in which they wish to develop, giving appropriate weight to quality, location, and phasing of development as well as efficiency in providing public services.

2. Adequate public facilities and services must be provided when and where needed at minimal cost.

3. Cost of providing public facilities and services should be equitably shared among present residents, new residents, industry, energy consumers, and state and federal governments with each community determining its own concept of equity in this regard.

4. A diversified tax base should be established or preserved in order to avoid long-term dependence upon a single industry for revenues in the region.

5. Local control of government and public decision-making on local issues should be maintained, especially with regard to revenue and expenditure decisions.

The 37-1/2 percent of rentals, royalties, and bonuses from Federal coal leases that is returned to the state could be raised to a higher percentage. This would require Congressional action; Interior Secretary Thomas Kleppe has suggested an increase to 45 percent (Coal Week 12/15/75). Secretary Kleppe also has suggested that the restriction on the use of these funds for only roads and schools be lifted. He further suggested that "the Federal government should guarantee at least a portion of the

TABLE RVI-6

Revenue Alternatives for Colorado Local Governments

	GENERAL SALES TAX	SELECTIVE SALES TAX	USE TAX	AD VALOREM PROPERTY TAX	GENERAL OCCUPATION TAX	SPECIFIC OCCUPATION TAX
DESCRIPTION	Excise tax levied on retail sales of tangible personal property (sometimes services) made inside the taxing jurisdiction.	Excise tax levied on retail sales of certain products inside taxing jurisdiction. Most common are tobacco, alcoholic beverages, motor fuel, public utilities, insurance, and parimutuels.	Tax on the privilege of storing, distributing, using, or consuming articles of tangible personal property in the taxing jurisdiction and on which no sales tax has been paid. It is generally complementary to sales tax.	Ad valorem tax computed on the assessed valuation of all property, real and personal, located within the territorial limits of the authority levying the tax.	Tax imposed for the privilege of carrying on any of a broad range of occupations within the taxing jurisdiction. Denver's head tax is an example.	Tax imposed for the privilege of carrying on certain occupations within a taxing jurisdiction. Utility occupation (franchise) taxes and beer and liquor occupation taxes are common in Colorado.
YIELD	For 1% tax, state average is $35 per capita annually. Localities vary as much as ±$20 around state. No important collection lag with respect to economic development.	State Averages: Cigarette tax--10 cents per pack yields $13 per capita annually. Alcoholic beverages--30 cents per gallon yields $6-$6.50 per capita annually. Motor fuel--7 cents per gallon yields $45-$50 per capita annually. No significant collection lag with respect to economic growth.	Generally about 1/10 the yield of a comparable general sales tax. For 1% tax, the state average is $3 per capita annually. No significant collection lag with respect to economic growth. For local governments, most revenue comes from use of building materials and motor vehicles.	For non-industrialized, but urbanized areas, a levy of 75 mills raises from $150-$225 per capita annually, the higher range for more urbanized areas. Each oil shale retort plant will generate roughly $10 million annually on a mill levy of 75 mills with up to a 2-1/2 year time lag in collection.	The two most productive general occupation taxes in the state, Denver and Durgango, raise roughly $20 and $4 per capita annually. May be collection lag with respect to economic growth.	All specific occupation taxes used by Colorado cities and towns together raise less than $3 per capita annually. Collection lag of up to one year is likely.
LEGALITY	Legal for home rule cities, counties, statutory cities and towns. Election required in all but home rule cities (unless charter requires election). 4% maximum cumulative levy for all cities and counties in any one location	Legal for home rule cities. No statutory authority for counties, statutory cities/towns. Localities with cigarette taxes do not receive cigarette tax distribution from the state.	Legal for home rule cities and statutory cities/towns. No authority for counties. 4% maximum cumulative levy for all cities and towns in any one location.	Legal for home rule cities, counties, and statutory cities/towns subject to extensive charter, constitutional and statutory limitations.	Legal for home rule cities within charter limits. Legal for statutory cities/towns. No authority for counties, districts.	Legal for home rule cities within charter limits. Legal for statutory cities/towns. No authority for counties, districts.
ELASTICITY	Unit elastic (range 0.8-1.3)	Strongly inelastic (range 0.0-0.8)	Unit elastic (range 0.8-1.3)	Moderately inelastic (range 0.4-1.4). Property tax base in Garfield and Rio Blanco counties will be dominated by oil shale facilities, not by local economic conditions.	Strongly inelastic as typically used. Can be structured to be less inelastic.	Strongly inelastic as typically used. Can be structured to be less inelastic.
INCIDENCE	Regressive to income. Neutral to household size. Taxes non-resident visitors. Relief programs can <u>reduce</u> regressivity.	More regressive to income than general sales tax. Neutral to household size. Taxes non-residents and visitors.	Same as general sales tax. Particularly hits purchasers of motor vehicles and construction and building materials.	Regressivity similar to general sales tax. Neutral to household size. Relief programs can reduce regressivity. Oil shale facilities will dominate tax bases in Garfield and Rio Blanco. Much of the tax would be exported out of the region.	Where taxes are levied on firms doing business locally, same as general sales tax. Where tax is on exporting industry, it is exported outside of the region. A flat rate is regressive to individual income above any exemption level. Government employees exempt.	Same as general occupation tax.
CONTROL	High degree of local control for home rule cities. Statutory cities and towns, and counties, must use state form of tax and state collection system.	Where legal, local control is good.	Local use taxes are administered by local government. Good control.	Statutory mill levy limits severely constrain local control in counties, statutory cities and towns, and districts. Oil company decisions will be very important in Garfield and Rio Blanco counties.	Excellent local control.	Excellent local control.
MARKET SIDE EFFECTS	Sets incentives for retail business location just outside of taxing jurisdiction.	Sets incentives for retail business location just outside of taxing jurisdiction.	Reduces incentives for retail business location just outside of taxing jurisdiction, especially with regard to autos and construction materials.	Disincentive to new market development. Could have an effect on development of oil shale resources.	Significant side-effects unlikely at levels currently used in Colorado.	Heavy specific occupation taxes may discourage affected businesses from locating in the area and/or may result in price increases and negatively affect consumption.
CERTAINTY/ PREDICTABILITY	Moderately good predictability in short run. Poor predictability over 3 to 5 year term.	Predictability depends on specific object of axation. Good for motor fuels, tobacco products, and alcohol.	Same as general sales tax.	Good predictability of residential portion of tax base. Industrial and mining portions are more subject to erratic changes if production is unstable.	Very good predictability.	Very good predictability.
ADMINISTRATIVE COST	Largest administrative cost due to vendor fee. Total administrative cost--3-10% for home rule cities. 4-5% for counties and statutory cities and towns.	Somewhat higher than cost for general sales tax.	High. May approach 10% or more of revenue.	The cost of increasing or decreasing reliance on property tax is extremely small.	Depends on size of tax. At higher levels, the administration cost approximates general sales tax.	Depends on size of tax. At higher levels, approximates selective sales tax.
CITIZEN ACCEPTANCE	Opinions vary with existing level. Has consistently topped property tax in popularity surveys. Fractions of 1% may be preferred at times.	Opinions vary with existing level. High level of taxation on tobacco and alcohol expected. Existing levels throughout Colorado low compared to other states.	Strongly favored by local merchants selling major cost items located inside sales taxing jurisdiction.	Considered regressive and unfairly administered. Frequently comes in last in popularity in research opinion polls.	May engender opposition as "new tax." Will have opposition from business community.	Citizens may feel they are being taxed at every turn. Businesses may argue that they are discriminated against.

Source: Briscoe, Maphis, Murray, and Lamont, Inc., <u>Oil Shale Tax Lead Time Study</u>, prepared for Regional Development and Land Use Planning Subcommittee of the Governor's Committee on Oil Shale Environmental Problems, Denver, Colorado, 1974. This chart is a summary of Section 3 of that study.

TABLE RVI-6 (cont.)

Revenue Alternatives for Colorado Local Governments

	USER FEES	SEVERANCE TAX	LOCAL INCOME TAX	REAL ESTATE TRANSFER TAX	SITE VALUE TAX	LAND VALUE INCREMENT TAX
DESCRIPTION	Prices charged the consumers of various public services such as water and sewer charges or recreation program charges. Fees may include charge for capital facilities as well as operating costs.	Tax on the production or extraction of certain minerals. Colorado's oil and gas production tax is a form of severance tax. It is levied on gross incomes derived from the production of certain types of oil and gas from Colorado deposits.	Tax on the income of resident individuals, estates, and trusts and income of non-residents derived from local sources. Also would apply to the incomes of corporations located in or doing business in the local area.	Tax levied on the conveyance of real property. The tax is analagous to a sales tax on real property.	Ad valorem tax on assessed valuation of land but not improvements.	Tax imposed on the net gain in the value of a given parcel of land or land with improvements between two points in time.
YIELD	One-time initial fees (expansion or plant investment fees) and continued use service fees (monthly utility and recreation fees) may be designed to cover all or only a share of the cost of the capital facility and its associated operating costs. Collection generally follows initial capital construction but precedes expansion.	Colorado's oil and gas production tax allows a credit against certain ad valorem taxes paid by producers. A 5% severance tax on the gross proceeds from the sale of oil from oil shale is estimated to generate $3-1/2 million annually per 50,000 bbl/day operation, excluding tax credits.Multi-year revenue collection lag expected.	For fiscal year 1972-73, Colorado collected in excess of $100 per capita in personal and corporate income taxes. A 25% local surcharge or a 1/2% flat rate would each raise approximately $25 per capita annually. Income tax collections are subject to multi-year lags from the occurance of economic activity.	Based on existing documentary fee collections, a 1% real estate tranfer tax would produce $10-$15 per capita annually. Tax collections would tend to lead economic development.	15-20% of yield from identical mill levy on all real and personal property. Same time lag problem as with property tax.	Depends on exact nature of tax, but generally low in existing applications.
LEGALITY	Legal for all types of local governments.	No existing authority for this tax. The General Assembly could enable such a tax at the state, regional, or local level.	A local income tax, levied by the General Assembly at the request of local political subdivisions, may be constitutional but unauthorized by statute.	Counties, statutory cities and towns, and special districts do not have express authority to levy a real estate transfer tax. The tax may be legal for home rule cities, but no court test has been made.	No authorization for statutory political subdivisions. May be legal for home rule cities. Does not appear to be prohibited by constitution.	Same as income tax.
ELASTICITY	Strongly inelastic with respect to inflation. Unit elastic with respect to population growth and real income growth.	Changes in revenue from severance taxes are not correlated with changes in local economic conditions.	Strongly elastic (range 1.3-2.0).	Generally elastic, yet subject to strong influence of money market conditions.	Same as property tax.	Highly elastic but subject to strong influence of money market conditions.
INCIDENCE	Paid by the beneficiary of the service or facility. User fees ignore citizens' ability to pay. User fees can insure growth pays its own way.	Mining companies faced with severance taxes attempt to pass them along to customers or their labor force. In tight labor markets, more taxes will be passed on to consumers, thus exported from the region.	Graduated income taxes (State of Colorado) are strongly progressive with respect to income. Corporate income taxes are exported by export base industries. Income taxes bear lightly on elderly and low income people.	Conditions in real estate markets determine tax incidence. In a soft, buyers market, the seller will bear more tax burden than in a tight sellers market.	Landowners of all types. Less burden on occupants of high density residences.	Landowners in areas experiencing rapid increases in land value.
CONTROL	Excellent local control. Control as a revenue source is enhanced by the fact that increased costs due to increased demand are self-financing.	Very poor local control. The General Assembly sets the rates and non-local factors determine the size of the tax base.	Because of the constitutional requirement that only the General Assembly may levy income taxes, rates would not be locally controlled. In the short run, tax base is outside local control.	Tax rate is subject to local control, but the tax base is influenced by non-local economic developments.	Statutory mill levy limits severely constrain local control to counties, statutory cities and towns, and districts. Oil company decisions will be very important in Garfield and Rio Blanco counties.	Very poor local control of rates (established by General Assembly) and tax base (sensitive to money market conditions).
MARKET SIDE EFFECTS	Set incentives for the efficient use of public services since users pay for only the amount used. High initial fees for public facilities are reflected in higher housing costs.	Set incentives for the taxed activity to locate outside of taxing jurisdiction or not locate in the area at all. The higher the tax, the stronger the incentive. Effects can be much broader after mining activity is established in an area.	Significant market side-effects not identified.	Creates incentives to avoid property sales. In a tight market, housing prices will rise to cover tax cost. In a soft market, housing prices will be less affected. Such effects correlate to the tax rate applied.	Creates incentives to put land into its highest and best use allowed by law. Favors full development of area.	Reduces return to land speculation. Would inhibit exchange if applied to real rather than accrued gains. If applied to accrued gains, would provide incentive to put land into highest and best use.
CERTAINTY / PREDICTABILITY	At fixed rate levels, good predictability. However, rate variations can be expected to affect consumption as well as costs.	Very poor certainty/predictability.	Moderately good predictability in short run. Poorer predictability over 3 to 5 year term.	Poor certainty/predictability.	Very good predictability.	Unpredictable. More so if real gains are taxed, as opposed to accrued gains.
ADMINISTRATIVE COST	User fee revenue systems may give rise to substantial costs due to rate studies, monitoring, consumption, individual billing, and expanded accounting systems.	Very low.	Very low for state-collected, locally returned local income tax.	Major cost is enforcement in major transactions. Generally low administrative cost. Lack of experience with this tax in Colorado suggests unknown administrative problems.	If land is assessed for property tax, little additional cost would result for site value taxation.	Administrative cost cannot be estimated due to lack of experience with this tax in the U.S. and because of the variety of forms of the tax.
CITIZEN ACCEPTANCE	Generally favorable. For low-income citizens, however, use of some public services may fall below a socially desirable level.	May be favorable if citizens feel energy consumers should share development costs and/or because severance taxes are largely exported.	Less favorable than federal income tax. Citizens can be expected to oppose a "new tax."	May engender opposition as "new tax," especially from realtors.	May engender opposition as "new tax" and since large rates are necessary to generate sizable revenues from small tax base.	Better acceptance if moderate gains accumulated over long periods were exempt. Tax on real rather than accrued gains would be more acceptable.

TABLE RVI-7

Non-Revenue Fiscal Devices for Colorado Local Governments

	GENERAL OBLIGATION BONDS	REVENUE BONDS	SPECIAL ASSESSMENT BOND	INDUSTRIAL DEVELOPMENT BONDS	REFUNDING BONDS
DESCRIPTION	Bonds backed by the full faith and credit of the issuing agency. Issuers promise to levy additional property tax to retire debt if necessary. Promise to pay is contractual and unrestricted. These are lowest interest rate bonds.	Bonds issued without backing of full faith and credit of the issuing agency. Bonds usually retired from revenues generated by the project, financed, or more broadly, from revenues from specified sources other than general fund.	Special assessment bonds are issued to pay for public improvements where specific private benefits exist. Payments from private individuals retire the bonds on the basis of benefit conferred.	Also called county and municipality development revenue bonds. Issued to aid industry in financing capital costs. Government incurs no debt, bonds retired by payments from industry. Bonds are tax exempt.	Bonds that are issued to change the form of outstanding debt, to achieve certain advantages. Any type of bond can be refunded.
PURPOSE	Used by local government to finance capital projects when it is felt that the project should be paid for by the entire public, spread over a long period of time.	Originally conceived to provide front-end financing for facilities that could pay for themselves over the long run. Recent applications permit use where self retirement of debt from the project is impossible, but pledge of other revenues permits utilization.	To enable property owners to amortize over a moderate period of years, at a low interest rate, the capital costs associated with constructing various public facilities, i.e., streets, storm drainage, water or sewer.	Must serve a public purpose whether it be attraction of industry to stimulate economic growth or the provision of services in furtherance of the public health or welfare.	Generally, to shorten term of issue, achieve more favorable interest rate, eliminate restrictive covenants of base issue, reorganize the maturity pattern or to consolidate debt.
LEGALITY	The state constitution requires that local government general obligation debt (1) be for a public purpose, (2) except as otherwise provided by a home rule charter, be approved by the electorate, and (3) fall within statutory debt limitations. Debt contracted for the purposes of supplying water is excepted from the above provisions.	Only applicable constitutional requirement is that the debt be issued for a public purpose. Except as provided by home rule charter, no debt limitation or voter approval requirements.	Specific statutory authority exists to permit cities, towns, and counties to create special assessment districts, sometimes called local improvement districts, that may borrow by issuing special assessment bonds.	These avoid the Colorado constitutional requirement that prohibits lending of public funds to any person, company, or corporation. Statute does not require election.	Generally, any bond that can be legally issued can also be legally refunded. Debt limitations are not additive and, therefore, are not a factor.
CITIZEN OR POLITICAL ACCEPTANCE	Due to election requirement, citizens' right to approve or reject is positive and direct on each issue.	Since facility user fees are the principal means of debt retirement, most citizen concern comes from users of facilities and how much they will pay.	Citizens who want a certain public improvement that will result in a direct and specific benefit often support this approach. Most districts are not created without some form of majority consent by the benefitting and, therefore, paying property owners.	Citizen understanding is often a problem. Feeling that issuance of bonds is a public subsidy to a private purpose is common. Full public disclosure of total program is necessary.	Citizen understanding and a clear public purpose are probably the keys to acceptance
ADVANTAGES	Gives local governments the best possible terms. Retired from ad valorem taxation over life of issue. A hedge against inflation. Projects can be financed which do not generate revenue.	No debt limitations. Default on issue does not burden local tax payers. Voter approval not always necessary. Concept of user pays is popular.	Requires little or no capital from the issuing agency. Does not ordinarily affect community debt limits. Formal election is not required. Citizen involvement tends to shape the project into a publicly acceptable form.	May permit small industrial developments to locate in an area where private financing might preclude it. Bonds are not subject to public debt limitations. Debt retirement is by the industry, not the public. Serves as a planning tool for local governments.	Offers opportunities for flexibility in modifying community debt structure. No election required. Issuance costs are low. Net dollar gain can accrue to issuing agency
DISADVANTAGES	Lag time obtaining funds can be very costly. Community debt limitations could restrain logical usage. When paid off with property taxes, costs are not necessarily paid for by the project beneficiaries. Can only be used for certain purposes in counties.	Typically higher interest rates than for general obligation bonds. In case of bond default, moral obligations may result in community obligations. Exposure to litigation is greater than for voter-approved general obligation bonds. Use may be limited to revenue-generating projects.	Special assessment bonds demand interest rates higher than general obligation bonds. Never 100% citizen support. Administrative costs can be high percentage of small project costs. Flexibility of bond issue may be significantly limited by statute.	Necessity for private company to deal with public sector inhibits some applications. Size and application limits restrict use. Local governments hesitate to use because of political problems and fear of hurting credit standing. Interest rates generally highest of all tax-exempt bonds.	Some administrative costs do occur. Therefore, savings must be significant enough to offset this loss.

Source: Briscoe, Maphis, Murray, and Lamont, Inc., Oil Shale Tax Lead Time Study, prepared for Regional Development and Land Use Planning Subcommittee of the Governor's Committee on Oil Shale Environmental Problems, Denver, Colorado, 1974. This chart is a summary of Section 4 of that study.

TABLE RVI-7 (cont.)

Non-Revenue Fiscal Devices for Colorado Local Governments

	LEASING/ INSTALLMENT PURCHASE	NON-PROFIT CORPORATION	SPECIAL DISTRICTS	LOCAL IMPROVEMENT DISTRICTS	GENERAL IMPROVEMENT DISTRICTS
DESCRIPTION	A technique by which local government can acquire equipment or public facilities immediately without the capital funds necessary for outright purchase. Lessor is a private leasing firm or a non-profit corporation.	A relatively new and flexible concept. A non-profit corporation may issue tax-exempt bonds for the purpose of creating public facilities that will eventually become the property of a sponsoring public agency when the bonds are paid.	These quasi-municipal units take several forms. Most are created to deliver a single urban service; e.g., water, sewer, parks. They are governed by a Board of Directors either governmentally appointed or elected by direct vote.	A device by which people in cities and counties can provide certain public improvements in the vicinity of their properties by assessing themselves (thru acts of their government) for the costs of the improvements. It is common for local improvement districts to borrow by issuing special assessment bonds.	A quasi-municipal entity with powers of taxation and borrowing created by a city or town to carry out some public purpose. Governing body of the district is the City Counci. Substantial involvement of tax-payers within the district is required. Debt of the district is not a debt of the city.
PURPOSE	Generally used by local governments facing substantial capital outlays who choose (for various reasons) not to pursue traditional forms of debt financing. Can be used to avoid debt limitation requirements.	To provide public facilities for a governmental agency with tax exempt bonds without creating any debt for the agency benefitted.	Purpose is to deliver an urban service that is not being delivered or cannot be delivered by existing general governmental agencies.	To provide a device by which public improvements benefitting specific private properties can be made without significant governmental expenditures. Private lands are assessed according to benefits received. Less than 100% of project costs can usually be assessed, therefore some general government costs are likely.	To create a quasi-municipal agency which permits taxpayers in certain areas to create certain public improvements without payment from the city. Payments from the tax-payers within the district or revenues from facilities created by the district may support tax-exempt borrowing.
LEGALITY	Legal problems exist, care in usage is necessary. Most local governments have the power to lease. Generally, they must (1) only be bound for 1 year, (2) make rental payment out of yearly revenues, (3) be able to "walk away" at the end of any yearly period.	Use of non-profit corporations as a financing device requires careful attention to legality in Colorado. It is possible that in certain applications, the non-profit corporation acts as an agent in acquiring debt on behalf of the local government.	Special districts are creatures of the state and their powers and creation are provided by express state legislation. County approval of special district creation is necessary.	Use in cities has a long history--legality not a question as long as proper procedures are followed and the specific benefit test is met. Use in counties is relatively new; some problems with bond issues.	Statutes permitting creation of these districts are reasonably long standing and application to parking-related projects should cause few problems. Liberal interpretation of what constitutes a public purpose facility under this district could create untested situations.
CITIZEN OR POLITICAL ACCEPTANCE	Generally, leasing does not seem to attract much public attention. Leasing may be particularly acceptable in a situation where standard forms of debt-backed purchases are turned down by the voters.	Since there has been little use made of the concept, public reaction is not well established. Concern could arise in the areas of (1) evading governmental debt limitations and (2) no election.	Formations are usually lightly noted by the citizenry at time of creation. Landowners see them as a way to permit more intensive use of their land. Conflicts with broad urban service programs ano goals often occur later.	Generally accepted when the facilities built clearly deliver a special benefit. Controversies often occur. Benefits may not always be as direct and positive as some citizens would like.	Should be generally positive if the public purpose facility planned is agreeable to the public. Sufficient tax-payer involvement is required during the procedures setting up the district to gain citizen approval.
ADVANTAGES	Impact on community debt limitations can be avoided if properly structured. No vote required. Lease can be custom tailored to specific need. Lessee may still acquire title to facility at end of lease period. Facilities may be acquired faster than with use of debt financing.	Could provide financing for projects otherwise not financible. Permits use of tax-exempt funds. Protects the debt capacity of the public body. Public body control over the entity is adequate to assure achievement of public purpose. Generally affords much greater degree of flexibility in financing public facilities.	Circumvents problems dealing with political boundaries. Economies of scale can be achieved. Broad geographic view of service need is possible. Relatively easy to create. Can function expeditiously if managed properly.	Provisions for public facilities without general fund tax dollars. Public involvement in "their" project is usually good. Projects lacking public support usually do not get built.	A vehicle to create public purpose improvements when other alternatives may not exist. The ad valorem taxing power vested in the district provides sound financial backing. The legislative body of the city is directly involved in the project to assure continuity with city programs. No city funds need to be spent on the project.
DISADVANTAGES	Interest rates are usually high. Lack of clear definition still clouds some potential applications. Limit to an annual lease is a problem. Implicit interest costs in some installment purchase agreements do not reflect tax exemption of interest payments.	Time requirement to set up project is significant. Conservative local governments may be reluctant to get involved with such new concepts. IRS ruling of tax exempt status on bonds may not always be easy to obtain if public purpose is not clear and simple. Requires significant guidance from fiscal advisor.	Can dilute the powers of local general governments. Not always politically responsive to public. Optimization of a single urban service may be counterproductive to optimizing a broad spectrum of urban services and goals. Seldom responsive to comprehensive planning efforts of local government.	Administrative requirements are substantial and add to the cost. Lapsed time on a project is usually longer than standard government funded project. Assesses some people who don't want or can't afford the project.	District creation is generally accompanied by red tape and administrative time lags. City government must give time and energy to the district even if no city monies are involved. Although the debt incurred is not a responsibility of the city itself, those who are encumbered to assure payment are less free to support costs of other full city obligation projects later.

TABLE RVI-7 (cont.)

Non-Revenue Fiscal Devices for Colorado Local Governments

	REGIONAL SERVICE AUTHORITIES	INTERGOV'TAL AGREEMENTS	REGIONAL REVENUE DISTRIBUTION	INDUSTRY ASSISTANCE TO LOCAL GOV'TS
DESCRIPTION	Political subdivisions of the state formed to meet numerous service needs on a regional basis--recently authorized by state legislation. Requires at least two counties. None exist at present. Created by and limited to services approved by the voters.	Contracts among various levels of government to provide certain urban services or to cooperatively purchase an urban service. One agency or private corporation can provide the service for two or more agencies on some fee basis--powers exist to create broad coverage taxing districts.	Sharing part or all property and other taxes throughout the region regardlesa of location of tax generator.	A multitude of techniques whereby induatry assists local government in delivering a broad range of urban services to citizena; i.e., industry built or financed facilities, purchase of bonds, purchase of short-term paper, third-party leasing, prepayment of taxes.
PURPOSE	Legislative purpose is to utilize single service authorities in providing multi-function services and facilities across local government boundaries to reduce duplication, proliferation, and fragmentation of some urban services.	To permit local government agencies to cooperatively use their powers to effectively deliver and finance urban services. Supports the concept of cooperation between agencies rather than reorganization of political boundaries and entities.	To encourage regional unity and avoid competition. To permit the area to share in the benefits of commercial and industrial growth as well as to deal jointly with complex problems of growth without competing for tax base.	To assist local government in providing needed facilitiea and services when it ia unable or unwilling to provide them on its own. Basic purpose is to eliminate imbalances between service demanda and local governmental resources.
LEGALITY	Constitutional amendment passed in 1970 provides authority. Enabling legislation was passed in 1972.	Enabling legislation is very broad as to powers of local government. This concept lets two or more local governments contractually share those powers including taxation. A broad but underutilized Act.	New legislation would be needed in Colorado. Limitations would be subject to the enabling Act.	Legality problem for local government except for due payment of taxes which raisea many questions.
CITIZEN OR POLITICAL ACCEPTANCE	Substantial citizen concern that RSAs may dilute power of local government. Concept is sound, but citizens have reservations about its workability.	Should be highly acceptable. No new government is created. Existing systems are reinforced.	Subatantial controversy could be expected. Those with the bulk of the anticipated tax base under present circumstances likely will be reluctant to share the revenue source.	Most techniques would elicit positive reaction from local community. Assistance resulting in the creation of a company town may not be acceptable. Generally, moat forms of assistance will be viewed as a commitment to induatry atability and longevity in the community.
ADVANTAGES	Broad view of a specific service is possible. Economies of scale. Circumvention of local boundary problems. Regional tax would create large revenue base. Politically responsive system. Planning for coordination and efficient development of physical, social, and economical elements are required.	No new government is created. Economies of scale. Existing government system is reinforced. Taxing district power gives broad revenue base. Political boundary problems can be avoided.	Regional distribution of monies without an additional layer of government. Funds could flow to population impact points. Maintains the existing fundamental tax structure. Regional solutions to regional problems.	Facilities and servicea become poasible that might not exist otherwiae. Front-end moniea from the community are not required. Induatry commitmenta to assist local government tend to spell atability and a poaitive outlook for the future.
DISADVANTAGES	Viewed as another level of government. May conflict with local government in broad urban service priority exercises. Regional planning requirement may not be supported locally.	Multi-agency agreements for services could cause conflicts when trade-offs are required with other urban services. Regional plan achievement might become more difficult. Competitive forces between local agencies could limit necessary cooperative attitudes.	Formula for distribution could cause controversy. Affluent counties would be "giving up" funds to their less fortunate neighbors. Erosion of one more power of local government for those desiring local autonomy.	People who make voluntary contributiona tend to attach restrictions to the "gifts." The "Big Brother" image could be created. A company town could be competitive with existing centera. Places demanda on induatry and resourcea that are not directly related to production or profit.

projected flow of revenue payments so that the states and local communities could borrow against these revenues." Assuming that these suggestions are approved by Congress, State enabling legislation would have to be revised to remove the 200 thousand dollar maximum disbursement limitation. If all of these legislative actions were taken, the tax-lead time problem could be further resolved.

Federal discretionary funds may also be available to impacted counties and communities for social program funding. The Departments of Health, Education and Welfare, Housing and Urban Development, Labor and Transportation, the Bureau of Outdoor Recreation, and the Farmers Home Administration each have various finding authorities that may be able to help finance new social support facilities. The 1974 Catalog of Federal Domestic Assistance (Office of Management and Budget 1974) provides a detailed description of the assistance that may be provided by these agencies.

The proper implementation of subdivision regulations in effect in each county of the study region would assure that new housing developments are provided with adequate water and sewer facilities, streets, parks, and land dedicated to school facilities. Application of these regulations would help mitigate impacts to the quality of life in the study region.

New demands for social support facilities that would result from the proposed Federal action imply new land requirements for these facilities. State and local governments could acquire Federal land for these facilities either by exchanging property (43 CFR 2200) or by lease or patent (43 CFR 2740). Except for Hayden all potentially impacted population centers are near or adjacent to tracts of Federal land that could be acquired under these regulations. Acquisition of such tracts could help mitigate demands for new social support facilities.

The degree to which all of the above mitigating measures for social impacts need be applied is a function of the expected population growth. The population projections in this Regional Analysis are subject to errors resulting from uncertain input data. To remove these data-related uncertainties proponents of new coal developments in the study region should be encouraged to inform concerned Federal, State and local agencies of the nature of their proposals. Planning by concerned government authorities for social impacts of coal-related developments could be more successful if locations, start-up dates, and employment levels could be provided by proponents of coal-related development with as much advance notice as possible. Many social impacts could be mitigated if the problems could be appreciated prior to actual coal development. Anticipation and management of these impacts is properly the function of municipal and county planning departments, county commissioners and city councilmen. By the continuing efforts of these local officials to maintain contacts with the applicants and with State and Federal agencies, many of the adverse social impacts could be avoided.

Economic Conditions

One element of the expected increase in the cost of living impact is speculative increases in home prices and rental rates. This impact could be mitigated to some extent if, in the processing of zoning amendments and building permits for new subdivisions, the county commissioners stipulated that a certain percentage of the development be devoted to low income dwelling units. This practice is already used in Boulder, Lakewood, and Aurora, Colorado.

Another mitigation to the cost of living impact could be implemented through the timely county or municipal approval of building permits for new retail establishments. This action would allow market forces to limit price increases through competition between several retail outlets.

Potential impacts associated with disequilibrium in the labor market for coal-related employees could be mitigated to some degree if a central clearing-house for new employment opportunities, such as the Job Service of Colorado Program (Colorado Division of Employment), could be used universally by proponents of coal-related development for filling new jobs.

Chapter VII

Adverse Impacts Which Cannot Be Avoided

THIS CHAPTER PRESENTS THE RESIDUAL ADVERSE IMPACTS THAT WOULD REMAIN AFTER APPLICATION OF THE MITIGATING MEASURES DISCUSSED IN THE PRECEDING CHAPTER. THE FOLLOWING DISCUSSION COMPLETES THE ANALYSIS EQUATION: IMPACTS MINUS MITIGATIONS EQUALS ADVERSE IMPACTS WHICH CANNOT BE AVOIDED.

CHAPTER VII

ADVERSE IMPACTS WHICH CANNOT BE AVOIDED

Geologic and Geographic Setting

Topography

Adverse environmental effects which cannot be avoided under the proposed mining plans would include alteration of the surface at and near the mine sites from its present natural contours and landforms to a mixture of natural and artificial forms. Small intermittent streams could not be reestablished in the mined areas because of slight topographic changes, and thus would be modified; presumably they would be replaced by man-made drainages where they cross the mined area. Locally the course of the main streams would be altered, as at Energy 3 mine where Fish Creek's meanders have been changed to a wide curving channel.

Whereas natural landforms are in equilibrium with degradational processes of the present environment of northwest Colorado, an undetermined period of time would be required for manmade ones to reach such an equilibrium. Thus different rates and modes of degradation by erosion, mudflows, landslides, slumping, etc. may be expected from the reclaimed areas than from the remainder of the areas mined. These rates would accelerate in proportion to the lack of care used in the mine reclamation.

The proposed W. R. Grace railroad would adversely affect the environment in that it would be a permanent fixture on the landscape, with its attendant cuts, fills, and river channel changes. The river channel changes on the Williams Fork (Route C) would shorten its course slightly, thus increasing its velocity and erosive power; the deep cuts would materially alter the nature of Williams Fork Canyon. If Route A were chosen, moving the Yampa River's channel slightly by piling sub-base materials along steep parts of its bank could not be avoided and would modify this river's character. If either Route A or B were chosen, the nature of Milk Creek would be changed substantially because of the necessary modifications of the narrow and rocky canyon.

Paleontology

Because of the variety of fossil forms lying in close proximity to and within the region's commercially valuable coal beds (Wasatch, Fort Union, Lance, Williams Fork, and Iles formations), some would be destroyed. Because of the questionable scientific and low economic value of most of these fossils, their loss is not considered significant. The economics of time delays requried for paleontological analyses and of requiring a full-time paleontologist at a mine precludes having expertise always available to assess fossil evidence as it is unearthed. All impacts would be directly proportional to the acreage disturbances referenced in Chapter V, and they would be directly linked to those occurring on fossil-rich formations.

Depletion of fossils by recreational collecting would not be mitigated. Significant impacts of this type would result from rockhounds illegally collecting vertebrate fossil remains, such as dinosaur bones.

Mineral Resources - Coal

The major environmental impacts that cannot be avoided as a result of the proposed action are the removal of approximately 340 million tons of coal reserves over the next 15 years.

Water Resources

Ground Water

The loss of habitat that results from destroying areas of ground water discharge would not be mitigated until those areas are reestablished. This would temporarily reduce the population of amphibians and aquatic invertebrates in the area, and if it is not deemed desirable for management purposes to replace this water source the reduction in numbers of amphibians and aquatic invertebrates would be permanent.

Surface Water

Sediment yield and dissolved solids

There would be unavoidable increases in sediment as a result of the mining and associated activities. Mitigating measures would control most of the problem but some sedimentation is unavoidable.

Tables RVII-1 through 3 show estimates of residuals of total sediment yield after mitigation for the periods 1976-80, 1981-85, and 1986-90. Computation methods are detailed in Appendix D.

TABLE RVII - 1

Residuals of Sediment Yield after Mitigation

1976-1980

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	4,825	22,100	90	19,900	2,200
Surface mines, revegetated	1,434	770	50	380	390
Underground mines	200	430	90	390	40
Power plants	1,000	2,150	80	1,730	430
Roads, new	420	1,930	80	1,540	390
Roads, revegetated	250	270	50	140	130
Railroads, new	420	4,000	80	3,200	800
Railroads, revegetated	420	1,150	50	580	580
Population	1,070	2,310	60	1,390	920
Mine facilities	400	1,840	90	1,660	180

TABLE RVII - 2

Residuals of Sediment Yield after Mitigation

1981-1985

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	9,470	43,500	90	39,200	4,300
Surface mines, revegetated	7,528	6,000	50	3,000	3,000
Underground mines	300	650	90	580	70
Power plants	1,000	2,160	80	1,730	430
Roads, new	1,150	5,280	80	4,220	1,060
Roads, revegetated	850	1,590	50	800	790
Railroads, new	60	320	80	260	60
Railroads, revegetated	480	10,400	50	5,200	5,200
Population	0	0	60	0	0
Mine facilities	300	1,380	90	1,240	140

TABLE RVII - 3

Residuals of Sediment Yield after Mitigation

1986-1990

Activity	Total Acreage Disturbed (acres)	Total Sediment Yield (tons)	Estimated Percent Mitigation	Sediment Yield Decrease Due to Mitigation (tons)	Residual (tons)
Surface mines	9,670	44,400	90	40,000	4,400
Surface mines, revegetated	9,596	17,300	50	8,650	8,650
Underground mines	0	0	90	0	0
Power plants	1,000	2,160	80	1,730	430
Roads, new	1,385	6,360	80	5,090	1,270
Roads, revegetated	1,130	4,190	50	2,100	2,090
Railroads, new	1,020	5,510	80	4,410	1,100
Railroads, revegetated	1,500	34,600	50	17,300	17,300
Population	120	260	60	160	100
Mine facilities	500	2,300	90	2,070	230

Total dissolved solids would also increase as a result of activity associated with the coal mining; namely, the activation of new steam generating power plants. These plants, Craig 3 and 4, would consume an estimated 12,000 acre feet of water annually by 1985 due to evaporation. This evaporation for cooling purposes would leave behind a residue of dissolved solids which is thus removed from the hydrologic system, and the loss of the water and salt from this system would ultimately result in an unmitigatable increase of 1.7 mg/l in the concentration of dissolved solids in the Colorado River below Hoover Dam. This increase would constitute a permanent and irreversible impact if the proposed coal mining action is permitted. This increase in dissolved solids is indicated in Table RV-1.

Air Quality

Air quality during the proposed development would be degraded in terms of all presently regulated pollutants; suspended particulates, sulfur dioxide, carbon monoxide, nitrogen oxides, reactive hydrocarbons, and oxidant. Although emissions controls are proposed at the power plants and mines and vehicular emissions are regulated, adverse environmental effects could not be avoided.

Emission control devices planned for the proposed power plants would be designed to remove major amounts of sulfur dioxide, particulates, and unknown amounts of other elements including phosphorous, selenium, arsenic, mercury, and fluoride, and to control the release of nitrogen oxides within emission standards. Materials that are removed would then appear in the bottom ash, flyash, and scrubber waste. The balance would be emitted to the atmosphere.

Proposed emission levels are equal to or below Federal and State standards, but do represent an unavoidable degradation of existing air quality. The emission of fine particulates and conversion of sulfur and nitrogen oxides to aerosols would cause a visibility reduction that could not be mitigated.

The coal that would be burned contains small amounts of trace elements and radionuclides, some of which would be released to the atmosphere during the operating life of the plant. Although emission levels and ground level concentration of these elements are predicted to be low, and within or below measured ambient air levels, pathways through the ecosystem of many of the elements are not well defined.

Visibility in the vicinity of mines would be decreased because of mine air pollutant emissions, primarily fugitive dust. Estimates indicate that total suspended particulate regulations would be exceeded near the center of the largest proposed surface mines. No other degradation in excess of standards is expected due to mining alone.

Proposed mining and power plant activities would require a large labor force. Exhausts from cars transporting personnel to and from work would be the primary source of hydrocarbons and carbon monoxide. In addition, coal support facilities and transportation systems would add to the background of these pollutants.

The labor force and their families would require the services provided by urban development. Pollution generated by increased population is expected to increase sulfur dioxide emissions by 1.9 tons per day and particulate emissions by 2.4 tons per day above present levels. These emissions associated with urban development would be an unavoidable addition to background levels leading to further degradation of existing air quality. Although the Federal sulfur dioxide standard would not be threatened by these emissions, the Federal total suspended particulate standard of 75 ug/m^3 would be exceeded in Steamboat Springs, Craig, and Meeker.

Soils

Disturbance of soil (including topsoil) on approximately 39,210 acres (0.7 percent of the study area) by 1990 would occur with implementation of mining activities (Table RV-12). This acreage would be occupied by mines, roads, railroads, mine buildings, transmission lines, power plants, urban development, and associated facilities. The natural soil productivity of the area would be lowered, to some degree, by soil disturbances such as compaction, mixing natural soils, and water and wind erosion.

On the area to be strip mined (23,965 acres by 1990), complete destruction of all soil horizons, parent material, and soil characteristics which have developed over long periods of geologic time could not be avoided. The present soil biota and soil-forming processes would be drastically altered. Once mining is completed and the area reclaimed, soil development of weathered and unweathered soil materials would start again. As an end result of mining, new soils would be forming with characteristics unlike the ones that existed prior to mining, and during their early geologic life would likely be less suitable to support vegetative cover similar to adjacent areas.

Reduction of soil productivity, permeability, and infiltration rates would be unavoidable. Increase in erosion and sedimentation rates would occur; estimates of total sediment yield after mitigation are shown in Tables RVII-1, 2, and 3.

Terrestrial Flora

Approximately 39,210 acres of existing vegetation would be unavoidably destroyed by 1990 as a result of the following coal related activities:

roads, railroads, power plants, powerlines, mine facilities, mining, and urbanization. Vegetation would be permanently removed on approximately 10,345 acres by roads, railroads, power plants, mine facilities and urbanization (Table RV-12).

The existing stage of plant succession would be unavoidably destroyed when vegetation is removed. Return to native vegetation or a self-sustaining ecosystem would depend upon the speed and success of reclamation efforts and natural succession. Since most of the mining companies plan to return only a few native species, return to native vegetation would depend almost entirely on natural succession.

The soil and micro-climatic conditions produced after mining might be very different from existing conditions, thus making it impossible to establish and sustain native vegetation. On spoils where topsoil was not replaced and only minor shaping was done, very little invasion of native species has taken place in 10-15 years (Chapter III Regional Analysis); if replacement of topsoil does not encourage invasion, loss of existing vegetation would be a permanent unavoidable impact. Even on areas successfully revegetated, a 10 percent reduction in productivity has been projected.

Terrestrial Fauna

Loss of habitat for a variety of wildlife species and the subsequent reduction in numbers of animals would be unavoidable if coal development in northwestern Colorado continues. The permanent loss of 10,345 acres of wildlife habitat resulting from the construction of powerplants, roads, railroad, mine facilities and urbanization would be unavoidable. The additional temporary loss of 28,865 acres of habitat resulting from mining operations and related activities between 1976 and 1990 would also be unavoidable with present strip mining practices (Table RV-12).

Direct impacts on both wildlife and domestic fauna that would be unavoidable include the deaths resulting from the construction of roads, power plants, powerlines, urbanization, and mining activities. These losses could not be avoided because of the large number and variety of animals involved.

Some loss of watering sites would take place in the region and total mitigation of this loss would be impossible. Such loss of watering sites would alter use areas of both domestic and wild fauna, reduce reproductive effectiveness of amphibians, and change the food web as associated with invertebrates and their use of these areas.

The increase in vehicle-animal collisions would be unavoidable due to increasing human population and vehicular use. ORV use would most certainly increase with a resultant unavoidable loss of animal habitat and increase in harassment.

The alteration or complete destruction of several segments of northwestern Colorado's ecosystem would be unavoidable as a result of the disturbance of soils, vegetation, and faunal food webs.

Aquatic Biology

There would be unavoidable local increases in sedimentation and loss of aquatic habitat resulting from the proposed mining activities.

The effects on water quality of this localized increase in sediment loading in streams would not have any major regional impacts. Thus a discussion of the effects of stream sedimentation increases resulting from the proposed mining activity is restricted to the site specific analysis segments of this statement.

Potentially, the most significant impact on the regional aquatic ecosystem would result from the failure to adequately mitigate sedimentation increases in the Yampa and/or Williams Fork Rivers caused by construction of the proposed W. R. Grace railroad. The Yampa River, from Craig to its confluence with the Green River in Dinosaur National Monument, is known to contain existing and potential habitat for four endangered fish species: the Colorado squaw-fish, bonytail chub, humpback chub, and humpback sucker. Consequently a significant increase in sedimentation resulting from the proposed railroad construction would constitute a violation of the Endangered Species Act of 1973 (Public Law 93-205, 93rd Congress, S. 1983, December 28, 1973).

Some unavoidable regional displacement of individual aquatic organisms in the Yampa River would occur as a result of the proposed railroad construction. Also, many organisms would perish, particularly members of the sedentary benthos community, due to the resulting adverse environmental impacts and the increased human population.

All other unavoidable impacts (e.g., increase in total dissolved solids in streams) as discussed in the site specific analysis would be localized, with no anticipated regional impacts.

Archeological Resources

Sites evaluated in intensive surveys as being ineligible for inclusion in the National Register, and therefore unworthy of further archeological study, would be destroyed directly by coal-related actions, though they may have local human-interest value. Others that are significant would be salvage excavated in an attempt to save the resource. However their in-place value would be lost, as well as their value as a future reservoir of archeological data. Impacts due to archeological excavation could not be mitigated. Destruction of unidentified surface values and unknown subsurface resources would also be unavoidable; the significance of this impact would depend upon the nature of the unknown resource.

Other cultural sites would be impacted due to the proximity of coal-related developments. For example, the mood-atmosphere values of a Fremont-age pictograph would be impacted by a railroad alinement 30 yards distant.

Increased vandalism and pothunting of archeological resources could be partially mitigated by withholding site location information, but these illegal activities would continue at relatively the same rate per capita as at present. The resulting increase in vandalism commensurate with population increase is unavoidable.

Historical Resources

As with archeology, historical resources that are evaluated as either not warranting further study or ineligible for inclusion in the National Register would be destroyed or damaged directly by coal-related development operations. Significant sites may be excavated, disassembled, and reconstructed at another site to salvage the resource; however, the on-site value of the resource would be an unavoidable loss.

Historical features lying in close proximity to proposed developments would be impacted by a loss of mood-atmosphere or interpretive values; for example, the first homestead in an area would be unavoidably impacted by a surface mine operation adjacent to it.

Pothunting and vandalism of historical features would continue at approximately the same rate per capita as presently occurs; this increase in vandalism due to population growth is unavoidable.

Impacts to existing and potential National Register sites would be mitigated by interpretive signing and protective fencing. One exception is the former Thomas Iles Ranch; it could be unavoidably impacted by the proposed W. R. Grace railroad. See the site-specific analysis for the detailed impact analysis.

Land Use

A major impact to land use that could not be avoided would be the loss of the existing use due to mining for a certain period of time or indefinitely. More permanent facilities such as roads, railroads, and office and shop buildings would constitute lasting commitments in land use, whereas the larger strip mined areas should be more temporary and would revert back to the former grazing or agricultural uses. While the land is disturbed due to mining or related uses, farming and grazing and some recreation and right-of-way uses would have to be deferred. Losses during these deferred periods of use would be in terms of AUMs, tons of hay, and bushels of grain which all have monetary value that can be calculated at the conclusion of the deferred period. Losses in right-of-way uses would be mainly in terms of inconveniences in rerouting, crossings, etc.

Aesthetics

If all suggested mitigations are employed, the net residual of adverse impacts would be significantly reduced. However, for all practical purposes several visually incongruous elements, or minus deviations, would be unmitigated. Proposed coal development in northwest Colorado would significantly alter the existing landscape character and its inherent aesthetic values.

The visual impact of surface mines themselves could only be partially reduced. Until successful reclamation occurs, impacts of the mining operation itself would be unavoidable. Reclamation would reduce most of them; however operations would not always be restricted from steep terrain. Earth-moving equipment simply could not negotiate slopes that are too steep, such as steep cut and fillbanks on roads; this severely hampers reclamation efforts.

Surface facilities at both surface and underground mines, as well as powerplants and many elements of urban development, could not completely borrow from the characteristic landscape features. Buildings, mine portals, tipples, emission stacks, and yarding areas contain inherent elements that could never totally blend with adjacent terrain; painting with special colors, careful attention to architectural design, and screening techniques would only partially mitigate their impacts.

Roads, railroads, transmission lines, and other rights-of-way have inherent features whose strong line-dominance is never totally mitigated. Often the most aesthetically suitable alinement would not be achieved. Those rights-of-way constructed on steep side-slopes, or in bedrock material, or those which fail to borrow from naturally occurring line-dominant features would unavoidably adversely impact the aesthetic environment. Specific combinations of topography, vegetation and soils would not always achieve as effective a mitigation as would be possible under ideal conditions.

All dust, air pollution and noise impacts could not be totally mitigated. Size of the proposed action areas, adverse wind, nature of overburden blasting and coal loading procedures, would make total dust, air, and noise control unfeasible. Total control of suspended particulates at housing developments in urban areas would not be feasible either. The result would be visual impacts in the form of haze and smog.

Economic considerations could make ridgetops or alluvial bottom mining highly desirable, and the responsible decision-maker may fail to exercise aesthetic controls.

Impacts on the region's mood-atmosphere values of isolation, solitude, and inspiration could not be completely mitigated. Where important natural values have been identified (see Chapter IV, Regional Analysis) there would be significant unavoidable impacts. For example, natural values in the Skull Creek Area would be significantly impacted by the proposed Moon Lake power plant.

The relative value of these unavoidable adverse impacts would depend on the visual exposure of the landscape visual units in which they occur. The most severe impacts would be those that can be viewed most directly, for the longest travel time, from the greatest number of points, and at the closest distance.

Major U.S. and Colorado highways provide visual access throughout the region. In addition, all proposed action areas are traversed by several county roads. Regularly scheduled commercial flights on Frontier Airlines into Hayden and Rocky Mountain Airways into Steamboat Springs and Craig would provide passengers with views of the region at moderately low altitudes.

The cumulative scale of the proposed development compared to present developments in the region is rather large; total cumulative acres disturbed by 1980 would be 9,385, by 1985 would be 23,415, and by 1990 would be 39,210. The cumulative area revegetated would equal 1,854 acres by 1980, 10,712 acres by 1985, and 22,198 acres by 1990, though it should be noted that revegetation does not constitute complete removal of aesthetic impacts. In terms of acres of surface, the area permanently removed from production would equal 3,510 by 1980, 6,320 by 1985, and 10,345 by 1990 (see Table RV-14).

Recreation

For all practical purposes, it is unrealistic to assume that impacts upon essentially urban-oriented recreation activities or facilities would be completely mitigated. The fact that deficits presently occur for several recreation activities, plus logistical problems of providing front-end monies for site development well in advance of population increases, indicate that these impacts would be at best only partially mitigated.

Recreational demands for activities and facilities would increase each benchmark year in Routt County (State Planning Region 12). But in Moffat and Rio Blanco Counties (State Planning Region 11), there would be a substantial decrease in demand in 1985 following the greatest need in 1980. Recreation-providing entities would be reluctant to develop recreation facilities to meet the 1980 peak demand when some of them would not be needed in 1985 and 1990; this adverse impact could not be avoided.

Increased demand for open space, off-road-vehicle (ORV) use, rockhounding, pothunting of cultural resources (theft and vandalism) would not be mitigated; no effective means are available to adequately control resource deterioration that results from increased dispersed recreation use. Impacts to the recreational capabilities of natural, primitive, and other areas with significant mood-atmosphere values would result from increased recreational use of the public lands as well as from subsequent resource deterioration. Open space acreage that would be at least temporarily lost by 1980 would total 9,385 acres; this would increase to 23,415 acres by 1985, and to 39,210 acres by 1990. Revegetation of several acres would be accomplished by each benchmark year, though its open-space character could still be lost (with electric transmission lines, for example). Unrevegetated acreage disturbances would total 7,531 by 1980, 12,703 by 1985, and 17,012 by 1990.

Permanent open-space acreage losses would total 3,510 by 1980, 6,320 by 1985, and 10,345 by 1990 (see Table RV-14).

Impacts to wildlife hunting and viewing potential would remain during the actual coal removal operation; however they may be improved in localized areas through successful reclamation efforts. Loss of wildlife hunting and viewing opportunities due to acreage disturbances could not be mitigated; secondary impacts to wildlife's recreational capabilities on adjacent areas in the form of increased hunting pressure could only be mitigated by seasonal changes or license restrictions if hunting is the population's limiting factor. However, this has not yet been determined (see Terrestrial Fauna).

Stream classifications by the Colorado Department of Health permit fecal coliform levels in the lower Yampa River exceeding those acceptable for primary contact recreation. Although coliform levels are currently under the limits, no regulations nor laws guarantee that they will remain safe. When the water quality exceeds the limits established for safe primary contact, recreation eligibility of this segment of the Yampa River (within the boundaries of Dinosaur National Monument) for inclusion in the Wild and Scenic Rivers System would be either reduced or canceled (see Chapter V).

Increased maintenance and overhead costs incurred by all developed recreation areas and sites could not be mitigated. Greater demand for and subsequent use of these areas would not be avoided; when visitor-use levels exceed recreational carrying capacities, a decline in the visitor's enjoyment as well as in the site or area's productive capacity would occur.

Destruction of recreational values inherent in cultural resources could not be totally avoided by conducting reconnaissance surveys because significant values may lie below the surface (see Chapter VII, History and Archeology).

The relative significance of all adverse impacts is determined by the availability of similar recreation resources in the region. Impacts would also be more severe when they occur to existing, rather than potential, public recreation resources (i.e., in terms of existing public access to them).

<u>Social Environment</u>

The proposed actions would generate population peaks, followed by declines in the early 1980s in Moffat and Rio Blanco counties; therefore during the period of population decline there could be under-utilization of those social support facilities built to meet peak demands. If the facilities are constructed to meet more stable population levels in the latter part of the study period, there would be over-utilization of facilities during the peak.

Based on the results of opinion surveys (cited in the social impacts section) seventy-five percent of present residents of Craig and Meeker would be displeased with the rate and level of population growth to which coal-related development would contribute. The small-town atmosphere of many communities would be lost forever, as population densities, traffic volumes, air pollution, and administrative bureaucracies increase. Some degree of permanent housing shortages and increases in crime rate, over and above existing rates, would not be avoided.

Economic Conditions

The section covering mitigation of economic impacts indicated that through anticipation of and planning for the economic shocks associated with the proposed action, some shock elements would be avoided; however some adverse economic impacts would not be mitigated. Some increases in the cost of living, over and above normal rates, would be expected as a result of rapid injection of new purchasing power in the regional economy. This unavoidable inflationary impact would most seriously bear on people with fixed incomes (usually retired people), and those people in the lower income brackets. This latter group is traditionally employed in the service sector where many wage compensations are equal to or slightly greater than the minimum wage. The disparity between wages of established workers and new employees associated with coal development would inevitably cause some labor turnover and loss of productivity impacts.

Transportation Networks

All transportation facilities within the study region would experience increased load demands during the time frame covered in this report. Existing highways would be especially over-used during the early stages of coal development because railroad facilities would not be developed adequately enough to sustain additional quantities of coal. Towards the latter stages of the time frame (1981-1990), the railroads would begin to relieve some of the traffic pressure from the highways. During periods of increased highway traffic (1976-1981), there will be an associated increase in road maintenance costs and traffic accidents. As railroads become established, the region would begin to experience higher levels of train traffic, rail maintenance, noise levels near residential areas, train/car accidents, and other associated construction needs.

railroads become established, the region would begin to experience higher levels of train traffic, rail maintenance, noise levels near residential areas, railroad accidents, and other associated construction elements with the proposed action; some of these elements would be avoided; however some adverse economic impacts would not be mitigated. Some increases in the cost of living, over and above normal rates, would be expected as a result of rapid influx of new purchasing power in the regional economy. This accelerated inflationary impact would most seriously bear on people with fixed incomes (usually retired people), and those people in the lower income brackets. This latter group is traditionally employed in the service sector where wage rate increases are equal to or slightly greater than the minimum wage. The disparity between rates of established workers and new employees associated with coal development would result in some labor turnover and loss of productivity, however.

Transportation Networks

All transportation facilities within the study region would experience increased road traffic during the time frame covered in this report. Existing highways would be operating over-capacity during the early stages of coal development because improved facilities would not be developed rapidly enough to handle additional quantities of coal. Towards the latter stages of the time frame (1985-2000), new railroads would begin to relieve some of the traffic pressure from the highways. During periods of increased highway traffic (1980-1985), there will be an associated increase in road maintenance costs and traffic accidents. As

Chapter VIII

Relationship Between Short-Term Uses and Long-Term Productivity of the Environment

THIS CHAPTER DISCUSSES THE EXTENT OF LONG-TERM IMPAIRMENT OR ENHANCEMENT OF RESOURCE VALUES THAT WOULD OCCUR, GIVEN THE SHORT-TERM USES OF THE ENVIRONMENT. IN THIS ANALYSIS OF TRADE-OFFS OVER TIME AND TRADE-OFFS AMONG RESOURCE VALUES, SHORT-TERM REFERS TO THAT PERIOD WHEN SUBSTANTIVE PARTS OF THE PROPOSED ACTION TAKE PLACE. LONG-TERM IS THAT PERIOD IN WHICH SUBSEQUENT IMPACTS, BOTH ADVERSE AND BENEFICIAL, STILL AFFECT THE ENVIRONMENT.

CHAPTER VIII

RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

Geologic and Geographic Setting - Paleontology

Impact on paleontological resources would happen both in the short-term and the long-term. Impacts resulting from coal-related developments themselves, plus impacts due to rockhounding, would cause the impacts to be greatest during the short-term. After mining operations cease, the additional people in the area would continue to collect fossils, resulting in a long-term impact.

Options for future use of paleontological resources would be foreclosed by destruction and appropriation of them in both the short and long-term. However the operation itself could disclose knowledge of fossils heretofore unknown; this would create options for future generations to benefit from the newly-found resources.

Mineral Resources

The short-term use of the coal resources of this region by the proposed actions would be relatively rapid mining by use of large equipment, such as draglines, in methods currently envisioned for use. Although allowing for more rapid and possibly more economical recovery, these methods are commonly considered to result in the loss of about ten percent of the mined bed(s). They also generally result in the loss of nearby overlying and underlying beds of coal which are considered by the operators to be too thin to recover economically, but which could be recovered by slower and more careful methods. Future methods may be devised by which the loss in mining could be minimized.

Water Resources

Ground Water

There would be no changes in the ground water due to mining coal that would impair the long-term productivity of the environment.

Surface Water

Water courses in and adjacent to mine areas are subject to impacts throughout the operation of the mine and for many years after mining ceases, at least until reclaimed areas can stop erosion. Small water courses would be destroyed during the mining operations; they would be replaced during natural runoff as new channels erode. The cutting of new channels would in itself produce sediment, and carefully placed and constructed ponds must be maintained to catch and hold the sediment in the mine area to prevent it from affecting more than the local area or reach of stream.

Erosion would occur because it is a natural phenomenon, but it need not be considered an entirely adverse condition as long as it can be controlled. As the ponds lose their capacity to hold water, they may be abandoned and others constructed to provide necessary water supplies. Vegetation should take hold in the sediment because it would come from soils that are generally free of toxic minerals. Spreader systems of small dams and dikes have been established successfully in other areas to trap water and sediment to provide an environment for vegetation. Thus proper management of runoff from disturbed areas can be beneficial to long-term productivity even in the immediate vicinity of the mining operations.

Air Quality

Assuming that land surfaces are reclaimed and returned to an equivalent of the pre-existing vegetative cover and general contours, air pollution resulting from mining activities would be a short-term phenomena; that is, it would occur only during active mining. Air pollution from vehicle exhausts and fugitive dust after mining is complete would also depend on the subsequent use of the land. Access to the properties involved will have been established. Lack of complete reclamation, specifically vegetative cover and erosion protection, could cause blowing dust to be a continual problem.

The residence time of the primary power plant emissions, sulfur dioxide, nitrogen dioxide, and particulates, varies from a few hours to a few days. Therefore duration of air quality deterioration is expected to coincide with the duration of the emissions source.

The long-term effects of air quality deterioration due to increased urbanization are difficult to determine. If the labor force remains in northwestern Colorado after major coal mining operations are completed urban background pollution will not recede. Furthermore re-employment might imply new sources of industrial emissions.

Soils

As a result of the alteration of the soils due to the proposed action, long-term productivity of the soils in the study region would decline. Some of this decrease in productivity would result from accelerated erosion on denuded and disturbed areas; however by far the greatest loss would be the alteration or burying of existing soils by the activities associated with development of northwestern Colorado coal. Other losses would result from topsoil stockpiling procedures and its replacement over the shaped spoil. Soil development is a slow process under the best conditions; the semi-arid climate of most of this region increases the time needed for soil development, thus magnifying the short-term impact on the long-term productivity of the area. Loss in soil productivity would be a long term loss on the 39,210 acres of land disturbed by 1990 (Table RV-12).

Terrestrial Flora

The short-term use of the environment for coal development would result in the total destruction of vegetation on 39,210 acres by the following activities: roads, railroads, power plants, powerlines, mine facilities, mining, and associated urbanization.

Vegetation would be permanently destroyed on approximately 10,345 acres by 1990, and would never be returned to production. The short-term uses would produce a long-term impact on the vegetation in that existing ecosystems would be destroyed, and would not be returned (Table RV-12).

The long-term productivity of the reclaimed land after mining is estimated to be 10 percent below current production, and will depend upon the success of current reclamation practices and the diligence of the mining companies.

Terrestrial Fauna

Wild Fauna

Permanent loss of 10,345 acres of wildlife habitat and temporary loss of an additional 28,865 acres, with most of it eventually drastically altered from its present species composition and density, would cause a change in the short-term use of the region (Table RV-12).

Mule deer carrying capacity would be reduced by over 900 animals and might never fully recover to present numbers. Elk would experience a decline in carrying capacity followed by an eventual increase to or beyond the present use. Antelope and sage grouse would both exhibit a reduction in short-term use and would never recover to present levels of productivity.

Wildlife species that are primarily associated with sagebrush, shrubs, and trees would experience a reduction in short-term use within the region and would never recover to full productivity because of permanent alteration or loss of habitat. Those species associated with grasslands and agricultural areas would have a reduced short-term use, but long-term productivity should be expanded because of the proposed increase in these two vegetation types from revegetation efforts (see Appendix D for a species list by habitat types).

In addition to habitat destruction the influx in human population would create a new set of environmental impacts. Human activity would result in wildlife harassment and animal loss due to increased recreation pressure within the impact region. Many species such as elk, coyotes, and fox would retreat from the areas of extensive human use even if no physical habitat destruction takes place. Other species such as house mice, English sparrows, and several species of bats would show an increase in productivity.

Aquatic Biology

The loss of endangered species habitat in the Yampa River that could result from the proposed W. R. Grace haul railroad construction is considered as a loss in long-term productivity of the environment. Every activity of man which adversely impacts endangered species habitat does irreparable harm to efforts to save these species from extinction. The Yampa River is possibly the last remaining habitat supporting spawning populations of these four endangered fish species.

Archeological Resources

The greatest impacts would be those unavoidably occurring during the short-run resulting from actual on-the-ground displacement, excavation and vandalism. After cessation of mining operations, vandalism, and pothunting would continue to be a problem in the long-run.

Destruction of archeological sites by any means foregoes options for future generations at the rate of resource destruction, which is significantly greater during the short-term, but also continues after project completion.

However, required intensive cultural surveys could reveal presently hidden values; this would create options for future generations to benefit from the newly-found resources.

Historical Resources

The relationship between the short-term use and long-term productivity of cultural resources will be the same for historical resources as for archeological values.

Land Use

Except for lands more or less permanently removed from livestock forage and crop production, short-term mining use would restrict grazing and farming at least 2-4 years including the actual mining time. This period of lost production is a very small amount of time compared to the indefinite period of use that will occur after mining. However to the individual farmer or livestock operator, who may be in business 30 or 40 years, the period of non-production would be more significant and represents a higher percent loss in income derived during the life of this business. Monetarily speaking, short-term mining use would add significantly more income to the national economy than grazing or farming use on the same land.

In some cases long-term productivity would be increased because of the methods of reclamation. Some lands presently grazed would be later converted to crop production, which is considered to be a higher use of the land. In addition, existing grazing lands may be improved by revegetating areas to grass and other plant species more palatable to livestock. If reclamation is not done properly, it is likely that long-term productivity would never reach levels that exist now or have existed in the past.

For permanent facilities such as roads, railroads, buildings, etc., long-term productivity would be gained through values the facilities add to the land rather than forage or crop production. Such values may be greater than those of existing uses.

Aesthetics

No specific benchmark year can be cited for the short-term; proposed action time frames vary considerably. If the suggested mitigating measures are incorporated, adverse aesthetic impacts would be reduced significantly during the proposal actions' duration; however, unavoidable impacts would be most severe during the short-term. Cessation of proposed coal development would begin the long-term, in which unavoidable adverse aesthetic impacts would still remain. The residual would decrease with the passage of time as the region approaches its original productivity; examples of long-term mitigations include gradual weathering of road cuts and fills and ecological succession of disturbed areas. For all practical purposes all unavoidable adverse aesthetic impacts (see Chapter VII) would not be eliminated in the long run.

Recreation

"Short-term" encompasses the time-frame of the proposed action; this varies widely and cannot be referenced to any one benchmark year (for example, see the site specific analyses). Short-term recreation impacts would be the most adverse as population growth rates would be highest at that time; this is especially true from 1975-1980. Lower population growth rates from 1980-1990 would result in smaller incremental increases in recreation use in State Planning Region 11. Region 12 would experience slightly larger recreation growth increments during each successive benchmark year (see Table RV-23).

Projections of total disturbed acres indicate that resulting short-term recreational impacts would increase slightly during each benchmark period.

The ability of recreation managing agencies and organizations to respond to rapidly growing demands would be most limited during the initial growth period, 1975-1980; lack of front-end monies and the large initial demand increase up to 1980 would be the greatest obstacles to overcome to meet initial short-term recreation demands. Tax lead time gained during the five-year period ending in 1980 would help municipalities and local governments satisfy demands for urban recreation after 1980; the decrease in demand from 1980 to 1985 in Moffat and Rio Blanco Counties would also help decrease the recreation supply deficit. Therefore urban recreation supply deficits should become even smaller during the 1985-1990 interval.

The recreation supply-demand deficit should become smaller in the long run; a larger tax base and greater tax lead time would help meet increasing demands.

Increased off-road vehicle use potential, additional geologic-industrial interpretive capabilities, additional rock-hounding potentials, and wildlife viewing opportunities would improve recreation capabilities on a long-term basis; new surface mine operations would become significant recreation attracitons for viewing and sightseeing. The degree to which mitigating measures are successfully accomplished plus ultimate industry management decisions would determine whether beneficial impacts would actually be realized (see Chapter V). However several unavoidable adverse impacts to recreational resources (see Chapter VII) would remain unmitigated in the long run. After all proposals are complete, there would still be continuing impacts upon recreation resources, on developed recreation facilities and perhaps a shortage of urban recreation facilities -- all due to a greater regional population and resulting increased recreation demand. Much of the open space loss would remain, and surface disturbances would not be immediately reclaimed. Irreplaceable resource losses such as cultural resources, would remain unmitigated in the long run.

Economic and Social Environment

The assessment of trade-offs between short-term social losses and long-term social gains is a value judgment based on the observer's inherent attitudes and biases. Therefore no attempt is made to judge the worthiness of long-term changes in the social environment that result from the proposed actions; nevertheless these changes can be described.

Existing small-town atmospheres would give ways to conflicts between old and new residents in the short-term. In the long-term, these conflicts would be replaced by more urban lifestyles and attitudes. In the short-term the capacities of social support facilities would lag the demands on these facilities. This deficit would recede to an equilibrium situation in the long-term, as property values increase to provide a tax base that would support new facility requirements. The short-term use of the environment for the development of coal mining would contribute to the long-term degradation of the quality of life as population density, traffic volumes, and administrative bureaucracies increase, and as air quality and aesthetic values decrease.

The existing balance in regional wage structure would give way to a disequilibrium situation in the short-term as a consequence of the disparity between earnings of mine employees and earnings of residents employed in established sectors. In the long-term, as population and employment stablize, this disparity would be replaced by a new equilibrium with higher wage levels in all sectors, reducing the disproportionate short-term rate of increase in the cost of living.

The long-term equilibrium would have its own potential to generate severe losses in regional economic productivity. The regional economy would be based on one industry to a great extent -- coal mining. A substantial portion of total regional employment and earnings would depend on the health of this industry. If changing market conditions cause a substantial drop in the price of steam coal, the study region could expect to suffer extreme economic recession.

Chapter IX

Irreversible and Irretrievable Commitments of Resources

THIS CHAPTER QUANTIFIES THOSE RESOURCES THAT WOULD BE CONSUMED AND PERMANENTLY LOST AS A RESULT OF IMPLEMENTATION OF THE PROPOSED ACTIONS. SUCH LOSSES ARE IRRETRIEVABLE COMMITMENTS: I.E., ONCE THESE RESOURCES ARE USED. THEY CANNOT BE REPLACED.

CHAPTER IX

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Geologic and Geographic Setting - Paleontology

Commitment of fossils in terms of unavoidable impacts would be, for all practical purposes, an irreversible commitment once the mine plan is approved with its attendant legal stipulations. After the proposed action completion, or at the end of the short-term, the unavoidable loss of fossils would be irretrievable.

Losses due to more intense fossil collecting would become irretrievable once the population increases. The increased impact on these resource values could be halted by again reducing the population base to present levels.

Mineral Resources

Coal

The major irreversible and irretrievable commitment of resources by the proposed mining activities would be the production for consumption of about 340 million short tons of coal.

Sand and Gravel

The report for W. R. Grace and Company's proposed railroad indicates approximately 91,000-108,000 cubic yards of gravel would be required as ballast, presumably from terrace gravels near Craig. An undeterminable amount of sand, gravel, and clinker would be required for mine roads and other support facilities. Inasmuch as none of these materials could be economically recovered after mining has ceased and the railroad abandoned, this would be an irreversible and irretrievable commitment of resources.

Water Resources

Ground Water

The only irreversible or irretrievable commitment of ground water resources would be in the local destruction of water-bearing beds due to mining.

Surface Water

Proposed power plants in the area which are contingent on future coal development are units 3 and 4 at Craig. It is assumed that cooling water would be required in the operation of these units, and although some of this would be recirculated, it is estimated that by 1990 an additional 12,000 acre-feet would be consumed by the power plants annually. This water would be lost by evaporation in the various phases of operation which would constitute an irretrievable commitment of the surface water resource.

Twelve thousand acre-feet of surface water is less than one percent of average undepleted supply of the Yampa River. Loss of this water, however, is not only an irretrievable commitment of water from the system, but it causes an increase in dissolved solids in critical reaches of the Colorado River. This increase, 0.7 mg/l, may appear small, nevertheless it aggravates an already borderline condition with respect to users of Colorado River water below Hoover Dam.

Air Quality

Local, very small changes in climate or the atmospheric resources would result from the redistribution of the surface material at the mines. Changes in contours and surface characteristics would irreversibly alter the wind field and surface heating of the air. The air quality degradation would be reversible if reclamation is complete.

Air quality degradation due to increased urbanization would be irreversible. Therefore the loss of present rural clean air would be irretrievable.

Soils and Terrestrial Flora and Fauna

It is difficult to predict the success of current reclamation practices on disturbed lands associated with coal development in northwestern Colorado. However considering existing climatic and soil conditions and replacement of topsoil by most mining companies, return to a self-sustaining ecosystem should be possible, but productivity is projected to be ten percent less.

The annual forage production that the disturbed areas could have produced would be lost during the time that mining and reclamation takes place, approximately four years. This increment of production lost would be an irreversible commitment of forage for livestock and wildlife. Approximately 10,345 acres would be permanently destroyed, and vegetative production would be irretrievably lost (Table RV-14).

Existing soil associations destroyed by mining operations would be irretrievably lost. Fertilizer (mostly ammonium nitrate) utilized in the reclamation programs has been estimated at a minimum of 1,500 tons by 1990, and would be irretrievably lost.

Wildlife resources that might be irretrievably lost include individual animals and habitats that would be destroyed and animals and plants that would have reproduced during the life of the mine. Most wildlife losses may be reversible if the species and habitat are not impacted to the point that their ability to reproduce is seriously impaired.

Aquatic Biology

The primary irretrievable commitment of the aquatic biological resource within the region would be the possible loss of the endangered fish species habitat and individuals which would result from the construction of the proposed W. R. Grace railroad. The anticipated commitment of aquatic habitat that would result from the construction of haul and access roads across streams and rivers should not be significant on a regional basis.

Archeological Resources

Commitment of the proposed action areas to coal development would result in an irreversible commitment of cultural resources, once the mine plan is approved and stipulations attached. Unavoidable impacts would then become irretrievable commitments of archeological resources as the impacts accrued. Additional irreversible commitments of resources are set in motion by increasing population levels; this could only be reversed by once again reducing the local population base. These commitments are not quantifiable on a regional basis as current intensive survey data is available for only about one percent of the study region.

Historical Resources

Irreversible and irretrievable commitments of historical resources would occur in the same manner as described before for archeological values. Destruction of architectural and historical themes due to urbanization and new development within already developed communities would be irretrievable.

Aesthetics

Commitment of the proposed action areas to coal production would be an irreversible commitment of aesthetic resources as relates to both unavoidable and long-term minus deviations. The long-term residual of unavoidable impacts would be irretrievable regardless of their relative significance.

Recreation

Commitment of the proposed action areas to coal development would result in irreversible commitments of recreational resources, both adverse and beneficial. Unavoidable adverse impacts upon existing recreation resources and facilities would be essentially irreversible given the increased recreational demand accompanying coal development. Destruction or deterioration of primitive or natural values, depletion of collectable minerals, loss of wild and scenic river potential and loss of cultural resources would be essentially irretrievable commitments of recreation resources.

Social Environment

The proposed action would contribute to, but would not be the sole cause of the irretrievable loss of small-town atmospheres in the population centers of the study region. 1,190 acres of land would be irreversibly committed to support population growth that would result from implementation of the proposed action.

As a result of coal-related population increases, and based on 1974 State and regional energy consumption patterns, 70 million gallons of gasoline, 8 billion cubic feet of natural gas, and 2.28 billion kilowatt-hours of electricity would be consumed in the study region over the fifteen year study period.

Chapter X

Alternatives to the Proposed Action

THIS CHAPTER IDENTIFIES AND DISCUSSES ALL REASONABLE ALTERNATIVES TO THE PROPOSED ACTIONS. ENVIRONMENTAL IMPACTS THAT WOULD RESULT FROM IMPLEMENTATION OF AN ALTERNATIVE ARE DISCUSSED TO THE EXTENT THAT THEY DIFFER FROM THE IMPACTS RESULTING FROM IMPLEMENTATION OF THE PROPOSED ACTION.

CHAPTER X

ALTERNATIVES TO THE PROPOSED ACTION

Alternatives to a proposed action normally are presented as a guide for the decisionmaker, Congress, and the public in a situation where three options are equally and clearly available: to approve, to approve with modification, or to disapprove. The situation discussed in this statement is far more complicated with respect to the proposed action and the options. The proposed action consists of many individual actions of various types, and the individual actions range from proposals now in hand to anticipated proposals with various degrees of specificity as to time, location, and other details. Some of the proposals are outgrowths of past actions; all are added to a base of existing activity that resulted from past Federal actions. Furthermore, the options to approve, modify, or disapprove are not equally available for the various types of actions. A discussion of these factors precedes presentation of alternatives, so the reader can understand the variables and their effects on the applicability of alternatives to the proposed development in northwestern Colorado.

In a regional impact statement such as this, where many individual proposals constitute the Federal action, alternatives are to the cumulative thrust of the collective proposals; alternatives to individual proposals are given in the site-specific chapters of this statement. Although the wide range of variables complicates discussion of alternatives to the collective proposals, it also increases the opportunities for modified approval of the cumulative thrust of the proposals. Therefore, regional alternatives are discussed in two general categories: (1) those that should be considered in the context of total approval or disapproval of the collective proposals, and (2) those that should be considered in the context of selective approval or disapproval of individual proposals in order to modify the collective thrust.

The question of analyzing one or more lower levels of coal development in northwestern Colorado arose early during the study. We realized, however, that two general circumstances made such analyses unwarranted: (1) we did not have an adequate rationale for limiting development to one or several particular levels, and (2) regardless of what actions the Federal government took, coal development on State and private lands in the study area could proceed more or less independently and at rates that would be largely conjectural. Under these circumstances it seemed arbitrary at best and probably misleading to imply that certain alternate levels of coal development were definable and quantifiable targets.

Identification of general lower levels of development based on judgmental limits and without regard for particular alternative objectives would be arbitrary. Furthermore, numbers generated for impacts at lower levels of development could imply far greater accuracy than is possible in view of the variety of conjectural factors induced. For example, if the Federal government took steps to reduce the rate of development of Federal coal in the region, the coal industry could largely abandon the region as a source of additional coal or could shift their emphasis to the abundant coal on State and/or private lands in the region. The degree of their continued activity would depend on market conditions, land acquisition problems, industry economics, State and local attitudes, pertinent future legislation at the local and State levels as well as Federal, etc., all of which make forecasting extremely conjectural.

It seemed more appropriate to look at alternative objectives of coal development in the study area and their particular modifications of impacts, recognizing that the degree of modification of impacts would be conjectural but that the overall effects of lower rates of development would be generally fewer adverse impacts on the physical environment. Adverse impacts on socio-economic conditions are not necessarily reduced with lower rates of coal development, but rather, commonly depend on one's point of view.

The various alternatives considered have adverse environmental impacts that range from greater to less than those of the proposed actions. A strict comparison of impacts, however, must be modified by consideration of other factors, such as potential effectiveness of implementation relative to the proposed actions, potential level of energy production compared with energy produced as the result of the proposed actions, and national objectives with respect to energy and the economy. Table RX-0 presents a summary of the alternatives considered, showing subjective judgments on relative effectiveness of implementation and comparative environmental impacts.

Alternatives Based on Disapproval of the Collective Actions

Disapproval of the collective actions presumes that each individual proposal now and in the future either can be disapproved by the Department

TABLE RX-0

Alternatives

Alternatives	Potential effectiveness of implementation relative to proposed actions	Environmental Impacts Relative to Actions As Proposed: Non-Living	Living	Cultural	Overall	Remarks
Provide equivalent energy:						
Local alternate sources of coal	Low		+		+	
Outside alternate sources: coal	Low	+		–		
oil and gas	Low	–	–	+	+	Lower priority of use
nuclear	Low	+	–			
oil shale	Very Low	+	+		+	Probably not able to provide equivalent energy
geothermal	Very Low		–			
hydropower	Very Low		+			
Federal development of coal	Very Low					Requires new legislation
Do not provide equivalent energy:						
Energy conservation	Very Low	–	–		–	Should be pursued regardless
Reduction of present level of development	Very Low	–	–	+		Requires new legislation
May or may not provide equivalent energy:						
Underground mining	Low	–	–	+		Reduced resource conservation
Maximum exportation	Equal	–				
No further power plants	Equal	–			–	
Maximum local power generation	Low	+		+	+	
No further leasing	High					Possibly reduced resource conservation
Accelerated development	Low	+	+	+	+	
Develop areas most effectively reclaimable	Low		–		–	

+ = greater impacts; blank = equivalent impacts; – = fewer impacts

TABLE RX-0 (Cont'd)

Alternatives

Alternatives	Potential effectiveness of implementation relative to proposed action	Environmental Impacts Relative to Actions As Proposed: Non-Living	Living	Cultural	Overall	Remarks
May or may not provide equivalent energy:						
Alternate reclamation objectives	High					
Uses other than power generation	Very Low					
Coal resource conservation	High					Lower priority of use
Slurry pipeline vs. railroad transportation	Low	+				Should be pursued regardless
Alternate power plant designs	Low	-				Water problems
Development phased with population growth	High			-	-	Should be pursued regardless
Development phased with development of other industries	High	-		-	-	

+ = greater impacts; blank = equivalent impacts; - = fewer impacts of the Interior or the same effect can be achieved by taking no action. Theoretically, according to current laws and policies, all could be thus disapproved, but some with far fewer constraints than others. The latitude for disapproval differs among the various types of actions under consideration in this statement; brief discusssions of those types of actions are given to help identify the problems. The reader is encouraged to consult the final Environmental Impact Statement for the Proposed Coal Leasing Program (U.S. Dept. of the Interior, 1975) for additional information on the subject.

1. Prospecting permits. - No prospecting permits for coal are outstanding in northwestern Colorado. Because issuance of prospecting permits is discretionary, additional development flowing from such permits can be stopped simply by taking no action on future applications.

2. Preference Right Lease Applications. - Applications for preference right leases are in hand for northwestern Colorado coal. Eleven applications cover 23,759 acres of land which contain an estimated 745 million tons of recoverable coal. Under present laws and policies a preference right lease is granted if the applicant has fulfilled all requirements under the terms of a valid prospecting permit, has demonstrated discovery of commercial quantities of coal, and agrees to stipulations attached to the lease that ensure environmentally acceptable and diligent development. Because the Secretary of the Interior is required to respond to a legitimate application, disapproval cannot be achieved simply by taking no action. Rather, disapproval can be achieved by rejection for cause on administrative, technical, or environmental grounds, or the same effect

can result from the applicant's refusal to accept stipulations or failure to meet them. The degree to which disapproval of current and future preference right lease applications can be applied in northwestern Colorado depends in part on matters now under discussion, particularly policy changes, language definitions (e.g., "commercial quantities"), and the complex issue of possible stipulations that can be attached to leases to minimize adverse environmental effects where no standards now apply.

3. Competitive Coal Leases. - The Secretary of the Interior is not required to respond to applications for competitive lease sales nor to initiate competitive sales. Therefore, the effect of disapproval can be achieved by taking no action on applications and taking no initiative on federally nominated lease tracts.

4. Mining and Reclamation Plans. - Four coal mining and reclamation plans now are in hand for northwestern Colorado. Others can be anticipated from holders of existing and possible future leases. In northwestern Colorado there are 35 undeveloped leases outstanding which cover 39,434 acres and about 667 million tons of recoverable coal. Under present circumstances, the Secretary of the Interior is obligated to respond to a legitimate application to conduct operations on a valid lease providing all terms and conditions of the lease have been met. Therefore, prevention of additional development cannot be achieved by taking no action on mining and reclamation plans. Disapproval would be necessary, and rejection currently requires that cause be shown. The Secretary can

reject a mining and reclamation plan if it does not meet administrative, technical, and environmental standards set by law, and his authority extends to various environmental values that are not specifically defined by law. Limits for rejection based on undefined environmental values are not clear. New Federal regulations currently are under consideration, as is Federal legislation regarding surface mining. Colorado is revising its surface mining regulations. In matters that involve undefined environmental values, the possibilities exist of challenges by leaseholders or repeated submittals of modified plans in search of an acceptable proposal. Thus the means to disapprove additional mining are available, but the degree of applicability cannot be forecast with certainty.

5. Right-of-way applications. - Applications for right-of-way across Federal lands do not now require a response from the Secretary of the Interior, so the effect of disapproval can be achieved simply by taking no action on applications.

In general the latitude for disapproval of further development differs substantially between lands under existing leases and unleased lands: development of unleased land currently can be stopped unilaterally by the Department of the Interior simply by not issuing further leases and permits; development of leased land also can be disapproved, but only in a legal context, because the leases are contracts that currently convey the right to develop, produce and market the coal if all terms and conditions are met by the leaseholder. Various procedures concerning leases also are matters of law. In the discussion of regional alternatives based on disapproval of the collective actions the assumption is that all additional development can be disapproved on undeveloped Federal coal lands whether leased or not, even though disapproval of development on existing leases might be less effectively achieved. There are about 800,000 acres of unleased Federal coal lands in northwestern Colorado which contain an estimated 14 billion tons of recoverable coal.

If there were no further development of Federal coal in northwestern Colorado, the estimated cumulative amount of coal not mined during the 15-year time span of this analysis is shown in Table RX-1, with the acreage of land not disturbed. In recognition of the distinctions between leased and unleased lands, also shown are those parts of the totals estimated to be from: (1) Federal lands currently under lease or for which preference right lease applications are in hand, and (2) unleased Federal lands, State lands, and private lands. However, this breakdown is highly speculative.

TABLE RX-1

Coal Not Mined and Land Not Disturbed
if No Further Development of Federal Coal Occurs

	Million Tons of Coal	Acres of Land 1/
Federal lands under lease and preference right lease applications	87	8,700
Unleased Federal lands, State and private	131	13,100
Total	218	21,800

1/ Assuming 100 acres per million tons of coal.

If there is no further development of Federal coal, the amount of coal not mined (218 million tons) differs from the anticipated cumulative production as proposed (340 million tons) because we assume that local sources will continue to provide fuel for existing and approved local power generating plants and that existing contracts for exported coal will continue to be fulfilled (see Table RI-2). The local sources would be existing mines on Federal lands and existing as well as future mines on State and private lands.

For comparisons with alternate sources of energy, the energy unit we use is megawatt-hours of power because the dominant use of northwestern Colorado coal is boiler fuel for power generation. Using an average Btu value of 11,300 per pound of coal in the region and 38 percent efficiency of coal-fired generating plants, the 218 million tons of coal in Table RX-1 converts to a cumulative total of 548.7×10^6 megawatts-hours during the next 15 years. The value of 11,300 Btu's per pound of northwestern

Colorado coal is derived from Table RIV-2a, using Williams Fork coals and assuming 11.4 percent moisture when converting dry samples to "as mined". The conversion to megawatt-hours is as follows: 11,300 Btu per pound = 22.6×10^6 Btu per ton. 218×10^6 tons = 4.927×10^{15} Btu. 3.412×10^6 Btu per megawatt-hour = 100% efficiency, so 8.979×10^6 Btu per megawatt-hour = 38% efficiency. Therefore, 4.927×10^{15} divided by 8.979×10^6 = 548.7×10^6 megawatt-hours from coal not mined if no further Federal action.

Impacts of No Further Development of Federal Coal

Several primary impacts, enumerated in the following paragraphs, are common to all alternate sources of energy because the alternative is predicated on no additional development of Federal coal in northwestern Colorado:

1. Cancel the cumulative impacts, beneficial as well as adverse, of additional development of Federal coal in northwestern Colorado. The cancelled impacts are those described in Chapter V of the Regional Analysis, less the mitigating measures and less the impacts stemming from non-federal development. The part of the projected development attributable strictly to additional Federal coal is difficult to estimate because the projection depends in large measure on conjecture about relative attitudes, policies and practices among the Federal, State, and private sectors. Furthermore, regional impacts, especially socio-economic impacts, do not necessarily bear a linear relationship to

development. Therefore quantification of impacts cancelled because of no additional development of Federal coal in northwestern Colorado is difficult. To give some basis for discussion however we estimate that about one-quarter of the new development still would be realized if Federal actions lead to no additional development of Federal coal.

Principal adverse impacts cancelled are disrupted land surface (approximately 34 square miles), stack emissions from two additional units at the Craig generating plant and from two projected new plants, water consumption (approximately 27,000 acre feet/year), and the adverse effects of increasing the population by about 10,000 people by the year 1990. Each of these in turn has adverse impacts on natural patterns of vegetation and wildlife, on cultural, historical, and aesthetic values in the region, and on quality of life for the population, all of which would be affected.

Principal beneficial impacts cancelled would be potential increases in productivity for cattle forage on reclaimed land where that is possible (about 10 or 12 square miles of the disrupted 34), greater access to, and more people to benefit from, the aesthetic and recreational attributes of northwestern Colorado and vicinity; and the economic benefits that result directly and indirectly from development. These and related secondary impacts are discussed more fully in Chapter V.

2. Reduce the potential for economic growth in northwestern Colorado. Impacts related to economic growth are treated separately because ramifications are widespread and the issue is controversial. Viewed traditionally

the cumulative impact of reduced growth potential is adverse. Fewer direct employment jobs mean fewer ancillary jobs, less cash flow, smaller tax base, etc., and therefore decreased opportunity to increase standards of living in the immediate region. This local result in turn affects larger areas in a ripple effect. A low growth or anti-growth posture in an area is regarded as an evil that results not just in a status quo situation, but in fact results in a relative decline of the area. Federal coal is not the only source of potential growth in northwestern Colorado, but the stigma of restricted growth in any part of the economy would have the general effect of lowering the growth potential of the area beyond that even indirectly attributable to Federal coal.

Others view the impacts of reduced growth potential as beneficial. Certainly reduced are the social ills that accompany rapid growth, such as demands on social services, which are difficult to meet under present conditions, and social problems that accompany increased population density. Also reduced is man's imprint on the land, which can be good but often is bad. Pollution potential is reduced with respect to the land as well as air and water quality. The question is raised that the traditional measure, "standard of living," perhaps cannot be equated with "quality of life." Increased standard of living created by economic growth can reduce quality of life. The argument continues that unrestricted growth is impossible in the long run because of limits on resources, and therefore steps should be taken now to change to a widely acceptable social and economic pattern that does not rely on economic growth for success.

In practice the answer lies between the two extremes. Increased public awareness of limited resource capabilities and environmental concern is a powerful force opposing unrestrained growth, and effects are seen in legislative and policy responses such as the National Environmental Policy Act, and social attitudes (for example declining birth rate and some recent trends by state electorates). But in the short term the number of people seeking jobs nationally will increase, and the only practical response now is to at least match the population growth with economic growth to accommodate the larger work force. The question then becomes not one of whether economic growth is good or bad, but of where and how economic growth can take place with the least destructive influence on the physical and social environment. The real impact of reducing potential for economic development in northwestern Colorado is to shift the impact to other areas, and with that must go the assumption that the other areas are better able to cope with increased development.

3. Limit expansion of local power generating capacity. Some of the projected power generating capacity in northwestern Colorado is predicated on additional Federal coal from the region. Fuel from State and private lands possibly would be substituted, or fuel might be imported with additional environmental impacts caused by greater rail traffic loads. But the likely effect would be reduction of potential local generating capacity. Adverse impacts related to power plants would be eliminated, such as water consumption and stack emissions. However, because much of the future market is in the southwestern quadrant of the nation, the practical effect would be a shift of generating capacity and related impacts to other regions, probably to the southwest, where

population density may be less, but where more arid climates generally reduce reclamation effectiveness.

4. Force revisions of plans by scheduled markets for Federal coal from northwestern Colorado. Some existing local markets for additional Federal coal would either seek new sources of coal or shut down. Shutdowns are unlikely because of large capital investments. Coal would be obtained from new local sources on State and private land, from existing local sources now marketed outside the region, or from sources outside the region.

The principal impacts would come from truck or rail traffic and mining. Locations and amounts of mining on State and private lands is speculative, but new local sources probably would not decrease the amount of land and wildlife disrupted nor decrease either traffic or load impacts on existing transportation networks. Existing coal, now exported, might in time be kept for local use by renegotiating market contracts. If that were done, exports by rail would decrease as would the attendant impacts created by rail traffic. Importation of coal from outside the region would increase costs as well as rail loads but would not increase rail traffic because imported coal would use empty cars now returned to the area after exportation of coal.

Impacts from mining of new local sources would shift from Federal to other lands where mitigation requirements and monitoring are no more stringent and may be less so. If coal is imported, the mining impacts are shifted to another region.

Markets for exported coal from additional Federal coal developed in northwestern Colorado are not well known but most probably would be in

Colorado and the Midwest. Revised plans by consumers in these areas could result in obtaining coal from sources nearer the market and therefore involve shorter transportation distances, but the results could well be lower quality coal and more adverse air quality impacts. Northwestern Colorado coal is a relatively desirable boiler fuel because of its favorable ratio of sulfur content per Btu. Mining impacts would shift to the area of alternate sources.

5. Leave approximately 218 million tons of Federal coal in the ground for the next 15 years, of which 175-200 million tons would be on Federal lands. The implication of this impact is clear: a nonrenewable resource is preserved. As steward of the nation's federally-owned natural resources, the Federal government is charged not simply with preservation but with conservation, and although conservation may include preservation, it also may include wise development of a resource. The impact is beneficial only if the net value of environmental, social, and economic aspects of wise development now outweigh the future value of the resource.

6. Reduce the potential contribution from the region toward the objective of national self-sufficiency in energy. The region's potential additional energy during the next 15 years is about 5 quadrillion Btu's. This represents less than 0.3 percent of the forecasted national demand during the same period, which makes the contribution small. However the objective of self-sufficiency is going to be difficult to achieve at best (Federal Energy Administration 1974), and any contribution however small is necessary. In this context the impact of reducing the region's contribution is adverse.

Alternatives That Provide Equivalent Energy

Local alternate sources

Coal on private and State lands in northwestern Colorado is sufficiently abundant to provide tonnage equivalent to the 218 million tons not mined if Federal actions led to no further development of Federal coal in the region. In practice however, it is unlikely that the full amount would be replaced locally. Part of the projected mining of Federal coal is predicated on additional power generation in the region, which probably would not reach the same level if Federal coal were not available. Existing generating plants in the region that would be served by new Federal coal would seek continued supplies rather than shut down operations that represent large capital investments. The part of the supply that would come from local, private, and State lands is speculative. If no rights-of-way across Federal lands were granted, some coal on State and private lands would be unavailable or uneconomic to transport compared to importation of coal from outside the area.

Total replacement from local sources is unlikely but would result in impacts equivalent to these of the proposed actions, or greater if haulage distances were longer. Control of environmental effects of mining on State and private lands would depend on the scope and application of State regulations.

Alternate sources outside the study region

The comparisons here are with sources of energy outside northwestern Colorado that could replace the energy resulting from no additional development of northwestern Colorado coal. The assumption is that the comparative electric power can be generated and marketed near the fuel source and does not necessarily have to supply the proposed markets for northwestern Colorado power.

The following sections draw on similar discussions in environmental statements for various energy developments, and from an expanded treatment of the subjects in a 1975 report entitled Energy Alternatives: A Comparative Analysis, by the Science and Public Policy Program, University of Oklahoma. The Oklahoma report was prepared for the Council on Environmental Quality, Energy Research and Development Administration, Environmental Protection Agency, Federal Energy Administration, Federal Power Commission, Department of the Interior, and National Science Foundation. It considers various alternate sources of energy in the light of practicality, present technological state-of-the-art, future directions, cost-effectiveness, and environmental impacts. Because each alternate source is complex, a full treatment in this statement is impractical. Therefore, the report, Energy Alternatives: A Comparative Analysis, is incorporated by reference, as is the treatment of energy source options in the Final Environmental Impact Statement for the Proposed Federal Coal Leasing Program (U. S. Dept. of the Interior, 1975).

The following sections are summaries tailored to the replacement of 548.7×10^6 megawatt-hours of power expected to be produced from northwestern Colorado coal during the next 15 years. The amounts of coal, oil, natural gas, uranium, and shale oil necessary to provide this amount of power are shown in Table RX-2.

Coal

Coal is the most abundant energy fuel in the United States; it underlies nearly 460,000 square miles in 37 states, constituting one-quarter of the world's supply and accounting for 80 percent of our proved energy resources. Proved resources of coal in the U. S. contain 125 times the total energy consumed nationally in 1970. Because of the general abundance of coal, the comparative environmental impacts are the principal distinctions among alternate source areas of coal. Because many impacts depend in detail on the specific site of coal mining or power generation, the following comparisons of large regions are generalizations and subjective. Table RX-3 summarizes these subjective generalizations and compares them with other alternate sources of power.

TABLE RX-2

Amounts of Alternate Fuels to Provide 548.7×10^6 Megawatt-hours of Power 1/

Coal	= 205.3 million tons
Oil	= 849.5 million barrels
Natural gas	= 4.8 trillion cubic feet
Uranium	= 8.8 million tons of uranium ore
Oil shale	= 1,408 million tons of oil shale

1/ Assumptions

1 ton coal	= 24×10^6 Btu (12,000 Btu/lb.)
1 barrel oil	= 5.8×10^6 Btu
1 cubic foot natural gas	= 1032 Btu
1 ton uranium ore	= 3 pounds U_3O_8
1 pound U_3O_8	= 214×10^6 Btu
1 ton oil shale (@ 25 gal./ton)	= 3.5×10^6 Btu
1 kilowatt-hour	= 3,412 Btu @ 100% efficiency
Fossil fuel power plants	= 38% efficiency
Nuclear reactor power plants	= 33% efficiency

TABLE RX-3

Environmental Impacts of Production of and Power Generation of Alternate Energy Sources Relative to Those of the Proposed Actions

Alternate Sources

	COAL					OIL & GAS				OTHER			
Impacts 1/	Alaska	Pacific Coast	Rocky Mtns.	Northern Great Plains	Interior & Gulf	East	On-shore	Off-shore	Import	Nuclear	Oil Shale	Geo-therm.	Hydro-power
Air quality			-	-	-		-	-	-		+		--
Water quantity		-	+	+	+	-				+	+	-	+
Land: short-term		-		-			--	--	--	-	+	+	
long-term	‡	-	+	+	-		-	-	-		+	-	‡
Socio-economic	+	-			-	-	+	+	‡			-	-

Explanation:

--	Considerably less impact
-	Less impact
(blank)	Equivalent impact
+	More impact
‡	Considerably more impact

Notes:

1/ Air quality: Combines gaseous and particulate pollutants.
Water quantity: Consumptive use relative to quantity available as surface and ground water.
Water quality: Both surface and ground water.
Land - Short-term: Short-term commitment of land that would be reclaimed after extraction of fuel.
Land - Long-term: Long-term commitment of land either because of long-term facilities such as generating plants, or because of relatively ineffective reclamation of land disturbed during mining - in general, impacts on soils, vegetation, and wildlife are related to the amounts and duration of land disturbance.
Socio-economic: Combines effects of labor requirements, capital requirements, and current economic and political considerations.

All assume extraction, processing, and power generation techniques currently in use, and environmental protection at currently practiced levels.

Alaska. Much of the coal in Alaska occurs in the northern part of the State where long-term impacts on the fragile environment can be severe. Reclamation is difficult and less effective; mining conditions are harsh. Perennial water is scarce in the northern part of the State but abundant in southern fields. Extensive transportation of either coal or power would be necessary because local markets for power are small. Population and labor supply are low so the influx of people for construction, operation, and support would have potentially severe adverse impacts.

Pacific Coast. Coal most suitable for power generation is in western Washington where water supplies are more abundant than in northwestern Colorado, and problems with contamination of supplies by sediment or toxic wastes are not significantly different. Underground mining is more common and resource recovery is less effective; many seams are discontinuous and difficult to mine. Reclamation is potentially more successful. Population shifts to provide labor and services would be fewer.

Rocky Mountains. Winds and arid climate contribute to greater particulate air pollution from strip mines in western Wyoming, Utah, southwestern Colorado, Arizona, and New Mexico. Water availability in arid regions is lower, so impacts from consumptive uses would be relatively more severe. Disturbed land would be equivalent or somewhat less than in northwestern Colorado because underground mines are more common, but revegetation of strip mines and spoil banks from underground mines would be less effective, leading to slower return to vegetative productivity.

Northern Great Plains. Air pollution is potentially higher than in northwestern Colorado because winds, drier climate, and widespread use of surface mining methods increase particulate matter, and the higher sulfur content per Btu tends to increase gaseous emissions from generating plants. Water is less abundant without large scale diversion projects or deep drilling. Effects on water quality should not be significantly different, but potential effects on aquifers may be greater if long belts of coal aquifers are disrupted along basin edges. Although the average Btu value is about a third less than in northwestern Colorado coal, coal seams in the Northern Great Plains region are significantly thicker. Therefore land disrupted for equivalent energy values would be less, but potential for revegetation also is less because of arid conditions and harsh climate, leading to longer-term effects on the land.

Interior and Gulf regions. These regions encompass the coal deposits between the Rocky Mountains and Northern Great Plains areas to the west, and deposits along the Appalachians to the east. Even though much of the coal in the Interior and Gulf regions has high Btu values, the ratio of sulfur to Btu is less favorable because of generally high sulfur contents. Higher sulfur contents lead to more adverse impacts on water quality owing to acid mine drainage, and on air quality owing to sulfurous stack emissions at generating plants. Water quantities are greater than in northwestern Colorado, but demands also are greater because of widespread use for industry as well as for agriculture and domestic consumption. Revegetation potential is good, which would lead to relatively few long-term adverse effects on land values and productivity. Population density and distribution would minimize adverse socio-economic effects.

East. Sulfur contents of eastern coals range widely, so potential for air pollution from fuel burned in generating plants may be higher or lower than in northwestern Colorado. Eastern coal used for power generation also ranges above and below northwestern Colorado coal in Btu values, but eastern seams generally are thinner. Strip mines in the western part of the eastern states would disturb more ground per ton of coal recovered unless Btu values were considerably higher than 11,000 per pound. Surface mines in the eastern part of the eastern states are in topographic settings that lead to contour mining, which tends to disturb larger amounts of land per ton of coal removed. Water is abundant, but where sulfur content is high, water quality may be severely affected by acid mine drainage. Revegetation potential in the region is excellent, but this advantage in the eastern part of the region is offset by special problems that result from steep slopes and spoil distribution at contour mines. Socio-economic impacts range from fewer adverse impacts in the western part of the region because of present patterns of population density and distribution, to potentially beneficial impacts in the eastern part of the region where underemployment of existing populations has been a chronic problem in recent years.

Oil and gas

Oil, and particularly natural gas, are more environmentally desirable fuels for power generation than coal. Their production requires less commitment of land and fewer adverse impacts than coal for equivalent amounts of electric power generated. The problems at present revolve around concerns for long-term supplies of oil and gas relative to demands, questions about priority uses for resources in short supply, and most recently, international economic and political stresses with respect to oil and gas prices and availability. Therefore, in spite of their desirability as fuels for power generation, oil and gas currently are not being urged as replacements for coal as boiler fuel. Indeed, the trend is to convert existing generating plants from oil or natural gas to coal, because of fuel supply problems and priority use assignments by the Federal Energy Agency.

Oil and natural gas in the U.S. or in foreign countries are sufficiently abundant now to replace the additional power that would be produced in northwestern Colorado. U.S. production of oil or gas during only a single year far exceeds the cumulative total of energy proposed for the next 15 years from northwestern Colorado. Additional oil or gas production to match the proposed production schedule of coal in the study area would be possible if one assumes otherwise static production demands. In practice, additional production is being encouraged, and is limited only by economic factors, equipment availability, and discovery success. If one assumes that production is to increase to provide U.S. energy self-sufficiency, additional production to replace energy from northwestern Colorado probably would not be possible within the next 15 years.

On-shore oil and gas production and power generation would have less impact on air and water quality relative to coal from the study region. Adverse impacts principally are related to fuel processing and power generation. Consumptive use of water also is related to fuel processing and power generation and would be equivalent to use for coal mining, processing, and power generation, depending on the specific sites of mines and plants. Commitment of land is substantially less per Btu recovered; therefore long-term effects on land are fewer even if reclamation potentials are lower.

Oil and gas from off-shore fields share equally with on-shore sources those adverse impacts related to processing and power generation. Commitment of land is limited to shore facilities, but adverse effects on water quality and related ecological problems are potentially more severe because of spills caused by equipment failure, blowouts, or human error.

Imported oil and gas also require processing and power generation on U.S. shores. Additional adverse impacts are related primarily to off-loading facilities and tanker traffic, both of which may affect water quality owing to spills and collisions. Adverse impacts of production would be shifted to the foreign source areas.

Oil and gas as alternate sources for energy from northwestern Colorado coal clearly are more desirable environmentally, but are much less desirable in light of present economic and political considerations.

Nuclear power

Electric power derived from the heat of fission reactions now constitutes about six percent of the nation's supply, and a large percentage of generating plants now under construction is nuclear powered. The hope of recent years was that nuclear reactors would provide inexpensive and clean power in vast amounts, thus continuing the trend toward a society based on abundant cheap energy supplies. For a variety of reasons, the hope has not been realized. The world price of uranium, the basic material of nuclear fuel, has nearly doubled in the past few years, and indications are that the price will continue to rise in response to short supplies of known reserves relative to increased projected demands. Additional sources will be found, and increased prices will make known low-grade deposits economically attractive, but the fuel costs for fission reactors will not be dramatically less than for fossil fuels. Furthermore, costs for nuclear fuel processing and generating plants have increased at a greater rate than for comparable fossil fuel facilities, largely because of engineering problems, site constraints, and economic considerations. The advantages once attributed to nuclear power no longer are clear.

Serious controversy now surrounds the environmental impacts of nuclear generating plants. There are honest differences of opinion about the long-term safety of normal operations, as well as the possibilities for, and ultimate hazards of, malfunctions or accidents. Large-scale accidents would be so devastating that they must be considered virtually impermissible. Claims for protection from large-scale accidents range widely but none suggests absolute certainty, especially from such things as sabotage. Small-scale accidents and malfunctions, as well as operational hazards related to low-level emission of radioactive materials, radioactivity of cooling waters, and radioactive waste handling and storage are regarded as manageable by some and unacceptable by others. The extent and effects of these hazards are not adequately understood to make definitive judgments. The principal issue has become the acceptable degree of risk, and because scientific data are neither complete or absolute, the issue is particularly subject to emotionalism.

The nation has uranium ore and potential reactor sites to generate an additional 548.7×10^6 megawatt-hours of power during the next 15 years. Because lead time for licensing and constructing nuclear power plants now is at least 10 years, it is not certain that the additional generating capacity would be operational in the time-frame of this study.

Impacts on air quality mainly would come from mining operations and generating plants. The quantity of uranium ore needed to provide fuel equivalent to northwestern Colorado coal would be less than five percent of the bulk (8.8 million tons of uranium ore as compared with 218 million tons of coal). Some uranium ore would come from surface mines in arid regions of western U.S.; other would come from underground mines. In general, the particulate pollution of mining the required amount of uranium would be substantially less than for the proposed actions. Emissions from generating plants also would be less, but the doubt about effects of low-level radioactive emissions tends to offset the advantages of no emissions from combustion.

Water for reactor cooling is required in large quantities and the integrity of the supply must be as nearly absolute as possible. Such demands on water supplies restrict potential sites for power plants.

Long-term effects of low-level radioactivity and thermal increases on cooling waters have impacts on water quality that are not fully understood, but the doubt alone tends to offset potential adverse impacts from coal mining and power generation.

Short-term commitments of land differ from the proposed actions mainly in the lesser amounts of land disturbed during mining of uranium with comparable power generating potential. However, much of the uranium ore now mined in the U.S. is in semi-arid and arid lands that would be less effectively reclaimed in the long term.

Other alternate sources

Other alternate sources of energy have, to one degree or another, serious drawbacks as to their potential to generate amounts of power equivalent to that from additional development of northwestern Colorado coal. Solar energy is in its infancy as an alternate source for large-scale power generation. Despite hopes for eventual advances in technology that would make this apparently limitless and environmentally desirable source a true alternative, present outlooks are not favorable within the 15-year time-frame of this study. Similarly, sources such as tar sands, wind, tides, nuclear fusion, and organic waste are not now valid alternatives because of either technologic or economic limitations. Each will contribute to future energy supplies as current problems are solved, but not at levels comparable to northwestern Colorado coal within the next 15 years.

Shale oil, geothermal energy, and hydropower do not now appear to be effective alternatives to northwestern Colorado coal as sources of electric power, but each either is a proved source of larger amounts of power or is available as a resource in sufficient quantities to provide equivalent energy.

Oil shale. Energy from oil shale has the potential to replace the 548.7×10^6 megawatt-hours of power from northwestern Colorado, but recovery programs are not yet at operational levels. Prototype systems are under development in the Piceance Creek basin of western Colorado and the Uinta basin of northeastern Utah, but production is not scheduled to begin until about 1980. It would be unwise to count on shale oil as a replacement fuel until production capability is demonstrated. Once it is proven, this fuel could substitute for coal in northwestern Colorado. The source is nearby to the southwest. Pipelines would traverse sparsely populated land of generally low productivity, and generating plants could convert to liquid fuel without major disruption. The question again is the priority of use for all fuels. Recent trends are away from liquid fuels for power generation, in spite of their environmental benefits, because coal is more abundant.

The nation's vast oil shale resources have not been considered part of the domestic energy supply in the past because of the ready availability of low-cost oil and gas; however, current needs may accelerate development of this fossil fuel.

Oil shale can be processed in-place (in-situ) or after its extraction using a surface technique. As with coal, oil shale may be extracted using either underground or surface mining techniques depending on geologic conditions.

The Green River Formation, which occurs in parts of Colorado, Utah, and Wyoming, contains the most abundant concentration of oil shale in the nation; approximately 600 billion barrels of oil are believed to occur in this region. Oil shale development poses several environmental problems, particularly with disposal of the huge quantities of spent shale which occupy a larger volume than before the oil was extracted. Also, prevailing arid conditions impede effective revegetation. In-situ processing would avoid some of these adverse environmental impacts, but disturbance of underground aquifers and contamination of ground waters are side-effects of both development techniques. Commercial development of oil shale in the Green River Formation would require large quantities of water from a region that is low on available supplies and where demands for water are in conflict.

Oil shale development would cause changes in existing land uses and have social and economic repercussions in an area now devoid of large-scale industry. Because the Colorado oil shale lands have some of the largest migratory deer and elk herds in the world, impacts on regional wildlife are expected.

Roads, mining plant sites, waste disposal areas, and utility line corridors would disrupt the land's vegetative cover and intensify sediment loads in the area's streams. Disposing of large volumes of waste water containing dissolved inorganic and organic compounds without degrading natural ground waters would be a continuing problem. Particulate emissions from mining and processing would lower ambient air quality.

A complete discussion of oil shale technology and environmental impacts is in the environmental impact statement for the prototype oil shale leasing program (U.S. Department of the Interior, 1973).

Geothermal energy. Heat from the earth can be used to generate electrical power, as demonstrated in existing plants in foreign countries and in California. The amounts of power now generated, however, are small relative to the potential from northwestern Colorado coal. Potential heat sources are abundant, particularly where the thermal differential is low, but technologic advances are required before the large potential can be realized as a valid alternative for large-scale power generation. Advances are being actively sought by government and industry, but they are unlikely to be achieved in time to provide replacement power in environmentally and economically acceptable forms within the 15-year time-frame of this study.

Impacts on air quality depend on the heat source. Some sources are relatively free from by-product emissions whereas others are rich in noxious gases. Of course, no products of fuel combustion are involved. Consumptive use of water generally is lower than in fossil fuel generating plants, but some techniques for recovering heat rely on circulated water. Impacts on water quality are more adverse if the heat source is water that contains dissolved solids, or if circulated water acquires pollutants from dry heat sources. If mitigating measures do not restore water quality, consumptive use increases, as do storage problems for liquid or solid wastes. Commitments of land for resource recovery and power generation are substantially smaller than for coal generating systems.

Hydropower. Power generated by water moving through turbine systems is a time-proven alternative to power generated by combustion of fossil fuels. Installed capacity in 1971 was about 52,000 megawatts, and in 1972 the Federal Power Commission estimated that the underdeveloped potential for hydroelectric generation in the lower 48 states alone is about 93,000 megawatts. Theoretically then, replacement of power from northwestern Colorado is possible; additional capacity required averages 4,560 megawatts per year to replace the 548.7×10^6 megawatt-hours of power that could be produced from additional development of northwestern Colorado coal during the next 15 years.

In practice, however, adding capacity for hydroelectric power generation is constrained by several factors: sites with the greatest potential for high productive capacity and low development costs already have been exploited; capital costs are high; land use and water use priorities may inhibit development of the few remaining potential sites; and irrigation, navigation, municipal and industrial uses, and flood control frequently are more important reasons to construct dams, and their needs are not fully compatible with power production needs. Even with pumped storage facilities to store water for peak demand periods, efficiency is low in response to seasonal and daily demand cycles. Owing to these factors as well as long lead times for site acquisition, design, and construction, it is unlikely that additional generating capacity could be made operational within the time-frame of this study.

Hydropower generation does not consume fuel or cause air pollution. Although it does not consume water, it does require commitments of huge volumes of water to storage and managed release. Impacts on water quality stem from changed flow and temperature regimens that result from storage and managed release.

Construction of a hydropower generating system represents a long-term, irreversible commitment of the land resources beneath the dam and reservoir. Beneficial impacts on recreation may partly offset the loss of land resources, but on balance the permanence of the loss makes the long-term impacts adverse.

Federal development of coal resources

As stated in the Final Environmental Impact Statement for the Proposed Federal Coal Leasing Program (U.S. Department of the Interior, 1975, p. 833): it has been proposed that the Federal government actively conduct its own exploration for, and subsequent development or extraction of, energy fuels. This would result in more systematic inventories of coal resources. The Federal government would not be limited in exploration by acreage or lease boundaries. It would provide more complete knowledge as to the extent of a given coal field.

Exploration and development by the Federal government would be responsive to the national energy emergencies. This alternative would probably require enabling legislation.

The Federal government would be subject to not only its own regulations, but considerable public scrutiny. Environmental impacts would be similar to those of the proposal.

Alternatives That Do Not Provide Equivalent Energy

Energy conservation

Nationwide efforts to conserve energy clearly are capable of saving the relatively small amount of additional energy available from coal in northwestern Colorado. The total of 4.9 quadrillion Btus that would not be mined in northwestern Colorado during the next 15 years, pales beside the savings of 33.4 quadrillion Btus per year envisioned by the Office of Emergency Preparedness (OEP) as possible after 1980 (OEP 1972). To achieve such a level of energy saving would require full implementation of all measures suggested by OEP, which is unlikely, but these measures would only have to be two percent effective to more than offset additional production in northwestern Colorado. Similarly the Project Independence report (Federal Energy Administration 1974) estimates that conservation could reduce petroleum demand by 2.2 million barrels per day in 1985, which would amount to an annual savings of almost ten times the projected annual production from additional development of northwestern Colorado coal on Federal lands. In practice, the magnitude of national demand forecasts, coupled with the national objective of energy self-sufficiency, seem to require significant conservation of energy regardless of whether sources are developed in northwestern Colorado. The overwhelming argument is that it just makes good sense to conserve energy derived from a finite supply of non-renewable fossil fuels, which when converted to useful work, pollute the ecosphere to some extent and often severely.

Several recent studies have considered various energy conserving measures and have investigated the problems of implementation, environmental impacts, and comparative energy efficiencies. They also have investigated the complex relationships among the often conflicting objectives of energy conservation, environmental protection, and balanced economic development. Two of these reports are incorporated in this statement by reference because of their expanded coverage and documentation in an extremely complex field:

1. Office of Emergency Preparedness, The Potential for Energy Conservation: Government Printing Office, Washington, D.C., 1972.
2. University of Oklahoma, Energy Alternatives: A Comparative Analysis: The Science and Public Policy Program of the University of Oklahoma, 1975.

The final environmental impact statement for the prototype oil shale leasing program (U.S. Department of the Interior 1973) includes useful discussions of matters related to energy conservation in sections on The Energy Situation and Alternative Energy Policies in Volume II, Energy Alternatives.

The basic target of energy conservation is per capita energy demand, a figure that is increasing at an alarming rate. Between 1950-1970 the per capita demand increased by nearly 50 percent; forecasts of per capita demand between 1970-2000 suggest a further doubling of the amount (U.S. Dept. of the Interior 1972). The effects of population increases are of less concern in the face of such precipitous increases in per capita demand.

Reduction of demand growth rate can be accomplished by decreasing the demand for goods and services that require energy to be produced, and increasing the efficiency of energy used to produce remaining goods and services. That sounds simpler than implementation would be; the United States has the largest and most sophisticated system of energy consumption in the world, and such a system is slow and difficult to change. The present economic structure and population distribution are an outgrowth of relatively inexpensive energy supplies and relatively little concern about future supplies; economic growth and material standards of living soared as a result. Rapid changes to meet new perceptions of supplies and costs could have serious consequences to an economy already buffeted by conflicting requirements, and would have short-term social consequences widely regarded as unacceptable. Therefore conservation of energy must be viewed not only with respect to effectiveness, but also with respect to ramifications of implementation, including economic, social, and environmental repercussions. Time is a particularly vital consideration.

The OEP report on The Potential for Energy Conservation considers a variety of measures directed at the four major consuming sectors: transportation, residential/commercial, industry, and utilities. Implementation could be regulated by standards and regulations, tax incentives, and educational campaigns. Examples of the thrust of these projected measures are:

1. Transportation.--Promote and set standards for automobile energy-efficiency (engines, weights, tires); promote mass transit and

other improvements in load factors; provide incentives to decrease transportation demand that results from current patterns of population distribution; promote improved freight-handling systems;

2. Residential/commercial.--Encourage improved energy-efficiency of structures (design, insulation, materials, windows) and of appliances (heating, cooling, lighting); promote adoption of good day-to-day conservation practices;

3. Industry.--Encourage improved energy-efficiency of processes and equipment; promote recycling and reuse of materials where energy savings are demonstrable;

4. Utilities.--Use regulatory powers and incentives to smooth out demand curves and encourage conservative use; promote wise and efficient practices in construction, generation, and transmission techniques.

A measure common to all sectors is support for research and development to improve the energy-efficiency of existing and new facilities, equipment, processes, and social attitudes and patterns.

A greatly simplified isolated example serves to illustrate the complex relationships among energy conservation, the economy, society, and environmental protection. Reducing the use of automobiles and increasing their efficiency clearly would conserve energy. Current population distribution, however, evolved over many years during which the cost of transportation by gasoline-powered automobiles was relatively low. Public policies encouraged this trend, and industries related to automobiles and their fuel became a major segment of the economy. The result is an economy and a social fabric that relies heavily on the automobile powered by an internal combustion engine, a machine that depends on a non-renewable fossil fuel of limited supply, which is also a major source of pollution.

Because of our reliance on the automobile for transportation, significant reductions in use must be offset in part at least by alternate means of transportation. The diffuse pattern of population distribution does not lend itself to currently available techniques of mass transit except at extremely high costs. If costs are borne by users, the economic impacts can be crushing and unequally distributed; if borne by public funds, impact still is severe. Reduced use because of higher gasoline prices is effective, but because of the necessity for automobiles, sharply higher fuel costs simply work unequal hardships on individuals. Higher fuel costs affect commerce as well, and increased costs add to inflationary forces. If considerable reduction in automobile use is accomplished, lowered demand for automobiles and fuel would depress the major segment of our economy that directly or indirectly depends on their production, distribution, and service.

More efficient automobiles, in terms of fuel consumption per passenger mile, are gaining wider acceptance, as indicated by the increasing demand for smaller cars with smaller engines. However, measures to reduce the serious problem of automobile-related pollution have led to practices that are less energy-efficient. Unleaded gasoline reduces certain types of pollution, but it is less efficient in today's engines. Some emission control devices similarly reduce pollutants, but at the cost of increased consumption per passenger mile.

The implication is not that changes cannot be made; they must be made, and indeed many are taking place right now. The point is that energy conservation measures, which may seem to be simple solutions to the problem, are difficult to implement fairly and safely without undesirable side effects. Time is the critical factor to permit orderly social and economic adjustments, and to permit technological improvements in the hardware of energy production and use.

Reduction of present level of development

Past Federal actions have resulted in a current level of development in northwestern Colorado which has been regarded as the base level in the foregoing alternatives. An extension of disapproval of all new Federal actions is reduction in the base level of development. Methods now available to the Secretary of the Interior for halting or reducing valid mining operations currently underway on Federal lands have limited applicability: operations can be suspended for reasonable periods and proper reasons, but suspensions cannot extend to the point that de facto cancellation would result. Effective reduction could be achieved only by cancellation of existing lease rights, by Federal acquisition of leases, or possibly by civil legal action. The Secretary does not now possess authority to cancel leases, and such authority would have to derive from Congress. Authority for the government to acquire leasehold interests is limited by applicable statutes and likely would require Congressional action that included funds for compensation. Legal action taken against the government or the leaseholders might reduce or halt mining, but the possibilities are purely speculative.

In practice, the likelihood is small that the current level of development would be significantly reduced. Not only are the means for reduction complex and speculative but the impacts of reduction on the economy of the region would be severe. Adverse impacts of existing mines would be reduced but at the cost of direct and indirect employment. Power generating plants currently operating on Federal coal either would shut down with loss of capital investment and employment, or would continue to operate with coal from other sources in the region or imported coal.

Alternatives Based on Disapproval or Modification of Some Individual Action

The proposed actions addressed in this impact statement include some in hand and others, unspecific in detail, projected for the future. Sequential development of this sort offers an opportunity to work toward alternative objectives or to adjust development characteristics to fit not only the present conditions in the study area, but also to fit future conditions which cannot now be forecast with certainty. It must be recalled, however, that disapproval of development proposals on Federal lands already under lease currently requires that cause be demonstrated, and because existing leases are a legal contract, the cause must be sufficient to meet legal tests. The most recent laws and policies seem to be broadening the opportunities for rejection of proposals for cause; the true scope of opportunities still is uncertain, particularly with respect to environmental matters for which no standards exist. Effects of future laws and policies are speculative and add to uncertainty. In the following discussions, we assume that broad latitude exists to disapprove or modify specific proposals to achieve various objectives, but we would be misleading the reader if we implied that all such disapprovals were surely possible. Therefore, to consider the following alternatives most realistically one should regard the various objectives not as absolutes but as goals to approach as closely as possible.

Alternatives Based on Specific Objectives

Underground mining

Selective approval of proposals could lead to development principally by underground mining methods. Most of the proposed coal mining in northwestern Colorado would use surface mining techniques; current techniques for underground mining cannot be directly substituted because of problems related to roof support in near-surface underground mines. However, coal is abundant in the study area at depths that can be mined by underground methods.

In general, resource recovery in underground mines is lower: 50-60 percent as compared with as much as 90 percent by surface techniques. Cost per ton is higher than for surface mining because productivity per employee is lower. Adverse impacts on surface values are reduced because less land surface is disrupted and most active operations are insulated from the surface. In Colorado in 1974, productivity in underground coal mines was 1.3 tons per man hour compared to 7.5 tons per man hour in surface mines. Health and safety hazards are greater in underground mines: fatal and lost time accidents in underground mines in Colorado during 1974 were at the rate of 22.7 per million tons of coal mined, whereas the rate was 1.1 per million tons by surface methods. The higher incidence of accidents is caused by such things as rock falls, fires, explosions, and problems related to dust inhalation (black lung).

Abandoned mines can be hazardous to wildlife and to humans as attractive nuisances.

Some underground mines collapse after the coal is removed and surface effects can result, depending on the depth of the mine and the strength of the rocks between the mine and the surface. In general, collapse of a shallow mine causes greater surface disruption; unlike systematic disruption from surface mining, collapse can cause unpredictable and disordered disruption which is more difficult to mitigate by reclamation techniques. Planned collapse behind longwall underground mining is less disordered and more predictable, but restoration of ground surface is just as difficult because collapsed ground is not as finely broken as surface-mined overburden and does not lend itself to smoothing and recontouring.

New technology for underground mining mainly focuses on equipment and techniques to improve resource recovery and safety and to eliminate or control collapse. None is likely to add adverse impacts, and elimination of collapse would decrease adverse impacts of surface disruption.

Maximum exportation

Some of the additional Federal coal from northwestern Colorado would be used by local power generating plants that are in operation or are approved and under construction. Of the remainder, some would be used in projected additional generating units, and some would be exported from the region. Exportation of all additional Federal coal would force existing markets to find local sources on State or private lands, or to import coal. Impacts of these situations were discussed earlier. Exportation of all additional coal not planned for existing local markets would mean adding 6.5 million tons per year by 1990 to the amount of coal exported from the study area.

The most direct route to the objective of maximum exportation is disapproval of additional power generating units in the region, an action not now within the direct purview of the Secretary of the Interior. Then coal for new local markets would be either exported or not mined. Stress on maximum export would reduce adverse impacts of mining only to the extent that some proposed mines would not be developed if new generating plants were not built, a figure we cannot anticipate at this time. Principal adverse impacts avoided would be those related to additional power generating units in the region: two additional units of 380 megawatt capacity each at Craig, and a four-unit 1,000 megawatt plant in the southwestern part of the study area.

Impacts of increased exportation largely would result from heavier traffic on the Denver and Rio Grande Western Railroad (D&RGW). If all coal planned for new local markets were exported, an additional 6.5 million tons of coal would be carried annually by 1990. This would require approximately an additional 774 unit trains of 84 100-ton cars each. Including return trips, this would require an additional four or five trips each day. Figures derived by Morrison-Knudsen, Inc., for the W. R. Grace Company indicate that the Moffat Tunnel, a one-track tunnel on the main line of the D&RGW between Craig and Denver, would not be a limiting factor for coal development as projected in the study area.

Consumptive use of energy to accomplish maximum exportation would be increased at the rate of approximately 690 Btu/ton mile (University of Oklahoma 1975), but the total amount would depend on the distance to market areas, an unknown at this time. Noise, accidents, and fugitive dust also would be increased proportionally to increased haulage distance and tonnage.

No further power plants

Additional power plants or units added to existing plants would require State and probably Federal approval, both of which could be denied. Disapproval is not now within the direct authority of the Secretary of the Interior. No further power plants would mean that two added units at Craig and a four-unit plant in the southwestern part of the study region, which were included in the assumptions for this impact statement, would not be built. Therefore, impacts directly related to the power plants would be reduced: combustion by-products in solid and gaseous forms, between 1,500 and 2,000 acres of land committed to plant sites, and approximately 27,000 acre feet of water annually consumed in cooling processes.

The effects on mining are speculative. Development of mines originally designed to support added generating units might proceed if outside markets were found; increased exportation was discussed in the previous section. Proposed mines to supply new plants might not be developed, however, if local markets were withdrawn; approximately 6.5 million ton per year by 1990 would not be mined, which would result in reduced impacts: mining of 6.5 million tons per year would require disruption of about 650 acres per year if surface mining techniques were used. Impacts on vegetation, wildlife, water quality, cultural components, and socioeconomic values resulting from these increases in disrupted land and population would not occur; the degree of impacts would depend on details not now known concerning the mine sites, methods, and haulage plans.

Maximum local power generation

Means to achieve maximum local power generation are not clear. The Secretary of the Interior does not now have the authority to directly designate markets for Federal coal, but the same objective might be approached through indirect stipulations on permits or by negotiation and persuasion. If all coal from anticipated development in northwestern Colorado were used to generate electricity in local power plants, an additional capacity of about 6,500 megawatts would be required beyond capacity now installed, approved or projected. Individual units range from 250 to 400 megawatts, so an additional 15 to 25 units would be required, probably in several groupings of units. Land committed to facilities would be about 1,000 acres per site; air quality would be affected by the burning of an additional 22 million tons of coal per year in the region, and water consumed in cooling processes would increase by about 97,500 acre feet per year. The adverse impacts of exportation of coal would be reduced, but the impacts of population increases directly and indirectly associated with power plant construction and operation would be added (approximately 75,000 people depending on the specific sites, timing of construction, and similar details not now known).

Although air quality, population increases, and consumed water probably would not be limiting factors, each would have significant impact on the region. Decisions for acceptable levels and priorities of use would be needed; such considerations would involve local and State attitudes as well as Federal objectives. They should look beyond coal development alone to assure that future options for development or protection of various resources would not be precluded.

No further leasing

This alternative and variations of it are discussed in Chapter 8-3, Leasing Alternatives, of the Final Environmental Impact Statement for the Proposed Federal Coal Leasing Program (U.S. Department of the Interior 1975). As stated there: this alternative involves development of existing leases and leases which will result from valid applications prior to undertaking additional leasing. Analyses of existing leasing indicate that: (1) existing leases are not necessarily in the ownership of companies needing coal reserves for early production; (2) some of the coal lands under lease are broadly scattered and lack potential for development due to isolation and limiting transportation facilities; and (3) some leases by themselves contain inadequate reserves to support economic mining operations.

Limiting development to existing leases in northwestern Colorado could be implemented simply by taking no action on future applications for leases. The effect of no further leasing probably would reduce the amount of coal mined; the amount is speculative. Emphasis would shift to coal on existing leases and on private and State lands. Logical mining units in these areas, however, commonly would include some unleased Federal land because the irregular pattern of land ownership bears only an accidental relationship to minable coal deposits. The result could be a less reasonable or efficient pattern of development, which could lead to greater adverse environmental impact per ton of coal recovered.

Controls on environmental effects would be no more stringent on private and State lands than on Federal lands.

Accelerated development

Means are available to encourage development of Federal coal in northwestern Colorado. Experts in the Department of Interior can evaluate resource possibilities on Federal land and investigate environmental problems related to development. Then tracts of land most favorable for development can be offered for lease sales and industry invited to bid. The decision to bid at acceptable levels is entirely at industry's discretion.

Factors in favor of accelerated development include: (1) the need for increased energy supplies to meet demands and attain energy self-sufficiency, (2) the relatively high quality of coal in northwestern Colorado as boiler fuel, (3) the abundance of coal in the region, (4) the relative success of mined-land reclamation in the less arid eastern part of the region, (5) the relatively low potential for water pollution from mining, and (6) the likelihood that water consumption rates are not at threshold levels beyond which conflicts for use are limiting factors.

Factors in opposition to accelerated development include increased adverse impacts on the physical, biological, and socio-economic environment, and increased commitment of a non-renewable resource.

Impacts of accelerated development are incremental in relation to the rate of acceleration and are added to the impacts of development, as described in Chapters V-VIII of this statement. Limiting factors would appear first in water supplies needed to support additional development of power generating capacity and population increases related to all additional development. Although not necessarily a limiting factor, rapid population increases may cause adverse impacts of such severity that they would tend to restrict the rate of accelerated development.

Develop areas most effectively reclaimable

The eastern part of the study region generally has greater potential for effective revegetation because of higher precipation rates. Site-scale studies would be necessary to identify specific areas with the best potential. New leases could be issued only in these areas where reclamation would be most effective. Proposed development of existing leases currently poses the problem of disapproval for cause, so assurance is less that development could be limited to the most effectively reclaimable leased areas in the study area.

Effective revegetation is the cornerstone of reclamation of surface mines. Prompt return of the land to the maximum possible productivity level minimizes long-range adverse impacts on erodibility, range or agricultural values, aesthetics, or wildlife. All site-specific analyses included in this impact statement are in the eastern part of the study region and therefore typify the revegetation potential in that part of the study area. Precipitation rates decrease moving westward, so reclamation would be proportionately less effective.

Alternate reclamation objectives

Most land used for mining, construction, and temporary rights-of-way is eventually abandoned to another land use. A variety of potential land uses could be considered after surface disturbance and topographic alterations have occurred on mined lands in northwestern Colorado. Post-mining land uses considered as optional alternatives within the study region are: grazing land for domestic livestock, wildlife habitat, recreation, cropland, residential and commercial development, and multiple land use combinations.

No reclamation

This alternative is no longer legally feasible and therefore is not considered a viable alternative.

Grazing land for domestic livestock

Areas having flat to gently rolling topography with potential for water reservoirs would be ideal for grazing. Reclamation would include replacing topsoil, fertilizing, and mechanical treatment. Both native and introduced species of vegetation could be used successfully.

Surface soil materials should be capable of supporting vegetation to provide adequate groundcover for erosion control and harvestable forage. The topography should vary from flat to gently rolling with no slopes steeper than 4:1; a considerable advantage would be obtained from gentler slopes which would allow machinery to be used for redistribution of topsoil, for surface manipulation practices, and for reseeding. Highwall areas should be reduced to an angle that does not represent a hazard to grazing livestock. Livestock fences and watering facilities should be included. If topsoil is replaced this objective has a high potential in most areas, considering existing climatic conditions.

Reclamation of lands solely for livestock grazing purposes would impact and limit other land uses. Wildlife habitat and recreation use would be limited; fences would interfere with some species of wildlife and recreation use. A less diversified vegetation would be established; this would limit wildlife diversity and would be less attractive for recreational purposes. Increased erosion would follow overgrazing, and other vegetation might be trampled and the soil surface compacted if proper livestock management were not enforced.

Wildlife habitat

Areas reclaimed primarily as wildlife habitat should be reshaped to approximate existing topography with slopes no steeper than 3:1. Highwalls should be reduced to the same slope to eliminate hazardous conditions. The soils should be stabilized by topsoiling, fertilizing, and special structures on slopes of 3:1 or steeper to prevent erosion.

A large variety of native shrubs and grasses should be planted with some establishment of trees in suitable areas. Limited areas of introduced species would add variety to the habitat. Variation in habitat and food sources would allow a greater variety of wildlife.

Water impoundments should be designed specifically for wildlife habitat; natural lakeside vegetation should be established. Highwall areas, if used to facilitate formation of lakes, should be fenced to protect wildlife.

Reclaiming disturbed lands purely for wildlife habitat probably would be the most difficult objective to achieve because of the lack of a source of native plant materials. Success would depend upon the intensity with which the plan is carried out, invasion by native species, and the extent to which native species are transplanted. W. R. Grace has initiated a research study to determine the feasibility of this objective on their mined lands in northwestern Colorado.

Rehabilitation of lands for wildlife habitat would shorten the time necessary for wildlife to repopulate the area and would result in least overall impacts of surface mining. Increased steepness and roughness of topography would not permit use of the lands for some forms of recreation, urban and commercial development, and cropland use. Potential for livestock grazing would be reduced because the type of vegetation would not constitute preferred forage species for livestock. Rougher and steeper landforms would result in decreased stability of some surface soils. Minimized use for other purposes would enhance the desirability of the land for wildlife and increase the rates of repopulation by wildlife.

Recreation

Recreation is possible on all types of landforms, depending upon the type of activity contemplated; therefore the possibility of returning mined lands to some form of recreational use has a relatively high potential, especially in areas close to population centers. If this reclamation objective is chosen, to be most useful it should be responsive to identified recreational needs.

For most recreational purposes, a maximum effort should be utilized to produce a stable vegetative cover approximately equal in diversity to vegetation prior to disturbance.

Water impoundments would be highly desirable for recreation use, and should be built to specifications that meet approval of the State Board of Health, both to prevent stagnant pools from forming, and to create waters that would support aquatic life. Shoreline slopes should not be greater than 3:1, or they should be bermed as a safety measure. Any other hazardous conditions should be eliminated if possible.

Additional recreational uses for disturbed lands would be off-road vehicle areas, geologic-interpretive areas, picnic areas, etc.

Recreation use of rehabilitated lands would result in an increase in littering and trash. Off-road vehicle use probably would be increased, which would result in destruction of plant cover and increased erosion and compaction of soils. The diversity of wildlife species and population numbers possibly would be reduced. Wildlife species sensitive to human disturbance could be displaced. Livestock use would be curtailed or totally absent from heavily used recreation areas. Pollution of impounded waters could occur. Air pollution and noise levels from vehicles would occur. Water impounded for recreation use would be unavailable to industry, agriculture, and other uses. This alternative could provide needed opportunities if population growth increases significantly in the area.

Cropland

Land with slopes less than 5:1, where topsoil is replaced to a depth of approximately 18 inches and fertilizer is used, would have a high potential for use as cropland for winter wheat, oats, etc. Because these crops have relatively shallow roots that probably would not penetrate past the topsoil, return to a productive use probably would be fastest on acres reclaimed to cropland. It may be desirable to plow under a green manure crop, such as alfalfa, before a crop is produced for harvest. Degree of slope, depth of topsoil, and climatic conditions would be the limiting factors of this objective.

Crop failures due to climatic variation and lowered soil fertility could be expected, and average yields could be uneconomical, unless fertilizer is used and topsoil replaced to a depth of at least 18 inches. Erosion might occur on dryland areas where summer fallowing is practiced, reducing water quality. Recreation use would be eliminated or severely restricted during most of the year. Most cropland would be seeded to a monoculture, limiting diversity of wildlife habitat. Livestock grazing would be limited to specific seasons of the year.

Residential and commercial development

Residential and commercial development would be best suited to flat or gently rolling topography; lakes and reservoirs would be desirable. The most important process in the reclamation for this use would be shaping and insuring good compaction on subsurface materials. Topsoil replacement would be desirable to aid in vegetative success.

Residential and commercial development following mining would virtually exclude other land uses permanently. Impacts from increased erosion would occur during construction operations, and ambient air quality would be reduced. Increased pollution of local water ways could occur, and noise levels would be increased.

Multiple use

Multiple use, or a combination of the above alternatives, could optimize uses that are in harmony with the land capability and regional needs.

Uses other than power generation

The government is not now authorized to designate markets for coal mined from Federal lands, but stipulations might be possible that would at least have strong influence on the proposed use. Present use of northwestern Colorado coal is almost exclusively for boiler fuel in coal-fired generating plants, regardless of whether the market is local or outside the region. The Btu content of the coal, its relatively low sulfur content, and the economics of recovery influence the present use; higher quality coal elsewhere in Colorado is used for metallurgical processes, and lower quality coal in the state is a less desirable boiler fuel because of higher sulfur/ Btu ratios.

Possible alternate uses could stem from liquifaction or gasification processes that generally are regarded as ways to improve the usefulness of lower quality coal. Liquifying and gasifying coal in commercial quantities is a target of current energy research and development. Synthetic natural oil is the end product of coal liquifaction; gasification produces synthetic natural gas. Of the two methods, researchers have devoted more effort to gasification because of the high costs encountered in producing synthetic natural oil. High costs and the elementary level of technology have impeded both synthetic natural gas and oil development; pilot plants have been operating domestically but commercial production levels have not been achieved. The role of synthetic natural gas and oil in the nation's future energy supply also will depend on environmental standards and the availability of water.

Environmental impacts result from plant construction and operation. A typical coal gasification plant would produce 250 million cubic feet per day of pipeline gas, consume from six to ten million tons of coal annually, use about 6,000 gallons of water per minute, and carry capital costs (including coal mine development) of more than $400 million. A plant would occupy about 200 acres of land. Sulfur, nitrogen oxides, and fly ash would be emitted during operations and water quality could be affected by waste products, particularly in storage areas.

To illustrate the magnitude of waste products that would have to be considered in a plant producing 250 million cubic feet per day of pipeline gas, the Federal Power Commission's Natural Gas Survey estimates the following, assuming coal containing 3.7 percent sulfur, which is considerably higher than most coal from northwestern Colorado:

	Tons/day
Sulfur (mainly as hydrogen sulfide)	336-504
Ammonia	112-168
Phenols	11- 78
Benzene	56-336
Oil and tars	Trace-448
Ash (based on coal with 10% ash)	1,680

Coal resource conservation

Resource conservation is a responsibility of the Secretary of Interior, particularly in regard to resources owned by the government. Deferring development of Federal coal in northwest Colorado clearly preserves the resource, but mineral resource conservation means more than preservation; it means following the wisest course of action in the context of the present and the future. Preservation is the wise course of action only if the value of the resource is greater left in the ground than developed. Value is estimated in a variety of ways including relationships between the present and future dollar value of the resource, between environmental impacts of development and importance of the resource to the nation, and among other variables such as the relative abundance of the resources related to alternate sources, and the responsibility of the Secretary to meet national policy objectives of the moment (e.g., energy self-sufficiency, economic recovery, national security, increased employment opportunities, and environmental protection).

If on balance, the wise course of action is deferral of further development, the increment of impacts flowing from further development is deferred for an equivalent time. If and when development begins again, the related impacts are added to the present base, plus impacts that result from other interim activities and natural processes.

Slurry pipelines versus railroad transportation

The extent to which the Department of the Interior or other Federal or State groups could influence industry to modify transportation plans is speculative. Direct authority to specify exportation systems may not exist at present, but the same result possibly could be achieved by legislation or indirectly by stipulations embodied in leases and mining plans.

All exportation of coal from northwestern Colorado now and as proposed is by railroad. No serious proposal has been made to export coal by slurry pipeline. At present, none of the major slurry pipelines planned or in existence is closer than 200 miles from the Yampa coal field in the study region. A proposed line would run southeast from Walsenburg, Colorado in the southernmost part of the State; two other proposed lines would be at least 200 miles to the northeast, enroute from the Powder River basin area in Montana and Wyoming to markets in Arkansas and Texas, by way of Nebraska and Kansas. Thus, a slurry pipeline serving northwestern Colorado would be an all new venture designed for specific markets not now identified.

Controversy surrounds present comparisons of economic and environmental factors between railroad and slurry pipeline transportation of coal (e.g., studies by Bechtel Corporation, Burlington Northern Railroad, and National Science Foundation by grant to the University of Illinois). With respect to northwestern Colorado, the specific issue would be new pipeline versus existing railroad. Considering large capital costs required for a new pipeline, and compared with relatively small costs for up-grading an existing railroad, the intuitive conclusion would be that use of an existing railroad is the more economic of the two transportation methods. Studies supported by data of various quantity (and perhaps quality) both support and question this conclusion. Similarly argued are the comparative environmental impacts.

Of particular concern in northwestern Colorado would be water requirements for pipelines and additional impacts resulting from increased rail traffic compared to new pipeline construction and operation. Projections of the amount of coal that would be exported if the actions are approved as proposed would reach an annual level of approximately 22 million tons by 1990. At the rate of one ton of water required to transport one ton of slurried coal, annual water requirements would be 5.28 billion gallons, or about 16,200 acre-feet. Although this amount of water is small relative to the annual flow of the Yampa River (between one million and one and one half million acre feet), any consumptive use of water should be weighed carefully in a region of generally modest precipitation and potentially large water demands for industrial and domestic use in the future. Ways to minimize the adverse effects of exporting water as part of a slurry delivery system include: (1) returning water by means of a parallel pipeline, a method that would be capital-intensive and increase environmental impacts of pipeline construction; (2) using water that is of such poor quality that it is not now useful for domestic or agricultural purposes, a method that would cause disposal and treatment problems at the market end of the line, and still would be exportation of water that might be treated for use locally; and (3) in a larger context, using water from a slurry pipeline to the east to substitute for water in present or future diversion systems designed to supply the Front Range urban corridor, which would result in the slurried coal riding in water that would be exported from the western slope of the Rockies in any event. Treatment to assure good water quality at the east end of the line could raise the cost of such a combined use system to unacceptable levels.

Other long-term adverse environmental impacts of slurry pipelines are related to preparation facilities at the input end of the line and dewatering facilities at the market end. Each requires commitments of land for such operations as crushing, water diversion, pumping, and water treatment and disposal. Noise, dust, and fuel consumption result from such operations, as well as the loss of land resources. In the event of stoppage or other failure of an operating slurry pipeline (at the present technologic state-of-the-art), it is imperative that the slurried coal be drained promptly from the pipeline into settling ponds along the right-of-way to prevent sludging and clogging of the line. Those settling ponds present potential problems of contamination of water, damage from blowing dust, commitment of land, and impacts stemming from cleaning ponds that have been filled with finely crushed coal. Well-designed pipelines and settling facilities could minimize the chances for using the ponds and the adverse effects in the rare event of use, but the commitment of land for the ponds and access to them would remain.

Short-term impacts would result from construction of a pipeline. Reclamation of the right-of-way and construction access roads could ensure maximum recovery of the land, but there would be some residual impacts, depending on the amount of land with low potential for vegetation along the selected route.

Adverse impacts caused by rail traffic would be reduced in proportion to the amount of coal exported through pipelines. These impacts include noise, dust, water pollution from possible spills in adjacent water courses, diesel fuel consumption, wildlife collisions, and highway traffic interruption and hazards at grade crossings. By 1990, 22 million tons of coal are projected to be exported each year. If that amount did not travel by railroad, rail traffic would be reduced by about 14 or 15 unit trains per day including return trips.

Export of all coal or even significant amounts of it by trucks rather than by railroad or slurry pipeline is possible in theory but extremely unlikely in practice. Rail transport, particularly on existing trackage, has proved economically more attractive elsewhere and certainly would apply to northwestern Colorado. Also existing roads would be grossly affected by large increases of heavy load traffic. Transport of 22 million tons of coal per year would require more than a million trips, or more than 100 trips every hour of every day.

Alternate power plant designs

Emissions controls employing electrostatic precipitators and wet scrubbers have been included in the impact assessment of the proposed power plants. Alternatives such as baghouse filters and venturi scrubbers are available. Plant design alternatives would also affect ground level air quality impact. Higher stacks, larger flue gas rates, and higher gas exit temperatures would all increase the effective elevation of emissions and therefore decrease ground level impact.

Once emitted into the atmosphere, pollutant impact is a function of the atmosphere's dispersive characteristics. Plume trapping and fumigation conditions represent worst case meteorology for elevated point sources, such as tall stacks. Therefore an alternative control technique would be operation of a supplementary control system which takes advantage of favorable meteorology. Under this type of system a plant would operate at full capacity during favorable dispersion conditions, and slow down or switch to high grade fuel during persistent worst case conditions.

Alternatives That Phase Development With Other Activities

Northwestern Colorado by itself is a dynamic region, and the region also interacts in a larger context of economic, social, and political forces. For this reason, impacts of the future Federal actions under consideration in this impact statement, those that are projected as likely to take place in the next 15 years but now are unspecific as to time, place and other important details, cannot be assessed with much certainty at this time. For example, during just the past few months prospects for the future development of oil shale nearby to the southwest have ebbed and flowed through a wide range. The level of development that actually will evolve in 5 years or 10 or 15 depends on factors beyond anticipation now; yet the level of oil shale development is an important consideration with respect to certain cumulative environmental impacts in the region. Because coal development in the region is not a single project that once started will proceed inexorably to a known result in the future, but rather, is a sequence of individual projects spread over time, there can be alternatives to presupposing approval of future activities as proposed.

One alternative is to defer all coal development insofar as possible until the future is clearer. Deferral would be valid only if there were some specific reason to believe that events in the near future would substantially alter all judgments made earlier. We know of no such reasons. Delay for the sake of delay or delay with the fond hope that something will come along are inadequate reasons to consider deferral.

A preferable alternative would be to evaluate later proposals in the context of that specific time. The objective would be to phase coal development most harmoniously with other types of development in the region. In that way coal development could proceed if appropriate, but not at the expense of other activities. Mechanisms to achieve the wisest and most effective integration of development could be at local, State, or Federal levels, could involve ad hoc or standing advisory groups [1/], or could be in some different regulatory form that might require new authorizations to implement. Consideration could be of one principal form of development (such as coal) in relation to others, or consideration of all types of development in relation to one another. By whatever means the information could be acquired, reviewed, and disseminated, the objective would be to evaluate a future proposal's effect on the then-current state of the region, with particular concern for cumulative

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1/ For example, the Oil Shale Environmental Advisory Panel, an official group representing a wide range of disciplines and points of view, advises the Oil Shale Mining Supervisor on a continuing basis about issues of the moment.

impacts that approach threshold levels and therefore threaten precluded options for subsequent decisions.

Several types of activities could have influences on the use of land, air, and water resources in the future in northwestern Colorado: new environmental standards established by local, State and Federal regulations and legislation, technological advances, changes in economic, political, and social factors bearing on energy development and demands, perceptions regarding acceptable rates of population growth in regions such as northwestern Colorado, and changes in specific developments or rates of development in a variety of industries in the region, such as oil shale, uranium, agriculture, water, and recreation. New standards established by laws, regulations, and policies would be implemented of necessity whenever applicable. Technologic advances in mining, reclamation, power generation and transmission, if not incorporated in future proposals, probably could be added by stipulation or negotiation. Changes in economic, political, and social factors bearing on energy development and demand probably would be reflected in the timing, types, and responses to proposals received in the future. Coal development most effectively could be phased with other activities in the future in matters of population increases and developments of other industries.

Coal development phased with population growth

Implementation of the proposed action would induce a new population increment to the study region. This increment would accentuate the peak-decline pattern of population growth that is expected without the proposed action. An alternative to the proposed action is to phase coal-related developments so peak-decline patterns can be minimized or eliminated.

To investigate the impacts of this alternative the assumption must be made that population without the proposed action would grow at some steady rate. For this purpose the 1975-90 average annual compound growth rate of the base scenario projection will be used (see Chapter IV, Future Social Environment Without the Proposed Action). This average rate, 4.50 percent per year, does not truly reflect the peak-decline pattern of the base scenario projection, but it may better reflect future population growth without the action, because the base projection is a worst case outlook that includes oil shale population effects. Recent developments indicate that these effects may not materialize.

Using this 4.50 percent growth rate to project a steady population growth without the action and assuming:

1. Any population growth over and above the base scenario would be induced by new coal production;
2. This population growth would be at some steady rate;
3. A constant relationship of 3.71 new people per new coal mine employee, and;
4. Coal productivity per employee is 55 tons/day, 260 days/year,

then for any population growth rate above the base rate, the new induced population and the corresponding annual coal production can be determined.

Table RX-4 presents the results of this analysis, showing the base scenario population and coal production at several population growth rates.

TABLE RX-4

Population and Coal Production Under Conditions of Steady Population Growth

	1980	1985	1990	Cumulative [2/] Production Through 1990
Base Population: (4.5% Growth Rate)				
Coal Production [1/]	32,232	40,166	50,052	66,375
5% Growth Rate:				
New Population	780	1,967	3,721	
Coal Production [1/]	3,006	7,581	14,456	160,161
6% Growth Rate:				
New Population	2,883	6,156	11,937	
Coal Production [1/]	9,184	23,725	46,005	360,917
7% Growth Rate:				
New Population	4,046	10,716	21,313	
Coal Production [1/]	15,595	41,301	82,141	582,283
9% Growth Rate				
New Population	7,566	21,068	44,164	
Coal Production [1/]	25,160	81,197	170,210	1,084,723

[1/] Thousands of tons.

[2/] Includes intervening years. Also includes 4.425 million tons per year to account for continuation of existing production levels.

The cumulative coal production that would result from the proposed action over the fifteen year time frame of this study is about 340 million tons. Table RX-4 indicates slightly more than this amount of cumulative production could be achieved with a steady population growth rate of six percent. This means that with a steady population growth rate of six percent, with no peaks or declines in total population, about the same amounts of coal could be produced from the study region as would be produced under the conditions of the the proposed action. Note however that the steady growth rate case assumes that all new coal will be exported from the region, i.e., no new coal-fired power plants will be built in the study region. This assumption precludes any population peaks that would be associated with the power plant construction phase.

The impacts associated with this alternative are essentially the same as those discussed under the maximum exportation and no further power plants sections of this chapter, with the following additions. Under this alternative the possibility of over or under-utilization of social support facilities that result from the peak-decline population pattern of the proposed action would be eliminated. Many of the adverse impacts associated with the boom-town growth pattern of the proposed action, such as disproportionate crime rates and mental health case loads, would be minimized. Furthermore, if a relatively steady population growth could be anticipated by concerned Federal, State, and local agencies, mitigation of the impacts of this growth could be planned for and financed with a greater degree of success than under the proposed action.

Coal development phased with development of other industries

Development of other industries in northwestern Colorado is unpredictable at present but several industries have the potential for substantial impact in the region, particularly oil shale, uranium, and water developments.

Oil Shale

If oil shale becomes economically attractive to mine and the industry moves to and beyond prototype operations, environmental impacts of that development would be added to those of coal development. The cumulative impacts of combined development that first may approach problem levels probably would be related to rapid population increases and consumptive use of water. At the time of future proposals for coal development, an updated evaluation of the prospects for oil shale development could lead to wiser phasing of coal development in order to minimize the possibility of: (1) exceeding acceptable population growth or water use rates, or (2) unknowingly precluding future development of coal or oil shale by leaving no room within limits to growth or water availability.

Uranium

As the world price of uranium increases, the possibilities also increase for vigorous renewed interest in low-grade uranium deposits north of Maybell. Construction of a new mill probably would be the key to renewed activity. Once in operation a mill would eliminate the current problem of high costs for transporting large volumes of low-grade ore for long distances. Air quality impacts from mining and milling as well as population impacts would be added to those of coal development, and the combined impacts would tend to concentrate in the center of the region near Craig, Hayden, and Maybell. Future coal development could be phased with then current levels of development of uranium in the region to minimize cumulative adverse impacts and avoid precluding future options for development.

Water developments

The principal potential water development within northwestern Colorado is the Juniper Reservoir project which would involve analysis of environmental impacts before it could be built. The possible relationship between the Juniper Project and coal development would involve more than consideration of water requirements for coal development and coal-fired generating systems; it also would involve cumulative socio-economic impacts, particularly during the construction phase, and changes in recreation opportunities and use brought about by a major new reservoir in the region. The timetable for construction of the Juniper Project is unknown. But because of related impacts on the region, it could be beneficial to phase future coal development with whatever level or rate of development evolves for Yampa River impoundments.

Other potential considerations involving water developments would be less direct but nonetheless could involve the water budget of northwestern Colorado. Water from the region contributes to the Colorado River system, and water management agreements and practices involving that system bear on northwestern Colorado. Two hypothetical and greatly simplified examples serve to illustrate the possible relationships: (1) it could happen that salinity of Colorado River water would threaten to exceed limits set by national and international agreements; reduction of salinity could be achieved by increasing flow from throughout the system or from areas within the system that have a relative excess of water; either could increase requirements from northwestern Colorado, or viewed another way, could reduce the amount of water available for consumptive use in the region; (2) it could happen that patterns of consumptive water use in the State of Colorado could change either because of industrial or agricultural requirements elsewhere in the Colorado River watershed, or because of diversions of water to the eastern slope of the Rocky Mountains for urban development needs. Although the consumed water might not come from northwestern Colorado, the State is required to release certain volumes of water to the river system, and it might be necessary to make up all or part of the deficit with water from northwestern Colorado; again the effect could be less water available for use within the study area.

Future coal development could be phased with future water developments by assessing cumulative impacts in the light of the situation at that future time. Although water now does not seem to be a limiting factor for coal development as proposed, future changes in water budgets could require careful evaluation to be sure that incremental decisions with respect to one kind of development would not lead to inadvertently precluding development of another kind in the region.

Combinations of Alternatives

In the interest of clarity, the previous sections have presented each potential alternative as a possible substitute for or modification of projected additional development of Federal coal in northwestern Colorado between 1976 and 1990. It is unlikely however, that a single definitive choice should or would be made among alternatives, or that pursuit of one alternative would preclude pursuit of others. The main reason is an anticipated shortfall of domestic supply relative to demand.

Project Independence (Federal Energy Administration, 1974) estimates the shortfall as 6.6×10^{15} Btus in 1985, if no emergency programs are imposed and if the world oil price is $11 per barrel. Only by accelerating development of domestic supplies and minimizing energy consumption through conservation can demand and domestic supply approach parity. Basic assumptions regarding various energy sources without steps to accelerate supply are:

1. Petroleum production is severely constrained in the short run and greatly affected by world oil prices in the long run. Before 1977 there is little that can prevent domestic production from declining or at best remaining constant;

2. Coal production will increase significantly, but is limited by lack of markets. Increases are limited by rate of electric growth, increasing nuclear capacity, and environmental restrictions;

3. Potential increases in natural gas production are limited;

4. Nuclear power is expected to grow from 4.5 percent to 30 percent of total electric power generation;

5. Synthetic fuels will not play a major role between now and 1985;

6. Shale oil could reach 500,000 barrels per day by 1985 at $11 world oil prices, but would be less if lower prices prevail;

7. Geothermal, solar, and other advanced technologies are large potential sources, but will not contribute significantly to our energy supplies until after 1985 or later.

Increases in domestic supply presume the following:

1. Standardization and expedited licensing to increase nuclear capacity 15 percent by 1985;

2. Significant new leasing, exploration and development of the Pacific, Gulf of Alaska, and Atlantic OCS;

3. Additional oil and gas pipelines from Alaska to the lower 48 states;

4. Increased Federal leasing and actions to allow additional oil shale production;

5. Opening Naval Petroleum Reserves 1 and 4 to full-scale commercial development;

6. Possible mandatory allocation or other actions to assure critical materials and equipment meet expected production levels.

The future mix of U.S. energy sources will depend on a multiplicity of factors, among them the identification of resources, research and development efforts, development of technology, rate of economic growth, the economic climate, changes in life style and priorities, capital investment decisions, energy prices, world oil prices, environmental quality priorities, government policies, and availability of imports. Some specific matters bearing on the problem are:

1. Historical relationships indicate that energy requirements will grow at approximately the same rate as gross national product;

2. Energy requirements can be constrained to some degree through the price mechanisms in a free market or by more direct constraints. One important type of direct constraint operating to reduce energy requirements is through the substitution of capital investment in lieu of energy; e.g., insulation to save fuel. Other potentials for lower energy use have more far-reaching impacts and may be long-range in their implementation; they

include rationing, altered transportation modes, and major changes in living conditions and life styles. Even severe constraints on energy use can be expected to only slow, not halt, the growth in energy requirements within the timeframe of this statement;

3. Energy sources are not completely interchangeable; for example, solid fuels cannot be used directly in internal combustion engines. Fuel conversion potentials are severely limited in the short term although somewhat greater flexibility exists in the longer run and generally involves choices in energy-consuming capital goods. The principal competitive interface between fuels is in electric power plants. Moreover the full range of flexibility in energy use is limited by environmental considerations;

4. A broad spectrum of research and development is being directed to energy conversion: more efficient nuclear reactors, coal gasification and liquefaction, liquified natural gas (LNG), solar radiation, and shale retorting, among others. Several of these should assume important roles in supplying future energy requirements, though their future competitive relationship is not yet predictable;

5. Major potentials for filling the supply/demand imbalance for domestic resources are:
   - More efficient use of energy,
   - Environmentally acceptable systems which will permit production and use of larger volumes of domestic coals,
   - Accelerated exploration and development of all domestic oil and gas resources,
   - Development of the nation's oil shale resources.

Chapter XI

Consultation and Coordination

CHAPTER XI

CONSULTATION AND COORDINATION

This section describes the organization and functioning of the EIS interagency team, and discusses the contribution of various Federal, State, and local organizations to the overall EIS preparation effort.

Organization of Interagency Task Force Team for the Environmental Statement

A memorandum dated March 7, 1975, from the Office of the Secretary of the Interior assigned the Colorado State Director, Bureau of Land Management, lead responsibility for preparation of this Environmental Impact Statement. The project was organized as a joint effort between the Bureau of Land Management (BLM) and the U.S. Geological Survey (USGS). During March 1975 a project approach was developed, including selection of team members and scheduling for the multiplicity of actions. The following items were agreed upon at these meetings, and subsequently implemented during the course of statement development:

1. Team members were selected for representation of broad categories of environmental concern, including soils and vegetation, range and wildlife, cultural values, socio-economics, hydrology and aquatic biology, geology, mining and ecological interrelationships;
2. Team members were selected from BLM and USGS resource areas;
3. EIS team offices were established at the Holiday Inn, Steamboat Springs, because Federal office space that would afford the needed work accommodations was not available in the local area;

4. The general work schedule was a typical five days on duty and two days off;
5. Total team membership averaged more than twenty people and was comprised of the following scientific and behavioral disciplines: range management, archeology, wildlife biology, aquatic biology, geology, mining engineering, hydrology, water and air quality, soils science, landscape architecture, economics, sociology, history, civil engineering, and outdoor recreation; support skills in the form of cartography, editing, drafting, illustrating, and administrative functions were also utilized;
6. BLM provided administrative and clerical support to all teams in residence;
7. Periodic review was provided in Steamboat Springs by a representative of the Office of the Solicitor.
8. Specialized services to assemble and analyze research materials and provide consultant assistance were secured by contract.

An industry meeting was held at the BLM State Office Building in Denver on March 21, 1975, with approximately 250 people in attendance. The purpose of this meeting was to notify all coal industry people of project plans and solicit industry's preliminary coal development plans. The industry people were given until April 30, 1975, to finalize and submit their mining plans. After this deadline, all letters of intent and mining proposals were assembled into a regional package and constituted the proposed actions which are analyzed in this impact statement. On April 2, 1975, the initial notification that the project was beginning was issued to Regions 11 and 12 of the Colorado Council of Governments (COG).

Consultation and Coordination in the Preparation of the Draft Environmental Statement

Federal Contacts

In preparation of this draft statement, data and/or review comments were solicited from the following bureaus and offices within the Department of the Interior:

--Advisory Council on Historic Preservation: Office of Review and Compliance,

--Bureau of Land Management,

--Bureau of Mines,

--Bureau of Outdoor Recreation:

--Mid-Continent Region,

--Bureau of Reclamation:

--Western Colorado Projects Office,

--Fish and Wildlife Service:

--Brown's Park National Wildlife Refuge,

--Geological Survey:

--Geologic Division,

--Paleontology and Stratigraphy Branch,

--Mining Enforcement and Safety Administration,

--National Park Service:

--Curecanti National Recreation Area,

--Dinosaur National Monument,

--Office of the Solicitor.

Because of other permits and actions involved in the northwest Colorado Coal EIS project, close coordination and input were achieved with the following Federal departments, agencies, and governing bodies outside of the Department of the Interior:

--Department of Agriculture:

--Agriculture Extension Service,

--Forest Service:

--Regional Office,

--Routt National Forest,

--White River National Forest,

--Flaming Gorge National Recreation Area,

--Rural Electrification Administration,

--Soil Conservation Service,

--Department of Commerce,

--Department of Health, Education, and Welfare,

--Department of Housing and Urban Development,

--Department of Transportation:

--Federal Highway Administration,

--Federal Railroad Administration,

--Occupational Safety and Health Administration,

--Environmental Protection Agency,

--Federal Energy Administration,

--Federal Power Commission,

--Interstate Commerce Commission,

--United States Senate,

--Water Resources Council,

--Advisory Council on Historic Preservation,

--Energy Research and Development Administration.

State and Local Contacts

Colorado

State

A close working relationship was established with State and local agencies in Colorado. All divisions of Colorado State Government having jurisdictional interests in the projects have been contacted and many supplied statement data. A complete list follows:

- --Office of the Governor,
- --Clearing House,
- --Department of Health:
  - --Air Pollution Control Division,
  - --Water Quality Control Division,
- --Department of Natural Resources:
  - --Division of Parks and Outdoor Recreation,
  - --Division of Mines,
  - --Division of Water Resources,
  - --Division of Wildlife,
  - --Geological Survey,
  - --Land Reclamation Board,
  - --Oil and Gas Conservation Commission,

--Division of Employment,

--Division of Highways,

--Division of Planning,

--Division of State Archives and Public Records,

--Historical Society and State Historic Preservation Officer,

--Office of the Colorado State Archeologist,

--Public Utilities Commission,

--Colorado State University,

--Department of Anthropology,

--Department of Economics,

--Department of Fishery and Wildlife Biology,

--Department of Forest and Wood Science,

--Plant and Soil Science Department,

--Entomology Department,

--Department of Recreation-Resources,

--Southern Colorado State University:

--Department of Anthropology,

--University of Colorado:

--Department of Anthropology,

--University of Denver:

--Department of Anthropology,

--Colorado River Water Conservation District.

Local

The following local agencies have been contacted in preparation of this statement:

--Cross Mountain Ranches,

--Upper Yampa River Water Conservancy District,

--Routt County Historical Society,

--Routt County Soil Conservation District,

--Routt County Assessor's Office,

--Routt County Regional Planning Commission,

--Routt County Road Department,

--Routt County Public Health Department,

--Moffat County Road Department,

--Moffat County Agricultural Extension Office,

--Moffat County Assessor's Office,

--Rio Blanco County Planning Director,

--Rio Blanco County Road Department,

--City of Steamboat Springs,

--Steamboat Springs Parks and Recreation Department,

--City of Craig,

--Town of Hayden,

--Town of Meeker,

--Town of Oak Creek,

--Town of Rangely,

--Town of Yampa,

--District 12 Area Council of Governments,

--District 11 Area Council on Governments.

Wyoming

The following State agencies have been contacted in preparation of this statement:

--Fish and Game Department,

--University of Wyoming:

--Water Resources-Recreation.

Utah

--Utah Outdoor Recreation Council,

--Utah State University:

--Institute of Outdoor Recreation,

--Department of Fishery and Wildlife Biology.

Montana

--Montana State University:

--Animal and Range Science Department.

Private Organizations and Companies

Consistent with their interest in coal development in northwest Colorado, the following organizations and industries were contacted in preparation of this statement:

--Public Service Company of Colorado,

--Mountain Bell Telephone Company,

--Yampa Valley Electric Association Incorporated,

--Mountain West Research Incorporated,

--Weiner and Associates,

--Club 20,

--Sierra Club,

--Colorado Open Space Council,

--The Nature Conservancy,

--Environmental Defense Fund,

--International Sportman's Club,

--American Sportman's Club,

--National Audubon Society,

--Ecological Consultants,

--Environmental Research and Technology, Incorporated,

--Dames and Moore,

--Morrison-Knudsen Company, Incorporated,

--Stearns-Roger Incorporated,

--VTN Colorado, Incorporated,

--Pacific Northwest Forest and Range Experiment Station,

--LTV-Recreation Development, Incorporated,

--Denver and Rio Grande Western Railroad,

--Moffat Tunnel Commission,

--Federation of Rocky Mountain States,

--Consumers Power Company,

--Cross Mountain Ranches,

--White River Electric Association,

--Moon Lake Electric Association,

--Shell Oil Company.

Meetings

During the course of the preparation of the Northwest Colorado Coal EIS, several public meetings were held with representatives of Federal, State, and local agencies, and with other interested parties to inform them of the nature and progress of the EIS. In each case, a presentation was made by one or more of the EIS team members, followed by discussion and questions from the floor.

On May 1, 1975, a public information meeting was held at the Routt County Courthouse in Steamboat Springs with approximately 25 people in attendance, including the entire planning commmission. On May 8, 1975, a public information meeting was conducted at the community center in Rangely, Rio Blanco County, with approximately 35 people in attendance, including the Rio Blanco County Planning Commission. On May 12, 1975, a public information meeting was held in the Moffat County Courthouse in Craig, with approximately 20 people in attendance, including the Moffat County Planning Commission. On June 27, 1975, a meeting was held with the Colorado Water Conservation District to discuss the EIS progress. Approximately 40 people were in attendance. On December 3, 1975, a coordination meeting was held with eight various Routt County officials to discuss proposed coal development activities in Routt County, associated population increases, and other data included in the Northwest Colorado Coal EIS. On January 4, 1976, a public information meeting was held in Hayden, Routt County, with about 60 people in attendance.

A management framework plan (MFP) for the Williams Fork Planning Unit was completed during fiscal year 1974. Most of the coal-related development proposed for Northwest Colorado is contained within the boundaries of this planning unit. As described in Chapter I, the management framework planning process is carried out in coordination and consultation with other Federal agencies, with State and local governments, and with concerned local publics.

The following is a breakdown of procedures that was utilized for public participation throughout the planning process in the Williams Fork Planning Unit:

1. News Media

A number (7) of local and regional newspapers were utilized for articles pertaining to the BLM's planning system and how it will affect the management of Natural Resource Lands in the Williams Fork Unit. Follow-up press releases relating to progress and the scheduling of public meetings were given the various newspapers. The local Craig radio station was utilized for announcing public meetings.

2. Letter Correspondence

Initial letters were mailed to all interested publics explaining the planning process. These letters also explained how the recipient could contribute to the future managment of the public lands in this unit. Follow-up letters announcing workshops and public meetings were mailed.

3. Public Meetings

Various public meetings were held to present multiple use recommendations to the public. These meetings consisted of a description of the planning system, the area concerned, resources in the area, and multiple use recommendations. Maps and overlays were displayed and a slide show was used for presentation of this material. Following the presentation, an open discussion was held, and questions and comments pertaining to the recommendations were solicited. Written comments were also solicited. The following meetings were held:

a. Recreation-Wildlife Public Meeting held in Craig, Colorado on March 7, 1974 - 20 people in attendance.

b. General Public Meeting held in Denver, Colorado on April 2, 1974 - 25 people in attendance.

c. General Public Meeting held in Hayden, Colorado on April 4, 1974 - 39 people in attendance.

4. Workshops

Various resource workshops were conducted for the purpose of obtaining additional information for the MFP. They also gave various publics the opportunity to express their opinions as to how the resources should be developed. The workshops were oriented toward special interest groups concerned with the particular resource topic. The following workshops were held:

a. Wildlife - Recreation Workshop held in Denver, Colorado, on December 4, 1973 - 18 people in attendance.

b. Wildlife - Recreation Workshop held in Craig, Colorado, on December 6, 1973 - 32 people in attendance.

c. Range - Watershed Workshop held in Craig, Colorado, on December 12, 1973 - 18 people in attendance.

d. Minerals Workshop held in Craig, Colorado in December, 1973 - approximately 20 people in attendance.

f. Wildlife - Recreation Workshop held in Denver, Colorado, on March 6, 1974 - 20 people in attendance.

5. A questionnaire was sent to all interested parties identifying resource conflicts and various alternatives for solution. The parties were asked to make written comments on their suggestions for resolving these conflicts.

Coordination in Review of Draft Statement

This is a list of all organizations who will receive a copy of the statement and be requested to submit written comments.

Federal:

--Water Resources Council,

--Federal Power Commission,

--Advisory Council on Historic Preservation,

--Environmental Protection Agency,

--Department of Health, Education, and Welfare,

--Department of the Interior:

--Bureau of Outdoor Recreation,

--National Park Service,

--Bureau of Mines,

--Geological Survey,

--Bureau of Land Management,

--Fish and Wildlife Service,

--Bureau of Reclamation,

--Energy Research and Development Admisitration,

--Department of Agriculture:

--Rural Electrification Administration,

--Soil Conservation Service,

--Forest Service,

--Interstate Commerce Commission,

--Department of Housing and Urban Development,

--Federal Energy Administration,

--Federal Highway Administration,

--Occupational Safety and Health Administration,

--Office of Solicitor.

State of Colorado Offices

--Office of the Governor,

--Clearing House.

Local Offices:

--Routt County Board of County Commissioners,

--Rio Blanco County Board of County Commissioners,

--Moffat County Board of County Commissioners,

--Routt County Regional Planning Commission,

--Rio Blanco County Planning Director,

--Moffat County Planning Director,

--District 12 Area Council of Governments,

--District 11 Area Council of Governments.

Other Organizations:

--Sierra Club,

--Colorado Open Space Council,

--The Wildlife Society,

--National Audubon Society,

--Rocky Mountain Center on Environment,

--Environmental Defense Fund.

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