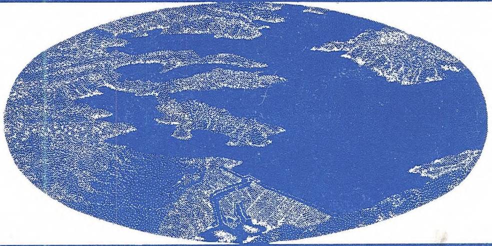
STATE DIRECTOR, WYOMING

DRAFT ENVIRONMENTAL IMPACT STATEMENT



FOR THE PROPOSED RESERVOIR ON THE MIDDLE FORK OF POWDER RIVER

U. S. Department of the Interior
Bureau of Land Management

DES 76-5

SUMMARY SHEET

(x) Draft Environmental Statement ( ) Final Environmental Statement

Bureau of Land Management, Department of the Interior, Washington, D.C. 20240

1. Type of action: (x) Administrative ( ) Legislative

2. Brief description of action: Proposed granting of a right-of-way for use of 141 acres of national resource land for a 50,000 acre-feet reservoir near Kaycee, Wyoming, for use by agriculture for irrigation and industry for undisclosed purposes. Additional rights-of-way may be proposed as required for road relocation.

3. Summary of environmental impacts and adverse environmental effects:

   A. Reservoir and agricultural water uses -
      (1) Air quality would be decreased temporarily.
      (2) Topography would be changed.
      (3) Soils would be taken from production; structure and parent material would be disrupted.
      (4) Stream regime would be modified. Evaporation would increase. Sediment load would be changed. Ground water conditions downstream of the dam and below the Sahara Ditch would be affected.
      (5) Vegetation in the reservoir area would be permanently destroyed.
      (6) Cultural resources would be destroyed or damaged.
      (7) Wildlife and aquatic habitats would be altered.
      (8) Aesthetic values would be adversely affected.
      (9) Recreational values would be adversely affected through the loss of hunting opportunities, alteration of two free-flowing streams, and the loss of interpretive opportunities of the destroyed cultural resources. There is potential for secondary regional impacts caused by recreational use of the reservoir.
      (10) Livestock production would be adversely affected in the reservoir area.
      (11) Some community facilities would be impacted to an unknown extent.

   B. Assumed industrial use of water -
      (1) Ambient air quality would be lowered.
      (2) Vegetation would be destroyed.
      (3) Soils would be disturbed and taken from production.
      (4) Water consumption would increase.
      (5) Cultural values may be destroyed.
      (6) Wildlife habitats would be altered with effects on populations.
      (7) Recreation use would be intensified.
      (8) Aesthetic values would be adversely affected.
      (9) Present productivity would be lost on sites for permanent facilities.
      (10) New transportation networks would be created.
      (11) Population, employment and income would increase.
      (12) All infrastructural facilities would be impacted.

4. Alternatives considered:

   A. Reservoir and agricultural water uses: reservoirs, water wells, flood water diversions, transbasin diversion, deep well drilling, different construction specifications, different operation plans, different sites, different diversion points for industrial use, different highway relocation routes.

   B. Assumed industrial use of water: coal liquefaction, coal fired steam generation, coal slurry.

5. Comments have been requested from the following: See attached sheets.

6. Date draft statement made available to CEQ and the public:
Draft statement: January 23, 1976

SUMMARY TABLE OF CONTENTS

A detailed Table of Contents and List of Figures precedes each section.

PREFACE

This statement contains a section assessing site specific impacts of the known portion of the action in the normal manner (agricultural water use and reservoir site) and a separate section dealing with probabilities and general impacts of an assumed phase of the action due to a lack of specific information (industrial water use).

The proposed action is to construct a reservoir to store water to allow better water utilization in an agricultural land irrigation system. The system involves 22 farms and irrigating 5,479 acres located downstream from the damsite. Only a portion of the stored water would be used for this purpose and the remainder designated for another use, presumably industrial in nature. The presumption of industrial use is reasonable, since approximately half of the proposed storage allocation (50,000 acre-feet) is controlled by Carter Oil Company and Atlantic Richfield Company. These corporations have large coal lease interests in the Wyoming Powder River Basin area. A relatively small portion, already owned by Carter, is proposed for transfer from another reservoir right filing in the same stream in order to make optimum use of the storage capacity of the proposed reservoir.

Discussions with these companies indicated that while they may likely use the water resource in conjunction with development of their coal resource reserves, they have no firm plans regarding water use. (See letter from Atlantic Richfield Company dated July 1, 1975, and letter from Carter Oil Company dated June 19, 1975, in Appendix 13.10.)

The Federal Government is involved through an application for a right-of-way from the Powder River Reservoir Corporation to inundate 141.66 acres of national resource lands within the total reservoir site of approximately 1,160 acres. This right-of-way would be necessary for construction of the reservoir facilitating related agricultural use. Additional rights-of-way affecting national resource lands and requiring Federal Government action may be required for the relocation of a road displaced by the dam and for relocating utility lines. Granting the right-of-way would indicate approval, or would at least carry implications of approval, of all the reasonably inferred actions identified. The magnitude of these actions leads the Bureau of Land Management to conclude that permitting the right-of-way would constitute a major Federal action having a significant effect on the quality of the human environment.

This environmental impact statement analyzes the site specific impacts of reservoir construction, inundation of land, resultant agricultural use, and alternatives to the proposed action related to such use.

The statement further provides system models for selected industrial uses and potential impacts related to those uses. Obviously, many options are open to both firms to utilize their water and coal resources through various arrangements, including several energy conversion processes, production of petrochemicals, or disposal of their holdings entirely.

In essence then, no proposed action rests before the Federal Government regarding industrial use of the water. However, an industrial end use has been assumed in the statement to provide the decision maker a frame of reference and order of magnitude by which to consider impacts of potential industrial development resulting from the construction of the proposed reservoir. The assumed end use is coal gasification. A further assumption is that the water available is adequate for each company to construct its own gasification plant, each plant to produce approximately 375 million cubic feet of product gas per day, and requiring a 1,000-acre plant site. No specific plant sites are known at present and none are assumed. Therefore, the statement does not assess site specific impacts of such potential use (plant sites, viaducts, pipelines, etc.). Submission of development plans by Carter Oil Company and Atlantic Richfield Company, and determination of federal action involved, are prerequisite to assessment of specific environmental impacts.

A further environmental assessment will be required for federally managed lands or resources involved when the plans of these companies become firm.

In addition, the 1975 Wyoming Industrial Facilities Siting Law contains environmental protection provisions and permit requirements for industrial plant facilities of the type described in this document.

Other alternatives to the assumed end use (coal gasification) will be considered, specifically coal liquefaction, coal fired steam electric generation, and slurry pipeline exportation of coal outside the region.

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LIST OF FIGURES - SECTION 1

1. Description of proposal - Introduction

As the ultimate use of the water is a part of this description of the proposal, the agricultural use and the assumed industrial use are described in sections 2 and 3 of the statement, respectively.

Federal action

The Powder River Reservoir Corporation of Kaycee, Wyoming wants to build the Middle Fork Reservoir. However, project implementation would require action by the Bureau of Land Management and other federal agencies. The actions include various authorizations and supervision of compliance with requirements such as the Archeological and Historic Preservation Act of 1974, the Endangered Species Act, and the Fish and Wildlife Coordination Act.

Bureau of Land Management (BLM)

The BLM action includes granting or denying a right-of-way for an essential portion (approximately 141 acres) of the reservoir site. Also a right-of-way under Revised Statutes 2477 (43 U.S.C. 932) would be granted for relocation of the Barnum county road. No application is filed under R.S. 2477, as no government action is required.

Other BLM action will include development and enforcement of stipulations, which would be made a part of all use authorizations. These stipulations cover all phases of project implementation and provide for mitigation of environmental impacts.

Other major federal agency involvement

A Corps of Engineers' authorization would be necessary under Section 404 of the Federal Water Pollution Control Act as Amended in 1972, which requires a permit for construction on navigable waters.

The U.S. Fish and Wildlife Service, under the provisions of the Fish and Wildlife Coordination Act, must prepare a report recommending mitigating measures for the project. This report must be completed prior to a decision on the project.

The Environmental Protection Agency (EPA) would be responsible for implementation and compliance with the Water Pollution Control Act. Maintenance of minimum flow on Middle Fork Powder River would be the primary compliance action.

Assumptions and analysis guidelines - reservoir and agricultural water use

Due to the lack of detailed information and the inherent uncertainties of the project, certain assumptions were necessary in the study to aid in quantification and establishing a frame of reference. The assumptions are made considering the facts available at present. As new information becomes available, the reader may use these assumptions as a basis for revising the conclusions of the study.

Assumptions

A. If approved, the project would proceed without major delays and would be completed and operational before 1980. The industries involved would be able to complete their planning and be able to utilize their share of the water soon after the reservoir became operational. There may be a short period after completion when the industrial share would not be utilized fully. This would mean the reservoir would have higher water levels and less fluctuation than under the normal operation plan. However, this period would last for only one to two years and would not be long enough to significantly change the impacts identified with the normal operation plan.

B. The presently proposed operation plan (Fisk, 1974) would be adopted and would not be altered to any great extent. The application for transfer of rights from the Pumpkin Reservoir filing to the Middle Fork Reservoir would be approved. The project would not be discontinued at any time in the foreseeable future. The past flow in the Middle Fork for the period 1931 to 1968 is representative of future flows.

C. The proportion of agricultural and industrial water use would not change appreciably. The agricultural portion would be used only on the designated lands. The industrial portion would be diverted at or near the dam site and transported to the area(s) of use by means of a pipeline or canal.

D. The reservoir would not sustain an appreciable loss in capacity through siltation for at least 100 years.

E. The cofferdam is for diversion only and will not interrupt streamflow.

F. There are no sources available at or near the dam site suitable for soil cement or concrete aggregate. This material would be obtained from a distant, presently used source so that additional environmental damage would not be significant. There is a source near the dam site which would probably be suitable for any aggregate or gravel needed for the relocated road construction. This source is in the area to be disturbed and will not cause additional environmental damage.

G. All fill material for the dam would be obtained from the emergency spillway area.

H. The county commissioners have stated the intention of not rehabilitating surface disturbance caused by the road relocation. Rehabilitation, however, is still felt to be a likelihood at least on some portions of the road, especially if the standards of the Wyoming Highway Department are to be used.

I. Processing of concrete and soil cement for the dam, and gravel and asphalt mix for the road construction, would not cause significant air pollution.

Data on time periods to aid impact analysis

A. The period of construction would be two years.

B. Depending on precipitation, it would take two to four years for the reservoir to fill completely after construction if the industrial portion of the water were not used during the filling period.

C. Time lags between disturbance and mitigation:

1) Cleared areas: two years of construction plus two to four years of gradual inundation.

2) Embankment and spillway areas: One year and ten months between initial disturbance and seeding, mulching, water barring, jute matting, etc. Two additional years before successful vegetation stands are established.

3) Road construction: One year between initial disturbance and surfacing the road surface, seeding, mulching, and jute matting of cuts, fills, and road embankments (if and where attempted). Two additional years before successful vegetation stands are established.

Project data

Acres inundated (normal water line)	1,160
Acres disturbed:	
Embankment and spillway area	163
Relocated road (acres):	
Proposed route	40
North shoreline alternative	30
South route alternative	40
Concrete batch plant (location unknown)	10
Asphalt (hot mix) batch plant (location unknown) .	10
Acreage below most probable clearing elevation (5,013 feet)	1,160
Actual acres of clearable vegetation	104
Disturbance (acres) involving removal of man-made structures outside clearable vegetation types	5
Volume of material moved (cubic yards)	1,860,000
Construction force:	
Relocated road	40 workers for one year
Reservoir	75 workers for two years

Area of consideration - reservoir and agricultural water use

This statement considers the impacts of the reservoir itself, as well as transportation and use of the water for agricultural purposes. The general impacts will largely occur within Johnson County. As described below, the area of consideration does extend a short distance into the South Big Horn Mountains in Natrona and Washakie Counties and into the Powder River Basin within Campbell and Sheridan Counties. These extensions involve components which do not lend themselves to county boundary limits, such as recreation and socio-economic considerations.

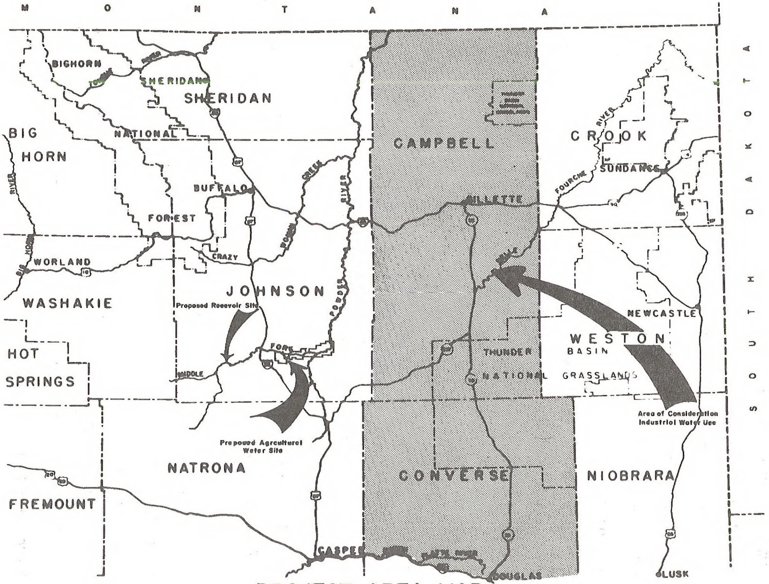
Specific impacts are considered in three basic areas affected: 1) the reservoir area including the relocated, paved county road, 2) the agricultural water transportation route which is basically the route of the Middle Fork of the Powder River and the Sussex Irrigation Ditch, and 3) the agricultural water use area between Kaycee and Sussex.

The reservoir site is located on the Middle Fork of Powder River approximately 12 miles west of Kaycee, Wyoming. The 1,160 acres covered by the reservoir when full will include the stream bottom for approximately 6.5 miles upstream from the dam and portions of several drainages which come into the Middle Fork along this segment. Also at the reservoir site the route of the proposed relocated road is considered as it traverses the upland area to the north (see Figure 8.3-A).

Besides these areas of major disturbance, the statement will include a broader area within a few miles to facilitate analysis of cumulative impacts nearby. These impacts consist of such aspects as: effects on ranches which will sustain a partial taking, ranches and other interests which depend on the existing state secondary highway as a major access route, or the effects of partial alteration of ecosystems extending beyond the area of inundation. The description will therefore cover at least certain aspects within an irregular area varying from a 2-to-10-mile distance from the site.

The transportation route of the water will be essentially the Middle Fork of Powder River stream channel from the dam site to the existing Sahara ditch diversion structure located five miles downstream from Kaycee, as well as the Sahara irrigation ditch conveying the water to the area of use.

The proposed agricultural water use area consists of the 5,116 acres of land where the water is to be applied (see Figure on following page). This land lies along the Powder River between Kaycee and the vicinity of Sussex on the flood plain and adjacent benches where soil and terrain



PROJECT AREA MAP

NE WYOMING

Figure I-A

are favorable for irrigation. A substantial amount lies below Sussex near the bend where the river turns north. Also a significant amount of land suitable for irrigation exists extending beyond the lowest point, northward for several miles. The description will be limited to only certain aspects of this land since the applicants have indicated that, although suitable for irrigation, it will not be considered due to the excessive cost of conveying irrigation water to it and the shortage of available water. This land also lies outside the irrigation district and an expansion would be required which is outside the capabilities of the present project.

The following is a list of the specific areas of consideration for each component of the analysis:

1) Climate. Only the localized area is covered within a few miles of the reservoir site and irrigated lands.

2) Air quality. Same as climate.

3) Topography: A few descriptive statements are made about the Powder River drainage basin, but the study area includes only the vicinity of the reservoir site and irrigated lands.

4) Geology. A few descriptive statements are made about the Powder River drainage basin, but the study area includes only the vicinity of the reservoir site, including the relocated road route.

5) Mineral resources. Same as geology.

6) Soils. The study area is confined to the vicinity of the reservoir site and the irrigated lands.

7) Water resources. The description contains background information on the Powder River Basin as a whole, but the actual study area is defined as the area where significant impacts would occur. This component is divided into a section consisting of the Powder River Basin in Wyoming (Johnson County and parts of Campbell, Natrona, Sheridan, and Washakie Counties); and a "Reservoir Area" section consisting of the reservoir site, the transportation route of the agricultural water and the irrigated land area. The study area would terminate at the lower end of the irrigated area since the effect of the irrigation return flow would be small.

8) Vegetation. The study area consists of the specific areas where vegetation would be impacted. These are categorized into: a) the reservoir area including the route of the relocated road, b) the agricultural water transportation route, and c) the agricultural water use area which consists of the vicinity of the irrigated lands.

9) Wildlife and fish. The study area consists of the specific areas where impacts are anticipated. These are categorized into: a) the reservoir site and b) the agricultural water use area.

10) Cultural resources. Background information is given on a broad area covering the Big Horn Mountains and Northwestern Plains. The Middle Fork Region includes the drainage systems of Middle Fork and Red Fork of Powder River and their tributaries. The specific study areas are reservoir area and water use area. The reservoir area includes the reservoir site and road relocation.

11) Aesthetics. The study area consists of the specific areas where aesthetic values would be impacted. These are categorized into: a) the reservoir area including the alternative routes of the relocated road and b) the agricultural water use area.

12) Recreation. Background information is given on a broad area consisting of the area of significant recreational opportunities, considered to be Johnson County and the South Big Horn Mountain area including portions of Natrona and Washakie Counties. The specific areas of impact are further categorized into: a) the reservoir area including the alternative routes of the relocated road and b) agricultural water use area.

13) Agriculture. Background information is given on the area of possible significant general impact which is considered to be essentially Johnson County. The areas of specific impact are categorized into: a) the reservoir area including the alternative routes of the relocated road, b) the agricultural water transportation route, and c) the agricultural water use area which consists of the vicinity of the irrigated lands.

14) Transportation networks. The area of consideration is the area where transportation networks would affect the project area. The analysis covers Johnson County and specifically the Barnum, Kaycee, Sussex area.

15) Land use controls and constraints. The analysis covers Johnson County with background information on statewide controls and constraints as they affect the proposed action.

16) Socio-economic patterns. Background information is given on Johnson County as a whole to set the scene for analysis. Specific information is given in the description and analysis on the reservoir area and the Barnum, Kaycee and Sussex vicinities.

Area of consideration - assumed industrial use of water

The geographic area (see page 1-6) considered in the portion of this document discussing industrial use is in that part of the Powder River Coal Basin in Wyoming lying generally eastward from the Powder River to the outcrop line of the coal resource and from somewhat north of Gillette to a point south of Douglas. Obviously, the companies may also have options for coal development outside the arbitrary boundary.

Those considerations having a broader scope of geographic impact such as social conditions, economic factors, atmospheric influence, water resources, and recreation are discussed on a larger regional basis.

This particular area is selected owing to its large deposits of economically strippable coal and current projections for development in that area (e.g., Northern Great Plains Resource Program, Environmental Impact Statement on the Eastern Powder River Coal Basin of Wyoming, etc.).

To the extent that assumptions or projections for development become a reality where national resource lands are involved, further specific proposed actions may be required. Such federal actions could involve consideration of applications for leases, rights-of-way, land disposals, and special land use permits.

In as much as the general area of discussion coincides with the geographic area considered in the Environmental Impact Statement on the Eastern Powder River Coal Basin of Wyoming, portions of that EIS are used in this presentation rather than referring the reader continually to that document. Where possible, the anticipated impacts will be scaled to the level of industrial use development stated in the assumptions.

Basic federal action

BLM approval of a right-of-way permit to inundate 141 acres of national resource land. Also involved is the non-federal construction of a 50,000 AF dam and reservoir to serve irrigation and industrial water supply needs and 1,019 A of private lands will also be inundated by the reservoir project. Industrial water use not known at this time but owners known; two oil companies and the statement hypothesize that it will be used to serve the water needs of two coal gassification plants at some unspecified time and location.

Gasification Plant

Assumptions and Analysis Guidelines

Assumed Industrial Use

1.	Assumed Number of Plants	Two
2.	Product Gas	375 MMSCFD/plant 3,325,000 ton/year/plant
3.	Coal Use	13,500,000 ton/year/plant
4.	Water Use	16,275,000 ton/year/plant 12,500 acre-feet/year/plant 0.16 acre-feet/year/person
5.	Water Evaporation	11,725,000 ton/year/plant
6.	Waste Ash and Dust	1,000,000 ton/year/plant
7.	Emissions:	
	Sulfur Dioxide	8,000 ton/year/plant
	Nitrogen Oxides	12,000 ton/year/plant
	Particulates (with dust control)	1,800 ton/year/plant
8.	Transport Systems:	
	Coal	3-4 round trips/unit train/plant 400 round trips/100 ton truck/plant 3 foot slurry pipeline/plant
	Product Gas	3 foot pipeline/plant
	Water	3 foot pipeline/plant
9.	Land Use	1,000 acre/plant 0.16 acre/family (residential) 6 acre/pipeline mile 10 acre/transmission line mile
10.	Population:	
	Construction Labor	peak) 2,500-3,500/plant average) 1,500,2,000/plant
	Operational Labor	1,000/plant
	Population Multiplier Factor	4-5
	Construction Population	10,000-17,500/plant
	Operational Population	4,000-5,000/plant
11.	Time Frame:	
	Construction	5 years
	Operation	30 years

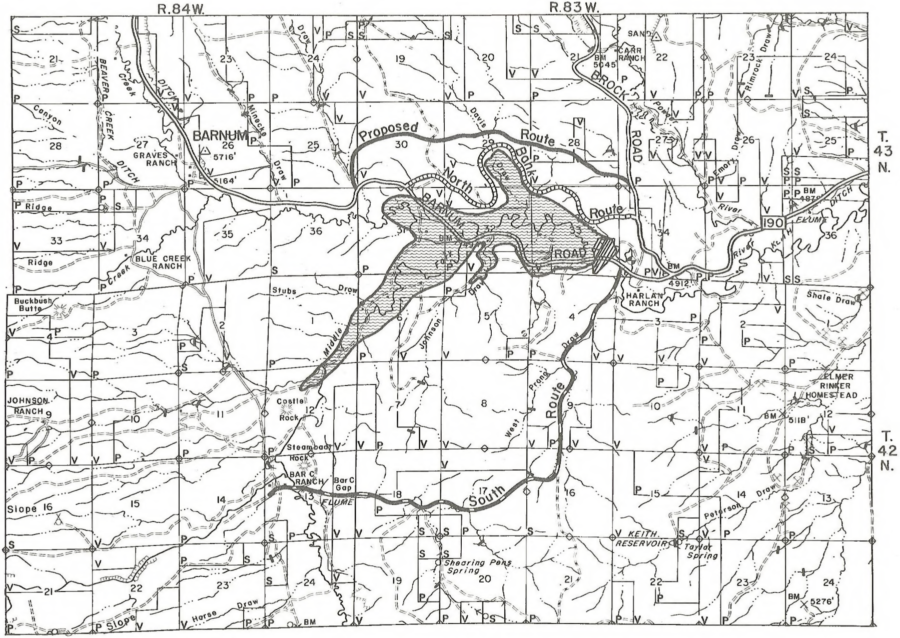


Figure 1-B
RESERVOIR AREA MAP

1.1 Description of application

1.1.1 Right-of-way application

The Powder River Reservoir Corporation of Kaycee, Wyoming has filed right-of-way application numbered W-40720 for a reservoir on the Middle Fork of Powder River, to be called the Middle Fork Reservoir, which will involve inundation of 1,160 acres, at normal high water line, of private and national resource lands (NRL) - federal lands under Bureau of Land Management jurisdiction, west of Kaycee, Wyoming. The right-of-way would grant the right to inundate approximately 141 acres of NRL in irregular parcels of varying sizes. These parcels are portions of two larger compact blocks of NRL of approximately 2,600 and 2,160 acres. Both of these compact blocks are in turn contiguous to much larger blocks of over 20,000 acres of State of Wyoming lands and NRL (see Land Status Map, Appendix 13.8 and Figure 8.3-A).

The right-of-way application was made under the provisions of the Act of February 15, 1901 (31 Stat. 790; 43 U.S.C. 959). The Bureau of Land Management has the responsibility for processing the right-of-way application under the regulations contained in Title 43 Code of Federal Regulations, Part 2800. The right-of-way is considered essential to the feasibility of the project due to the crucial location of the NRL involved.

Reservoir corporation. The Powder River Reservoir Corporation was formulated to facilitate the handling of the construction of the reservoir. It consists of members of the Middle Fork Irrigation District. This district is the entity which will mainly benefit from the agricultural portion of the water (see 1.2 and 2 below for more detail).

The corporation has employed J. T. Banner and Associates, Laramie, Wyoming as engineering consultants for the project. They have continued in this capacity as development of the project has progressed. The corporation has also employed Mr. William J. Kirven of Kirven and Hill, Buffalo, Wyoming, as legal consultant on the project.

1.1.2 Reservoir project

The proposed dam and reservoir on the Middle Fork Powder River is intended by the Powder River Reservoir Corporation to serve as a source for irrigation and industrial water. The Middle Fork reservoir was first reported on in 1940 (Bennett, 1940) and has been subject to intermittent study ever since. The currently proposed reservoir was the subject of a feasibility study by Banner (1970). Subsequent discussion of dam construction and reservoir operation is based, to a great extent, upon the current engineering feasibility report.

Due to the relatively small acreage irrigated from the existing Sahara Ditch, the proposed reservoir was not economically feasible in the past. Assessments against this land would not have been adequate to service the construction loan. A firm, long-term contract for the purchase, by industry, of approximately half of the storage has made the proposed reservoir possible.

1.1.2.1 Design and specifications

The proposed dam and reservoir site is located in Section 33, Township 43 North, Range 83 West, 6th P.M., Wyoming.

1.1.2.1.1 Dam

The dam will be a zoned earthfill structure. The inner zone (Zone I) of the dam will consist of impervious soil. The intermediate zone (Zone II) will be semi-impervious to pervious soil while the outer zone (Zone III) will consist of pervious soil. A U.S. Bureau of Reclamation study (Bureau of Reclamation, 1967) of possible source materials concluded that rock for rip rap would be relatively costly. Therefore, it was proposed that upstream slope protection be provided with 36 inches of soil cement.

The Bureau of Reclamation (1967) identified eight borrow areas for source materials. Of the eight, one borrow area is located adjacent to, and downstream from the right abutment. It was estimated that this borrow area contained sufficient source material for most of the embankment construction. The excavation of the borrow material will coincide with the proposed emergency spillway which passes through the borrow area. Therefore, it is anticipated that this borrow area will be utilized as the primary source area. Three potential sources of concrete aggregate were located within 13 miles of the reservoir site, but these sources have poor quality material. A satisfactory source still remains to be found.

The dam will be 135 feet high with a crest length and width of 1,800 and 30 feet respectively. The crest will have a camber of from 3 to 5 feet, and will be covered with select gravel material approximately

4 inches thick. The foundation will be both granular overburdened soil and sedimentary bedrock. A cutoff trench beneath Zone I will extend through the overburdened soil and five feet into the bedrock. A trench width of 75 feet is proposed. The upstream slope is 3 to 1 and the downstream slope 2 to 1, in accordance with requirements of the Wyoming State Engineer's Office. The dam will have 17 feet of freeboard at the normal high water level and 10.5 feet at maximum high water level.

1.1.2.1.2 Spillways

The dam will have a principal and an emergency spillway. The principal spillway will be located on the right abutment of the dam. The approach channel, gate structure, chute, and stilling basin will be of reinforced concrete construction. The emergency spillway will be located south of the dam, cutting through a hill at this location. This spillway has a proposed width of 800 feet with 4 to 1 side slopes. It will be bottomed on sedimentary bedrock. The length of the spillway is 2,200 feet with a 1% slope. The spillway will terminate in a natural drainage 1,600 feet from the Middle Fork Powder River, and subsequently drain into the Middle Fork. Replacing of topsoil and grass planting in the spillway channel is anticipated in the engineering feasibility report (Banner, 1970). The crest elevation of the principal spillway is 5,002 feet. The elevation of normal high water line is 5,013 feet, corresponding to top of the spillway gate in a closed position and the crest of the emergency spillway. At the normal high water line the discharge of the principal spillway will be 8,100 cubic feet per second. Under conditions of the reservoir containing its full storage capacity, outlet works closed, and the occurrence of the maximum probable flood, the principal spillway discharge will be 78,100 cubic feet per second and the emergency spillway 93,000 cubic feet per second.

1.1.2.1.3 Outlet works

An outlet works is planned which will have a capacity sufficient to satisfy downstream water rights. The outlet works will consist of intake structures, approximately 500 feet of tunnel, 8 feet in diameter, leading to the gate chamber located below the dam crest and 600 feet of discharge tunnel, 13 feet in diameter. The works will be located under the right dam abutment. The capacity of the outlet works will be 1,800 cubic feet per second at maximum high water level, 1,730 cubic feet per second at normal high water level, decreasing to 600 cubic feet per second when approximately 1,750 acre-feet of active storage remains.

1.1.2.1.4 Reservoir

The reservoir will have an active storage capacity of 50,000 acre-feet. The reservoir dead storage will be approximately 2,000 acre-feet. A surcharge of 6,400 acre-feet would exist between the normal and maximum high water lines.

When at maximum high water elevation, the reservoir would inundate approximately 1,276 acres. At normal high water elevation 1,160 acres would be covered while approximately 145 acres would be covered if the reservoir were drawn down to dead storage. These areas were determined from the area-capacity curves shown in Figure 1-C. To facilitate interpretation, a reservoir depth versus reservoir surface area graph was extracted from the area-capacity curves and is shown in Figure 1-D. The reservoir depth is the depth at the dam.

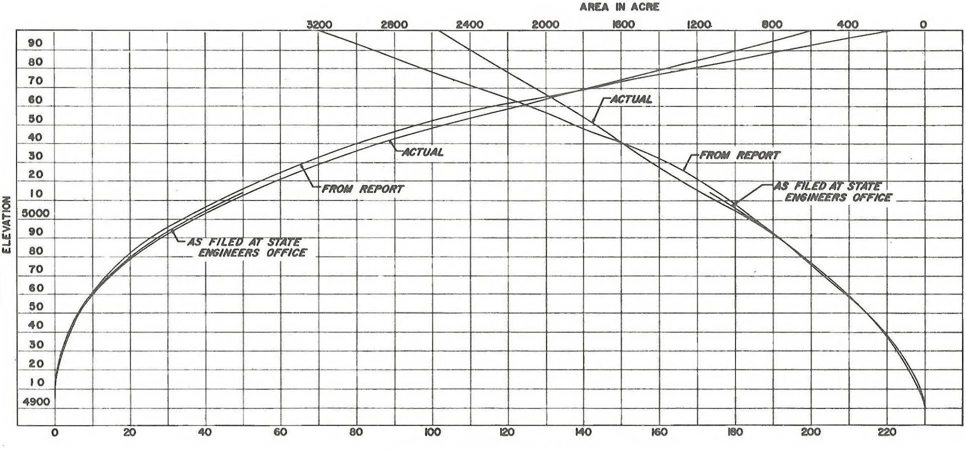


Figure I - C

AREA - CAPACITY CURVES

Source: J. T. Banner and Associates, 1974.

Crest elevation for principal spillway is 5,002 feet.
Crest elevation for emergency spillway is 5,013 feet.

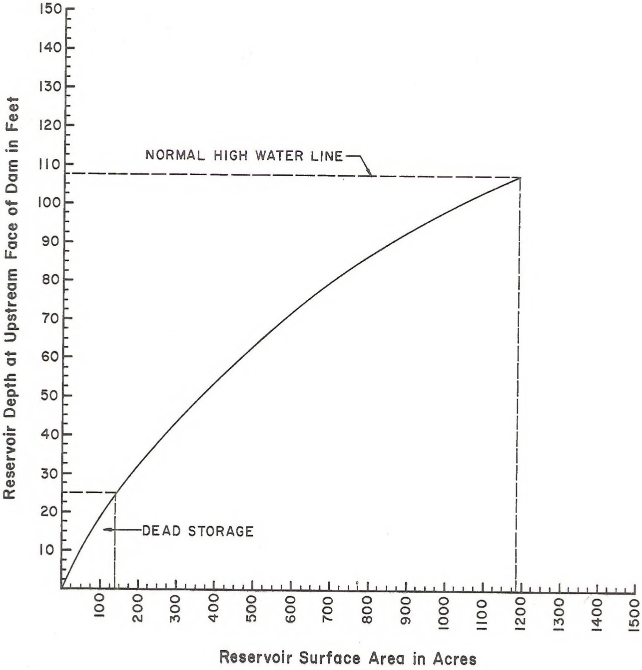
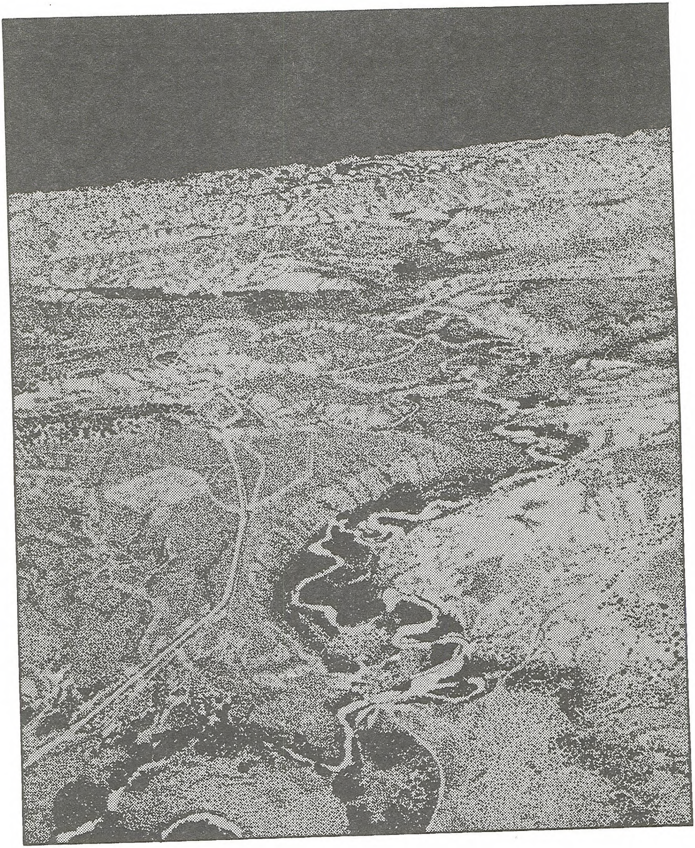
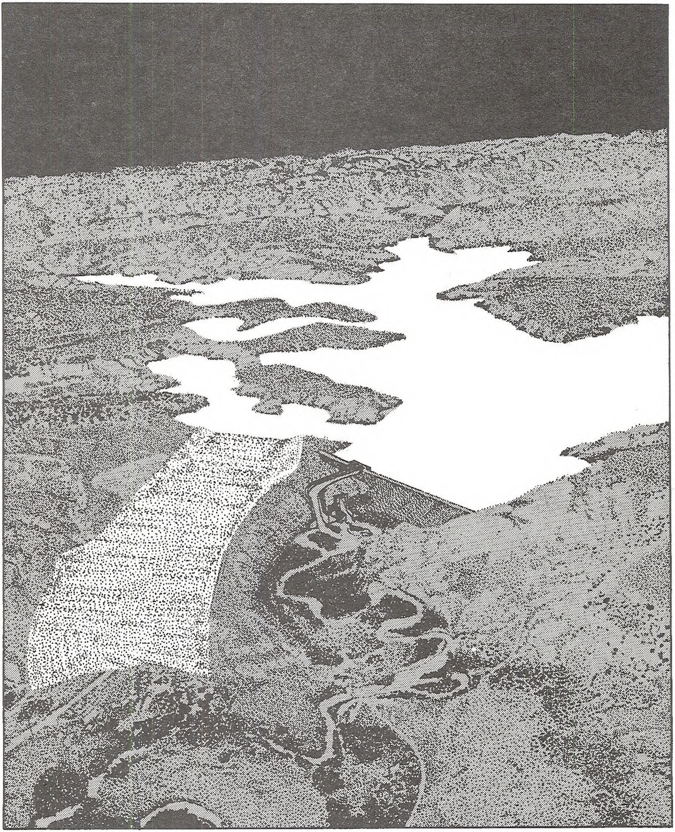


Figure 1-D

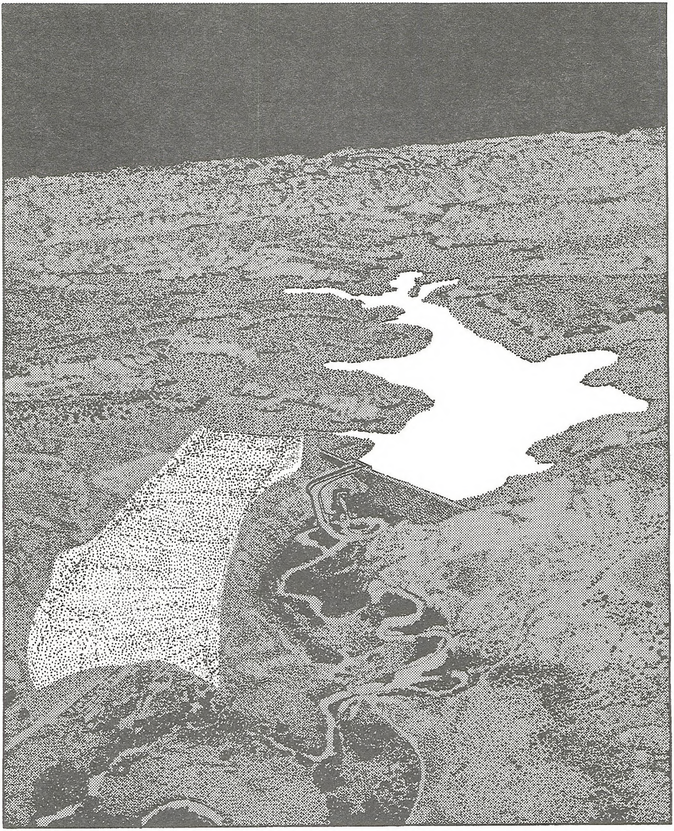
Reservoir Surface Area as a Function of Reservoir Depth.



Project Site Without Reservoir
Figure 1-E



Reservoir at Full Capacity
Figure 1-F



Reservoir at Half Capacity

Figure I-G

1.1.2.2 Dam construction

Construction for purpose of description could be considered in five phases. These phases are assumed to be typical of reservoir construction. Since the construction phase of this proposed reservoir has not been designed these phases will be considered as the most probable employed. Some operations may occur simultaneously or in slightly different order. A visual conception of this process is included in Figure 1-H.

The total time for all phases is two years. This is based on the use of the following major equipment:

NUMBER	TYPE
8	Motor scraper, self-loading, 30 cubic yard capacity
4	Crawler tractors with dozer blades or brush blades
4	Self-propelled compactors - sheep's foot and vibrator types
2	Water tank trucks
2	Track-mount rock drills with compressor units
2	Trucks - end dump or belly dump
1	Front-end loader
1	Motor grader
2	Cement mix trucks

There would be a central fuel supply and storage facility. The fuel storage would probably consist of a minimum of two skid mounted tanks, each with a capacity of ten thousand gallons. One tank would be for gasoline and the other for diesel.

Most construction companies find it convenient to operate the parts and tools from a trailer van. This van can be spotted at the most convenient location for most of the operations. Generally, not too far removed from this central area would be a construction shack consisting of an office trailer. The whole site would occupy about ten acres.

1.1.2.2.1 Phase I

The land below the 5,013 foot elevation, which covers some 1,160 acres, would be cleared of all vegetative material over five feet tall having a stem diameter of more than two inches. This is considered to be the highest probable level of clearing. Normal clearing specifications vary considerably. The applicants are contemplating clearing to the 5,017 foot level, but have stated they would change clearing specifications if further study indicated a smaller amount of clearing was justified. All man-made structures would be modified or removed. Within the 1,160 acres are 104 acres of willows and cottonwood, 432 acres of sagebrush, and the remaining land is either small brush or grass types or cultivated land. Man-made structures outside the willow-cottonwood vegetation type occupy an estimated 5 acres total. This clearing would be done with crawler tractors with dozer blades or brush blades to scrape and gather the majority of material for burning. Larger trees would be cut as close to the ground as possible with chain saws. These stumps would remain in the ground and trunk and tops would be dozed into piles with the other vegetative material for burning.

Man-made structures such as barns, houses and sheds not salvaged would be reduced to approximately ground level by the dozer and covered with about two feet of soil.

The outlet works would begin with construction of a trench to provide a bed for the concrete conduit. The trench would be constructed to an average depth of 60 feet below existing ground level with motor scraper and a crawler tractor.

Stripping of the dam site would include removing that top layer of soil material which contains any organic material, usually about six inches. Motor scrapers would be used in the bottom of valley and crawler tractors on the steeper sides. The stripped material would be stockpiled for later use in revegetation.

The concrete batch plant would be constructed at some time during this phase.

This operation would be arranged with a conveyor set at the source of the material selected. If the source selected is located on a moderate slope the equipment is usually positioned in a stairstep fashion down the slope. This type of setup would lend itself to loading directly into a hopper set slightly below the working bench or the gravel face.

From this conveyor the material goes directly to a screen and crusher if needed, then on to the storage piles. The material would probably be separated into a minimum of three grades or piles, two of the piles for the concrete batch plant and the third being composed of fines and silt that would be removed to a storage pile, located at some distance from the other two, to be used at a later date in the soil cement mixture.

The batch plant is generally composed of three overhead storage units, one being a silo to store cement. The other two units are for the coarse and fine aggregates. These storage units would be set adjacent to each other with the batching scales set between and under the units for direct batching into a mixer.

The mixing on a job of this size could be accomplished by two different methods, one being a central mixer and then the concrete transported to the point of use in hopper-style trucks; second, and probably the preferred method, would be to charge a conventional mixer truck, similar to the ready-mix trucks common in the urban areas.

The minimum amount of surface disturbance for this unit would be about five acres. The site might be located on one of the lower slopes that would fall under the high water line upon completion of the reservoir.

These plants generally do not emit dust because there is no dryer associated with the operation. The crusher and screens produce a nominal amount of dust that is confined to the immediate area of the operation. The material handled generally has a relatively high moisture content, hence the lack of excessive dust. The traffic around the batch plant site will probably generate the most dust.

Approximate time for Phase I would be four months.

1.1.2.2.2 Phase II

A temporary coffer dam about forty feet high and diversion channel would then be built with the motor scraper and crawler tractor. This would be used to control the river around the foundation areas until the outlet works are completed. Once completed the main stream of the Middle Fork would be diverted through these works.

The concrete conduit for the outlet works would be placed in sections with crane and jointed. The concrete gate chamber would be poured in place. The entire works would then be covered with the same equipment that was used to excavate it.

Those areas which could not be stripped due to construction of the outlet works or relocation of the river would be stripped in the same manner as the dam site. This may also include the emergency spillway which is also the major borrow area.

The construction of the principal spillway would begin with excavation. Both a front-end loader and crawler tractor would be used, then the forms would be set for the approach channel, gate structure, chute and stilling basin.

Approximate time for this phase would be six months.

1.1.2.2.3 Phase III

The majority of all the preceding work would be setting the stage for the main embankment, the dam. This would begin with crawler tractors excavating down to bed rock to form a cut-off trench ranging in width from 75 feet on the left abutment to 20 feet on the right abutment. The bed rock would be drilled with a track-mounted drill down to a five foot depth and shot, then excavated with a front-end loader and crawler tractor to form a keyway. A concrete cap would be poured into the keyway and allowed to set up. The cap would be drilled through into the bed rock. The cap is used to seal off the next treatment, the pressure grouting. About 300 tons of grouting would be pumped into these holes to seal off the bed rock from water seepage.

Construction of the main embankment would begin with the excavation of materials from the major borrow area with motor scrapers assisted by crawler tractors. To properly maintain the best moisture content for compaction the excavated material may be wet down before excavation by motor driven tank sprinklers. Some intermediate stockpiling and separation of these materials may be required to build the three zones in the dam in their proper sequence.

Normally, soils are classified and stockpiled for use in the embankment. The movement of material from these stockpiles would go by conveyor belt into motor scrapers or belly dumps to the embankment area. The three zones in the embankment would be built together in layers of about six inches. These six-inch lifts would be watered again with the tank units, mixed with the material with a crawler tractor or motor grader and compacted with a self-propelled sheep's foot type roller.

The total operation involves movement of 1,860,000 cubic yards from the emergency spillway which would compact to about 1,750,000 cubic yards needed for the dam embankment. Assuming the motor scrapers would carry about 30 cubic yards each trip for an average distance of 1,500 feet, then it would take about 64,000 one-way trips. If eight motor scrapers were used and each scraper would take about 10 trips per hour and would operate about 8 hours per day, the total time would take about 100 days.

Approximate time for this phase would be twelve months.

1.1.2.2.4 Phase IV

Once the embankment is finished the next phase would be the placement of soil cement on the upstream face of the dam.

The soil cement batch plant would be set up as a continuous flow operation. A mixing chamber or drum would be fed by two conveyors, one with selected soil material and the other cement. The soil material would be loaded from a stockpile with a front-end loader and the cement from a silo. A surge tank located next to the silo would supply the water to insure a constant water flow. The trucks hauling this material will produce more dust than the plant itself.

The soil cement would then be transported in a belly dump or dump truck to the dam site, spread out with a crawler tractor or motor grader and rolled in lifts with a vibrating, self-propelled roller.

The stilling basins would be excavated with the crawler tractors, forms set and the concrete poured.

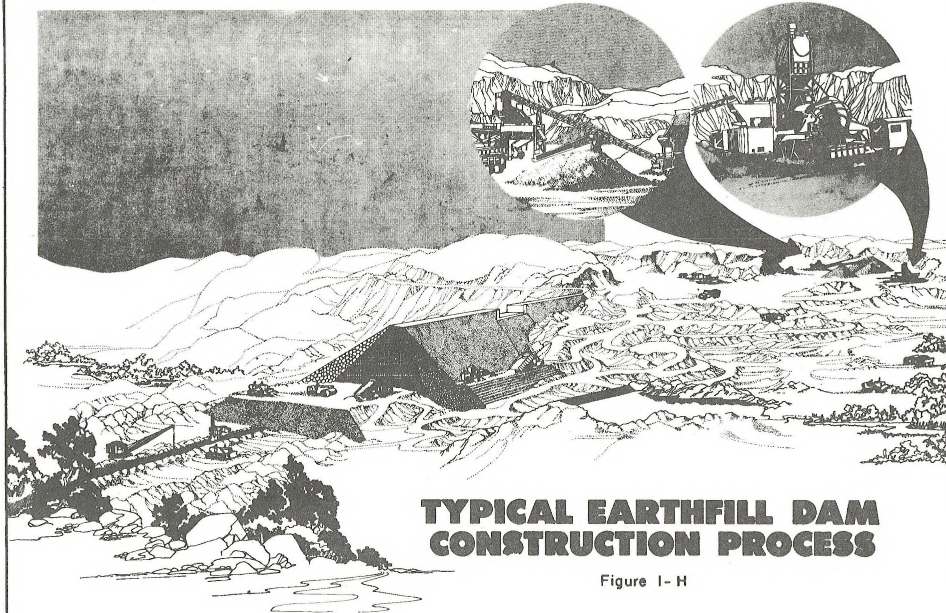
Rip rap, or large rocks, would then be placed at the discharge points of the outlet works and principal spillway. This would probably be done with dump trucks and front-end loaders.

All the above stages of construction would require numerous haul roads for dispersion of material. The majority of these would disappear as the construction progressed.

Approximate time for this phase would be two months.

1.1.2.2.5 Phase V

The last major phase would involve general clean-up and rehabilitation. Major areas of surface disturbance such as the borrow area,



TYPICAL EARTHFILL DAM CONSTRUCTION PROCESS

Figure I- H

the emergency spillway and temporary roads would be shaped with crawler tractors and motor graders to provide a suitable bed for grass seeding and planting sites for trees and shrubs. All slopes cut adjacent to the reservoir area would be reseeded and mulched. The majority of seeding would probably be done with a range seeder pulled behind a tractor and the mulch would probably be straw or a wood fiber used to retain moisture.

Approximate time for this phase would be two months.

1.1.2.3 Operation

In the State of Wyoming, permits are granted for the beneficial use of water. The use of water from interstate streams is further controlled by interstate stream compacts. Impoundment and use of water from interstate streams must include provisions for the protection of any senior water right gained under state law or interstate stream compact.

The proposed reservoir would be operated on the basis of a 1940 storage right on Powder River and transfer of a portion of a storage right from the proposed Pumpkin Reservoir site. It will be operated as a storage reservoir for seasonal irrigation water and a constant industrial supply.

1.1.2.3.1 Water rights

1.1.2.3.1.1 Wyoming Water Law

The water of all natural streams, springs, lakes, or other collections of still water within the boundaries of the State was declared to be the property of the State in Article VIII of the Wyoming State

Constitution. Provisions for the appropriation of water for beneficial uses and supervision of these appropriations were also established in the constitution. The State was divided into four water divisions, each with an appointed division superintendent. The office of State Engineer and the Board of Control (comprised of the State Engineer and the four water division superintendents) were established to supervise the waters of the State.

A water right is a right to use the water of the State, which has been obtained by the procedure set forth by state law. In the case of irrigation water, the water right is attached to the land and a maximum diversion of one cubic foot per second for each 70 acres irrigated is allowed, except a supplemental one cubic foot per second can be obtained from flood flows, subject to availability (Wyoming State Engineer's Office, 1969).

The right to store water in reservoirs is obtained in a manner similar to other water rights and must also be shown to be a beneficial use of the water. Unlike irrigation water rights from other water bodies, irrigation water rights from reservoir water are not necessarily attached to the land (Wyoming State Engineer's Office, 1969).

The priority of a water right is established by the date of filing with the State Engineer's Office and includes rights established under territorial law. This priority of water right filings gives rise to the doctrine that first in time is first in right.

1.1.2.3.1.2 Interstate compacts

Interstate stream compacts divide the flow of interstate streams between States. Of the several compacts between Wyoming and other States, the Yellowstone River Compact is of particular interest. The Yellowstone River Compact between Wyoming, Montana and North Dakota allocates the flow of the Yellowstone River and its interstate tributaries. It recognizes all water rights existing as of January 1, 1950, provides for a supplemental water supply for the precompact rights, and allocates the remaining divertible flow between Wyoming and Montana.

Under the Yellowstone River Compact, 42 percent of the unused and unappropriated flows of the Powder River, a tributary, are allocated to Wyoming. An average 121,000 acre-feet of water per year are available for consumptive use in the State, in addition to supplemental water for pre-1950 water rights. However, during years of drought, little if any water would be available under the compact. Supplemental supplies to pre-1950 water rights would probably utilize all available water (Wyoming State Engineer's Office, 1973).

1.1.2.3.1.3 Powder River water rights

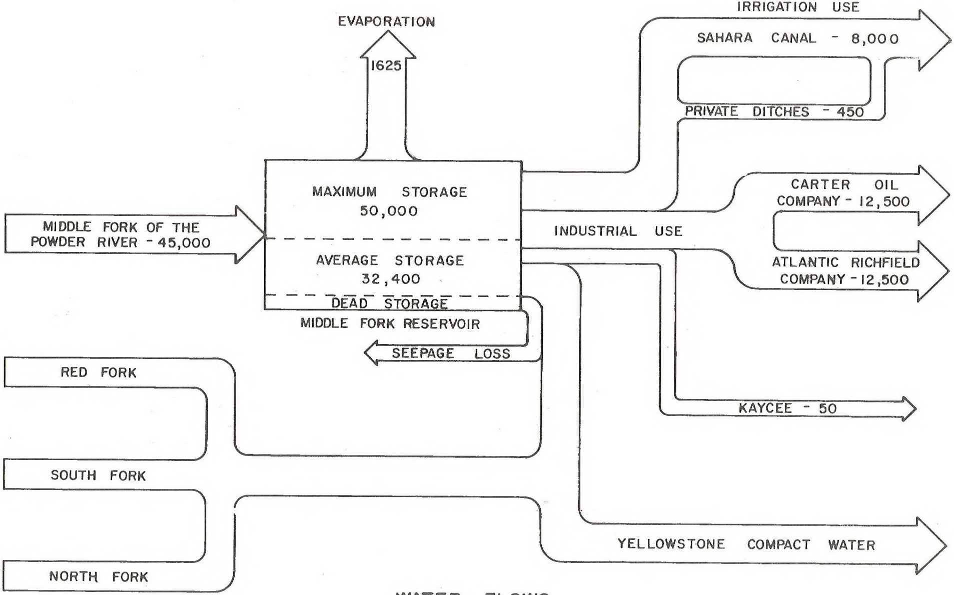
The largest present use of water in the Powder River Basin is for irrigation. As of November 30, 1971 irrigation water rights in good standing covered a total of 166,308 acres. Of this, 160,216 acres have adjudicated rights, and an additional 6,092 acres are covered by permits in good standing (Wyoming State Engineer's Office, 1972).

Approximately 6,916 acres of land are presently being irrigated from the Middle Fork Powder River below the proposed reservoir. This land includes about 5,116 acres under the Sahara Canal and about 1,800 acres under 8 private ditches between the dam site and the Sahara Canal. Water right permits for about 1,275 of the 1,800 acres are dated before January 21, 1902, the date of the principal filing for 2,710 acres under the Sahara Canal. Filings for the remaining 525 acres are interspersed among subsequent filings under the Sahara Canal lands (Banner, 1970).

1.1.2.3.1.4 Middle Fork Reservoir rights

Any water available in the Middle Fork at the reservoir site after all prior rights on the Middle Fork and mainstem of Powder River below the proposed reservoir are satisfied could be stored. In addition to Middle Fork flow, water entering Powder River from the Red Fork, North Fork and South Fork would be available to satisfy downstream rights (Banner, 1970).

The Middle Fork reservoir application was originally filed in 1940. This temporary filing, number 19-2/83 TF, has a priority date of March 7, 1940 and was for a capacity of 41,110 acre-feet. Since it was filed prior to 1950, this volume of water would be considered as allocated and not subject to the Yellowstone River Compact. In the engineering feasibility report (Banner, 1970), it was anticipated that an application would be filed to increase the capacity to 49,583 acre-feet. The application was filed on December 29, 1970, which is then the priority date for the additional storage. Since the existing Sahara Ditch rights have priority dates before 1950, the fraction of the additional storage used for supplemental irrigation would not be subject to the 42 percent allocation of the Yellowstone River Compact. That fraction of the addi-



WATER FLOWS

(IN ACRE FEET PER YEAR)

Figure I - I

tional reservoir storage used for the irrigation of new land would be subject to the Yellowstone River Compact. However, if all the reservoirs in the Powder River Basin for which filings have been made were constructed, it was concluded that little water would be available under this priority date (Banner, 1970).

Provisions for financing the construction of the dam include the sale of about one half of the stored water to Carter Oil Company for industrial purposes, which is discussed below. The engineer retained by Carter Oil Company for the project proposed a modified storage plan. This plan has been accepted by the Powder River Reservoir Corporation and is, therefore, assumed to apply. Fisk (1974) proposed that the reservoir be designed for an active storage of 50,000 acre-feet. Carter Oil Company possesses a permit, number TF 18-41334, for a reservoir (Pumpkin Reservoir) on the main stem Powder River. This reservoir site has a priority date of February 13, 1962 and is therefore subject to the Yellowstone River Compact. However the priority predates several other proposed reservoirs on the Powder River. Fisk (1974) proposed that the additional reservoir storage for the Middle Fork be obtained by the transfer of a portion of the temporary filing at Pumpkin Reservoir. He proposed that 8,925 acre-feet of the Pumpkin Reservoir right (total storage under the 1962 priority is 206,985 acre-feet) be transferred to the Middle Fork. The remainder of the Middle Fork storage with a priority of 1940 would then be 41,075 acre-feet. The additional storage in the Middle Fork would possess a greater degree of assurance than it would have under the priority date of December 29, 1970. It was assumed in Fisk's operation plan that neither priority would be limited by provisions of the Yellowstone River Compact (Fisk, 1974). However, that portion of the 1962 priority used to irrigate new land or used for industrial purposes would probably be affected.

Included in the above plan is an application to the State Engineer's Office for a temporary filing by Carter Oil Company for a diversion of 50 cubic feet per second. The water is to be taken from the reservoir during the period October through April for industrial use. Due to the season of use, it would be without curtailment by downstream senior appropriators.

1.1.2.3.2 Operation plan

A reservoir operation plan presents the method of reservoir operation. The historical streamflow record from a gage at or near the reservoir site, which is assumed to be representative of future flows, is often used as input to the reservoir. Restrictions imposed upon the reservoir operation by downstream water rights or other legal requirements are included. A water budget for the reservoir is then constructed by considering all reservoir inflows and outflows (including losses by seepage and evaporation). Alternate plans can be studied by changing operating assumptions such as timing and volume of releases, storage volumes and priority of water use. Changes in operating assumptions must be consistent with the imposed restrictions. The operation plan selected is usually that which most nearly meets the desired objectives in view of legal and inflow restrictions.

Banner (1970) studied three alternate reservoir operation plans. However, the transfer of rights from the Pumpkin Reservoir site will probably be approved. Therefore, the operation plan prepared by Fisk (1974), which is based upon this transfer of rights, is the most probable plan and is summarized here.

In Fisk's operation plan, the objective is to maximize the probability of industrial water delivery. Although the present contract between the Powder River Reservoir Corporation and Carter Oil Company calls for the delivery of 25,000 acre-feet a year, Fisk's operation plan is predicated upon an industrial delivery of 28,000 acre-feet a year.

Two storage accounts would be maintained. The storage under the 1940 priority would be managed on the basis of an October through September water year, while the storage under the 1962 priority would be managed on a proposed May through April water year. In either account the amount storable during a year would be the maximum storage less the amount in the storage account on the last day of the preceding year.

Industrial withdrawals from storage would be made first from the 1962 storage account during the period October through April and first from the 1940 storage account during the months May through September. When storage in one account was inadequate, withdrawals would be made from the other account. Irrigation withdrawals would be from the 1940 account and limited to a maximum of 10,000 acre-feet in any one year and 24,000 acre-feet in any three consecutive three-year period. Irrigation withdrawals would be restricted further by the amount that could be withdrawn in any given month during the growing season. Irrigation water transport is discussed in Section 2.

With the assumption that past streamflows are indicative of future streamflows, a monthly water budget for the water years 1951 through 1968 was developed. A summary of the operation is shown in Figure 1-K, which is a graph of the reservoir surface elevations resulting from the reservoir operation.

1.1.2.3.3 Controversy in the water use agreement

The agreement has been the subject of much discussion since it became known to the public. The requirement for large amounts of water to support the rapidly expanding minerals industry in Wyoming has focused great attention on Wyoming's limited water supply. Whether available water from the State should ever be used for minerals development which would largely benefit others outside the State has become an issue. The Middle Fork Reservoir was cited in the 1974 gubernatorial campaign as one of the several examples of this issue.

Unlike many other situations, the Middle Fork Reservoir project has the attraction of providing otherwise unavailable irrigation water for the benefit of agricultural users in the State, in addition to benefiting the minerals industry. Opinion is divided between those favoring the project and those who believe Wyoming agriculture might not be benefiting sufficiently.

1.1.2.4. Relocation of existing facilities

The paved road from Kaycee to Barnum is a major access route for ranchers living in the Barnum area. The road also provides an important route into the South Big Horns area to the west for ranchers, recreationists and others. This road is a state secondary road from Kaycee to

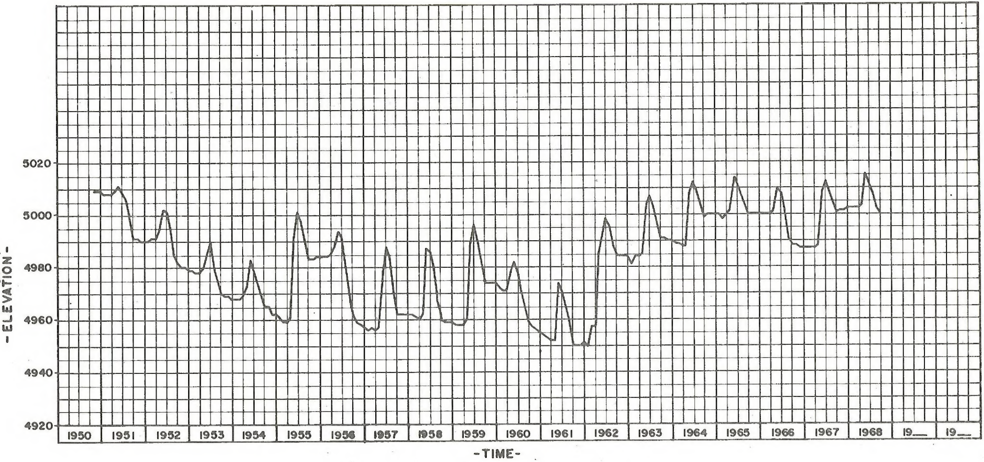


Figure I - J

MIDDLE FORK RESERVOIR OPERATION

50,000 AC.-FT. ACTIVE STORAGE
POST FEASIBILITY OPERATION NO. 2

Source: J.T. Banner and Associates, 1974.

a point near the dam site. From this point it is designated as a county road to Barnum. The Barnum Mountain road, extending westward, is used by the public but is not officially designated as a county road.

The road traverses the reservoir basin area for approximately 4 miles and would have to be relocated. The applicant has proposed a route for relocation which would involve construction of approximately 6 miles of new road around the north side of the reservoir basin (see Figure 1-B). Some NRL would be crossed in this relocation, and a right-of-way would be required under R.S. 2477 procedures, but no discretionary Federal action would be required.

The Johnson County Commissioners have outlined their intended standards for the road which will be designed and built for them by the Wyoming Highway Department under the Industrial Road program.

The Highway Department would attempt to design a maximum 10 percent vertical grade and to obtain a design speed of 45 to 50 miles per hour. The surfaced road area would be 24 feet minimum width. The subgrade width would be 30 to 36 feet, depending on surfacing requirements. The ditch section minimum would be 2 feet in depth and 10 feet wide. The cut slopes would be placed on 1-1/2 to 1 and proceed to low fill slopes of 4 to 1. The number of drainage structures would be kept at a minimum. At this time, the commissioners are recommending that the road not be fenced and that cattleguards be placed where necessary. However, it appears that fencing may be necessary and this recommendation may be changed in the future.

The county commissioners have recommended that due to the lack of vegetation along the route and due to the high cost of rehabilitation, there be no attempt at salvaging topsoil, fertilizing, or reseeding.

The gravel source has not been investigated, but consideration is being given to a source near the dam site on the south side of the river. This would be near, or possibly the same as the source of fill for the dam.

The construction and inundation would also require relocation of being six miles of telephone line and one mile of 14.4 KV, single-phase R.E.A. power line. The exact routes of these relocations are uncertain.

1.1.2.4.1 Road relocation construction

The existing road through the reservoir area would require relocation, first on a temporary basis to allow the dam construction activity at specific stages and finally on a permanent basis when reservoir inundation reached the old road level.

It is assumed the construction period for the road would take one year with the following types of major equipment:

NUMBER	TYPE
2	Crawler tractors with dozer on U blades
2	Motor scrapers
1	Self-propelled compactor with sheep's foot
1	Smooth roller compactor
1	Motor grader
1	Front-end loader
2	Dump trucks
1	Rock drill with compressor
1	Asphalt finishing machine

Construction would begin with a pioneer road built with a crawler tractor. The road would normally be limited to one tractor's blade width (about twelve feet) and would be used for access for the next phase.

Clearing, the next operation, would also be done with the crawler tractor. It would be minimal due to a lack of large vegetative material within the road prism. Trees when encountered would be piled outside the road prism and burned.

Next, large drainage structures would be laid in the original drainage course. Structures over sixty inches in diameter would probably be constructed on the site, while smaller structures would be set in major sections. Once in place the structure would be covered with fill and tamped in six to twelve inch layers.

Excavation would begin with crawler tractors by widening those parts of the pioneer road which didn't require major fills or large cuts. Areas requiring excavation over approximately 200 feet would be constructed with the motor scrapers. The scrapers would move the material from the cut sections to the major fill sections. In sections less than 200 feet between cut and fill the crawler tractor would drift the material. The fills would be compacted in six to twelve inch lifts with the self-propelled roller.

After the sub-grade for the road was constructed a motor grader would shape the surface for the rock base. The rock would be hauled with the dump trucks and spread out to a uniform depth with the motor grader and compacted with the roller. The rock material would include three layers which would gradate from large rock on the bottom to a one to two inch size top layer.

At some time during this operation the asphalt batch plant would be set up.

The physical size and amount of disturbance caused by this activity would probably be about ten acres. The area would provide room for the material site, crusher, stockpiles, asphalt plant, equipment parking, weight and lab facilities, and some access around the site.

The material stockpiles would probably require the largest area. This material would be broken down into the following general categories: sub-base, base, select topping, and the aggregate used in the asphalt mix.

Asphalt plants have a tendency to spread out. This is caused by a linear arrangement with the drier and revolving drum units to make a flow-through process without the excessive use of conveyors to move material.

Under the State's Clean Air Quality Act all hot mix plants are equipped with dust collectors set alongside of the drier.

Other units around the hot mix plant would be a storage tank for the hot asphalt; or, in some cases the asphalt is used directly from the trucks as this saves reheating the material.

Most asphalt plant driers are fired with liquid propane gas and the tank for such fuel would be located close to the dryer. It would probably have about a two-thousand gallon capacity. The materials control laboratory associated with the asphalt plant would generally located some distance from the rest of the operation.

The running surface would be laid down with an asphalt finishing machine fed by hot asphalt mix by dump truck from the hot mix plant. This would normally take two passes which would finally be rolled by a self-propelled smooth roller.

1.1.2.5 Land and property acquisition

Negotiations are under way for acquisition of the needed rights for construction and operation of the reservoir. The taking area includes all the land inside the reservoir basin, using a line drawn at 5,030 feet elevation as the take line. This provides a buffer zone of land extending from the maximum high water line elevation of 5,019.5 feet to the 5,030 foot elevation, a vertical distance of 10.5 feet which would amount to approximately 290 acres overall.

The nature of the acquisition varies between purchase of the land in fee and purchase of a "flowage or inundation easement," depending on the situation encountered during negotiations. In some cases additional land was purchased above the 5,030 foot elevation where the owner did not wish to retain small isolated parcels which would be difficult to manage. In other cases the flowage easement was required, mainly in areas where only a small finger of the reservoir would extend up a drainage or ravine. In this situation, the owner wished to retain title since the desired use would not greatly affect his management of the land.

In addition to the acquisition to the 5,030 foot elevation, an easement 100 feet wide is to be acquired surrounding the reservoir for access for inspection, maintenance, and repair. These access rights are limited to persons employed by the reservoir corporation and persons making inspections of the reservoir when such inspections are required by law.

The buffer zone between the 5,019.5 foot and 5,030 foot elevations is to be opened for public access and recreational use. This area is also to be opened for the use of the former owner for generally the same purposes as before acquisition, including livestock grazing and watering. The former owner can also use the land for recreational purposes. The use of this land by the former owner is to be without charge except for the obligations to pay real estate taxes until the reservoir is constructed and in operation. At this time the reservoir company would be obligated to pay the taxes. The use of the buffer zone land by the public and former owner is to be generally without restriction except in certain areas near the dam site which are considered dangerous. Such areas are to be plainly designated and signed.

Accommodating structures such as fences and water gaps to facilitate use of adjoining land are to be worked out between the former owner and the reservoir corporation. Generally the corporation plans to at least construct fences around the area of inundation where they are needed or desired.

There are eight different land ownerships involved in the reservoir acquisition program. Four of these are owners who do not live in the vicinity; two residences in the vicinity will not be within the take line, and two are within the take line and must be abandoned or relocated.

Both landowners to be relocated have families, but neither has decided whether to move the residence to higher ground on remaining property or to move out of the locality. There are two additional farmsteads or sets of buildings located inside the take line which are unoccupied. Figure 5.12-A shows the amounts of land to be taken in the program within the maximum high water line (5,019.5 feet) as well as the area permanently needed in the vicinity of the dam.

1.2 Arrangements for impounded water use

A portion of the available water is to be used for farmland irrigation downstream from the dam site (see no. 2 below) and another portion is to be used for industrial purposes, the nature of which is as yet uncertain as explained below (see no. 3). The plan also provides for a small portion (50 acre-feet) to be used to supplement the municipal water supply of the town of Kaycee.

1.2.1 Industrial firms involved

The reservoir project has been under study since prior to 1940. A major obstacle in its adoption has been funding. The present arrangement provides a solution through the initial involvement of the Carter Oil Company. The reservoir corporation plans to finance construction through a loan from the Wyoming State Farm Loan Board as authorized by state law. The loan is secured by means of annual sale of 25,000 acre-feet of the stored water to the Carter Oil Company through a contract dated May 22, 1973. Carter subsequently sold half of this amount to Atlantic Richfield Company.

The Carter Oil Company is additionally involved through the transfer of their 1964 priority water from the Pumpkin Reservoir filing as discussed above.

The reservoir corporation, therefore, is acting as a seller of the 1940 priority water and is providing storage space for Carter with regard to the 1962 priority water.

1.2.2 Contract between Powder River Reservoir Corporation and the Carter Oil Company

The May 22, 1973 contract between the Powder River Reservoir Corporation and the Carter Oil Company sets forth in considerable detail the obligations of both parties in taking the necessary steps for completion of the reservoir project and for continued operation and maintenance of the reservoir. The provisions of this contract which are felt to be significant to this environmental impact statement are summarized briefly, as follows:

a) The Powder River Reservoir Corporation is to organize an irrigation district and assign to the district its permit to construct the Middle Fork Reservoir from the State Engineer's Office.

b) The district will then make application to the Wyoming State Farm Loan Board for a loan sufficient to defray the entire cost of the reservoir. The term of the loan is to be 40 years.

c) The security for the loan will be the pro rata assessments for construction against the lands of each landowner in the district, a deed of trust or mortgage to cover the reservoir including the real and personal property involved, and also, if required, as additional security, an assignment of water rights and the payments to be received from Carter for the purchase of the water.

d) Carter purchases 25,000 acre-feet of water annually using a water year beginning October 1 and ending the following September 30. The water is to be delivered at an approximately uniform rate. Payment must be made even if Carter does not use the water or the water is not physically or legally available. This agreement will be in effect as soon as the water is available or January 1, 1985, whichever is the earlier. Carter is obligated to pay approximately half of the annual operation and maintenance costs.

e) The district is entitled to 24,000 acre-feet in any consecutive 3 year period, but not to exceed 10,000 acre-feet in any one year after the amount sold to Carter is delivered. The reservoir is to be operated within applicable law in a manner maximizing the certainty of delivering the industrial water share.

f) Irrigation water deliveries will be limited to the extent necessary to prevent the active storage capacity from being lowered below 15,000 acre-feet on May 31; 12,500 acre-feet on June 30; 10,000 acre-feet on July 31; 7,500 acre-feet on August 31; 5,000 acre-feet on September 30. No deliveries for irrigation are allowed from October 1 to April 30.

g) Carter can purchase 25/32nds of any excess water over this original amount if it can be withdrawn without hazard to the original supply sold to Carter or to the supply of the district.

h) Carter has a preference right to purchase any additional water the district may wish to sell to a third party at the same price offered by the third party if the district desires to accept that price. The contract does provide an exception, stating that up to an aggregate of

500 acre-feet for agricultural purposes can be sold which is exempt from Carter's preferential right of purchase.

i) The district has a preference right to buy back upon the same terms and conditions any water which Carter proposes to sell to direct irrigation users, but there are no further restrictions on Carter's right to resell any of the water purchased from the district.

j) Carter cannot assign the contract without the district's consent to any other corporation which is not wholly owned by Carter or Carter's parent corporation.

Revisions of this contract may be necessary to accommodate the change in operation caused by the recent decision to transfer the water with the 1962 priority from the Pumpkin Reservoir. One item that remains to be resolved is the provision for compensation to the reservoir corporation for storage of the 1962 priority water.

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2. Agricultural use of the water

The Middle Fork Irrigation District consists of a group of ranchers whose holdings are located largely along the Powder River below Kaycee, Wyoming. The river flows due east for 18 to 20 miles below Kaycee and then makes almost a right-angle bend to the north. The lands to be irrigated are located along this stretch of river between Kaycee and the bend. There are other irrigable lands further downstream and the study of the project made by the Bureau of Reclamation in 1967 contemplated development and irrigation of these lands through a series of pumping systems. This earlier study allowed for only 10,000 acre-feet to be used for industrial purposes which left much more available for irrigation. The lower amount of water available for irrigation in the present proposal indicates that it is unlikely these additional lands will be developed.

As discussed above, the amount of water available for agricultural use will be variable according to the annual supply. Allocations must be made each year in a predetermined manner according to the share of each recipient.

A relatively small amount of the agricultural water may be allocated to the ranchers outside the irrigation district whose holdings are situated between the dam site and the Sahara ditch diversion. Negotiations are still under way as to how much water may be involved. A figure of 450 acre-feet has been set aside for this purpose. The majority of the water will be allocated to the members of the Middle Fork Irrigation District.

A total of 22 individuals are on the 40-year assessment roll for receipt of the water and payment of the operation and maintenance cost. This roll apportions a total of 8,000 acre-feet among owners according to the number of irrigable acres owned within the district based on approximately 1.5 acre-feet per irrigable acre. The total of 8,000 acre-feet is used as the normal amount to be available according to the contract which states that not more than 24,000 acre-feet can be used in any three-year period. However, a maximum of 10,000 acre-feet can be used in any year, provided the three-year total of 24,000 acre-feet is not exceeded. A total of 5,116 acres of presently irrigated lands will receive a supplemental supply and 363 acres of previously non-irrigated lands will receive an original supply as they are developed.

The stored water for irrigation use would be released into the natural stream channel as it is needed during the irrigation season. The water would be allowed to flow down to the Sahara ditch diversion structure (approximately 20 miles downstream from the reservoir), located in T. 43 N., R. 81 W., Section 13, NE 1/4 SW 1/4, where it would be diverted into the Sahara ditch and routed to the irrigated lands. No new tributary ditches will be required for the supplemental irrigation, while extension of some currently existing ditches and/or construction of limited numbers of new ditches would be required for the new lands.

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3. Assumed industrial use of water

Industrial development of coal and water resources offers several alternatives to the developer. The production of synthetic natural gas by the process of coal gasification is very feasible, and several such plants are proposed or under construction now. The synthesis of crude oil from coal is possible using the coal liquefaction process; however, this process is still in the pilot stage and still requires more development work. Coal fired steam generation of electricity is a quite common process (Jim Bridger plant or Dave Johnston plant); however, neither of the companies buying the water is traditionally in the business of electric power generation. The coal can be finely crushed, slurried with water, and transported through a pipeline to a market not in the area of study, but, again, this has not been the usual method for these companies.

Coal gasification appears to be the most likely utilization of the coal and water resources available. Thus, it will be studied as the principal probable action for industrial water development. The other processes could, however, be implemented and will therefore be dealt with as alternative probable actions.

Since there is no definite proposal as to industrial use of water, no specific site is analyzed, but there are general impacts associated with these process plants, regardless of where they may be located in the study area. Thus, the following will be a general picture of what coal gasification is, what a typical plant might need in the way of resources, and what would result as products.

The construction, operation, and phase out of the plant, as well as transport systems for raw materials and products, will be discussed in terms of what is required--materials, equipment and labor. These points will also be considered in the discussion of coal liquefaction, coal fired steam electric generation, and coal slurry pipeline as alternatives.

3.1 Coal gasification

The concept of coal gasification is not new. Since before 1900, it has been used in Europe to make a low heating value gas called "town gas." From that time to now, the process has been used whenever an area has available coal, but a critically short supply of natural gas. Production of coal gas was more costly than natural gas production, and coal gas was of much lower heating value, thus gasification was used only as a final resort.

In the last twenty years, considerable research has been generated by the encroaching energy shortage and desire to become "energy independent." Sophisticated processes have been designed and tested on the pilot plant scale--many of which seem viable. Although as yet no operating plants exist in the United States, it seems possible to produce synthetic pipeline gas (SPG) which can be used like natural gas and which meets Federal Power Commission standards with respect to minimum heating value, flow properties, and trace gas composition. As natural gas prices have risen, gas (SPG) has become increasingly commercially competitive.

Chemically, coal is composed of an organic fraction containing carbon, hydrogen, oxygen, nitrogen and sulfur; and an inorganic ash fraction consisting of silica (SiO_2), alumina (Al_2O_3), salts or oxides of calcium, sodium, potassium, iron, chlorides, sulfides, sulfates, carbonates and bicarbonates; and several trace elements such as mercury, cadmium, zinc, copper, and arsenic. Most coal contains moisture at levels between ten and thirty percent of total weight. Relative amounts of these fractions vary from region to region, mine to mine and even shovelful to shovelful, and this composition is what chiefly determines the heating value of the coal. The analysis of the coal is also critical as to many subsequent environmental impacts of processing the coal. Principally, coal is utilized in three ways: combustion in air (oxidizing conditions), heating in an oxygen free atmosphere (inert conditions), and heating in a hydrogen rich atmosphere (reducing conditions).

(1) Coal combustion in air has been used as a source of heat for centuries. This process produces oxidized species of the various organic constituents in coal--carbon dioxide (CO_2), water vapor (H_2O), sulfur oxides (SO_2, SO_3), and, at elevated temperatures, nitrogen oxides (NO_x). The inorganic constituents, called "fly ash," remain as a solid residue.

(2) When coal is heated in an inert atmosphere, as in the production of coke for steel making, the volatiles (organic compounds easily converted to the gas phase) are virtually boiled off as light oils, phenols, and tars. This leaves a material called char or coke, consisting mainly of fixed or elemental carbon.

(3) Heated under pressure in a reducing atmosphere, the coal is stripped of volatiles, the resulting char reacting with hydrogen and water vapor to form methane (CH_4), carbon monoxide (CO), and further hydrogen (H_2), as well as other reduced species such as hydrogen sulfide (H_2S), ammonia (NH_3), and hydrogen cyanide (HCN). Only residual inorganic fly ash remains. This process is coal gasification.

To form methane from coal, one is going from coal with a carbon: hydrogen ratio of roughly 1:2 to methane with a ratio of 1:4. The hydrogen required for this enrichment is supplied by steam (H_2O). After the coal volatiles have vaporized, steam and carbon react in a heated, pressurized vessel to form carbon monoxide and hydrogen:

$$(1) \quad H_2O + C + heat \longrightarrow CO + H_2$$

As soon as some hydrogen has been formed, a portion will react with carbon to yield methane. This reaction is exothermic (heat releasing):

$$(2) \quad C + 2H_2 \longrightarrow CH_4 + heat$$

This is the raw gas, similar to town gas, which must be further processed to yield synthetic pipeline gas. The gas is treated in a shift converter where it is enriched in hydrogen. Carbon monoxide in the gas stream is made to react exothermically with steam to form carbon dioxide and hydrogen:

$$(3) \quad CO + H_2O \longrightarrow CO_2 + H_2 + heat$$

This gas is cleaned of impurities--volatiles, steam, carbon dioxide, hydrogen cyanide, ammonia, hydrogen sulfide, and fly ash--and passed through a catalytic methanator where hydrogen and carbon monoxide are made to react exothermically producing methane and water vapor:

$$(4) \quad 3H_2 + CO \longrightarrow CH_4 + H_2O + heat$$

Water is removed from the gas stream and the final product is similar to natural gas and ready for commercial use.

Several processes have been investigated. These differ primarily in the method of supplying process heat and the recouping of heat from the last three exothermic reactions, 2, 3 and 4, to sustain the initial endothermic (requiring heat) reaction 1. The various processes utilize different energy sources and equipment designs and yield slightly different by-products and wastes. But all methods derive the same product from basically the same resources in the most economically efficient way possible.

3.1.1 Plant disposition assumptions

In discussing coal gasification, there is a relationship between the amount of water available and the amount of synthetic natural gas which can be produced. A plant of fairly typical size would be rated at a production of 250 million standard cubic feet per day (MMSCFD). This would require about 8,300 acre-feet of water per year. This gives a scaling factor of 0.03 MMSCFD per acre-foot of water. Since each company has available some 12,500 acre-feet, they each have the necessary water to support a 375-MMSCFD coal gasification plant. The total water available for industrial use would support a 750-MMSCFD gasification plant.

There are three probable alternatives if the companies institute gasification development. Most probable is the possibility that both Atlantic Richfield Company and Carter Oil Company will build their own plants, each having approximately a 375-MMSCFD capacity. Although this is slightly larger than the typical 250-MMSCFD plant being proposed for most development now, a 375-MMSCFD plant is well within the range of feasibility, and much larger plants have been proposed.

There is a second possibility that the two companies may pool their water resources and build a complex capable of yielding 750 MMSCFD of product gas. This complex would likely resemble two adjacent 375-MMSCFD plants.

The third possibility is that the two companies would combine their water resources in some way to support the three 250-MMSCFD

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plants which could be supported using 25,000 acre-feet of water. In this case, three separated plants could be built within the study area. However, this is probably less likely than the first two possibilities owing to the difficulties of coordinating water rights and the complex water transport system to supply three plants.

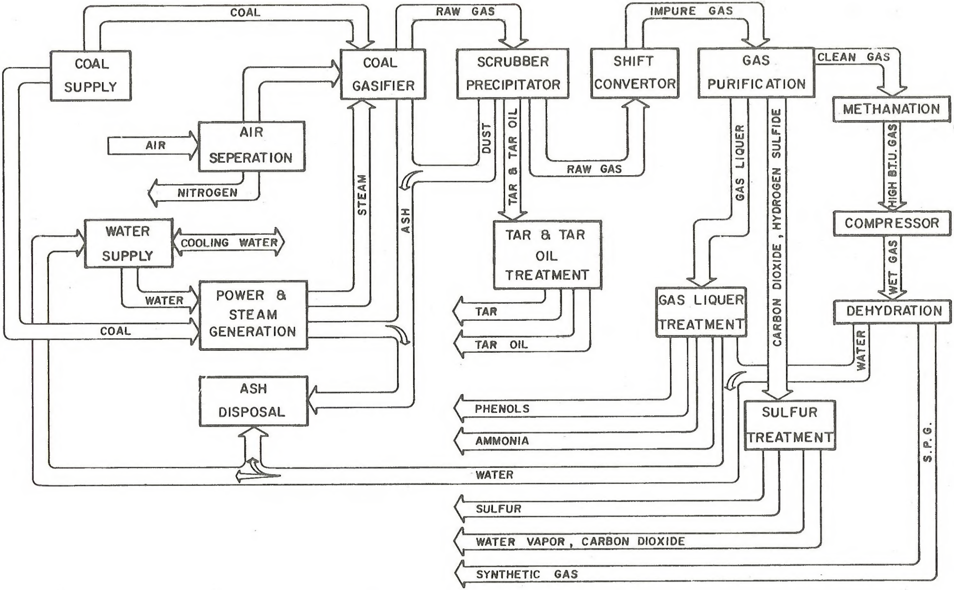
3.1.2 <u>The coal gasification plant</u>

As mentioned before, there are several processes which will convert coal and water to a marketable synthetic natural gas. Many of the processes are still in the pilot plant stage and it may be years before they can be implemented commercially. Most of the gasification plants proposed or now under construction have adopted the Lurgi process since it has been used commercially. Most information available on commercial coal gasification plants deals with the Lurgi process; therefore, most of the description following covers Lurgi plants. No matter what gasification process is chosen, the plant will be very similar to the one described below. The various amounts and kinds of raw materials and products may differ, but essentially the differences will be technical engineering variations.

The following page shows a simplified flow diagram of the major components in the system. In any one plant design, these may be arranged differently or combined under different names, but every plant will contain these components. The process plant can be considered categorized into two areas--process components and support components.

3.1.2.1 <u>Process components</u>

<u>Coal Supply</u> - This is coal mining, sizing, stripping and storage. It may include mines, railroads, coal slurry pipelines, crushers, screens, conveyors, and storage bins. For the Lurgi process, coal must be crushed to a maximum topsize, screened and separated into size fractions, and stored separately. Coal too fine to be gasified can be



SIMPLIFIED FLOW DIAGRAM
COAL GASIFICATION
Figure 3.1-A

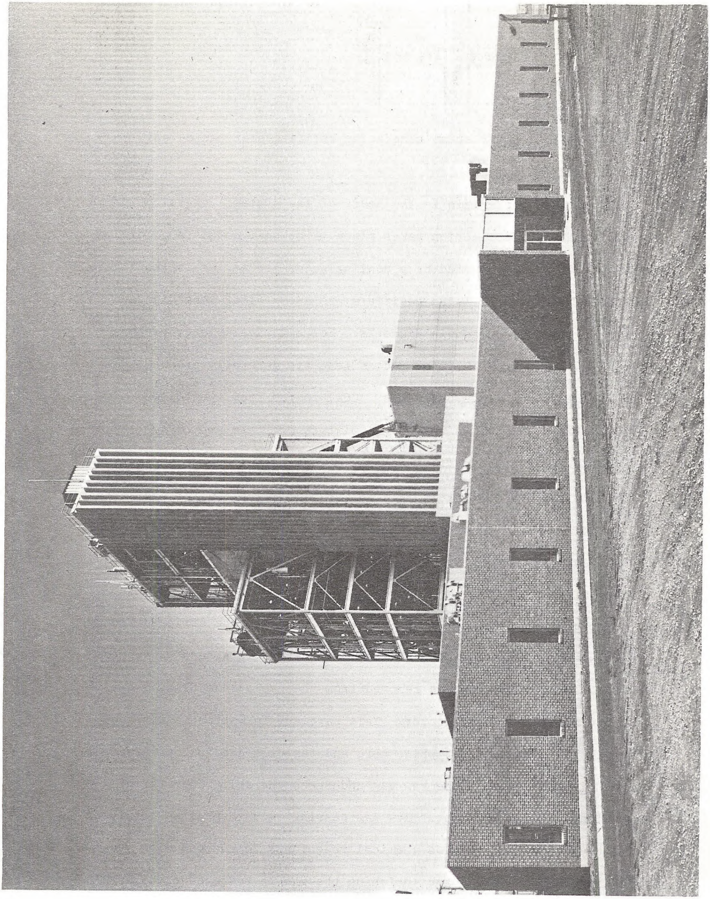


Figure 3.1-B - Coal Gasification Pilot Plant (CO_2 Acceptor)
Consolidation Coal Co., Rapid City, South Dakota

used as fuel to power steam generating facilities or can be sold to another coal consumer.

Coal Gasifier - This is the heart of the system - where the principal gasification reaction takes place. The unit consists of a pressure vessel surrounded by a cooling water jacket, as in the figure on the following page. The gasifiers are about fifty feet high and generally under ten feet in diameter. For a typical plant, perhaps fifty gasifiers would be required. These are generally grouped together in one or two large buildings. Coal is fed from the top and distributed evenly into the vessel. A mixture of steam and oxygen, under pressure, is introduced from the bottom, countercurrent to the falling coal. As the coal falls, it is first devolatilized and the char reacts with the rising steam and oxygen, producing raw gas which leaves from the top and residual fly ash which falls through the grate to the ash lock and out.

Scrubber and Precipitator - Tars and tar oils are stripped from the raw gas in this component by cooling the gas in a heat exchanger. Dust, suspended fly ash, is removed from the gas stream using a cyclone or some similar dust collector. This particulate matter is disposed of with the gasifier ash, while tars and tar oils are further treated.

Shift Convertor - The raw gas undergoes the shift conversion reaction in this component. Raw gas passing over a specific catalyst (a substance which promotes chemical reactions) is reacted with steam yielding carbon dioxide and enriching the gas in hydrogen necessary for later reactions to increase the heat value of the gas.

COAL GASIFIER

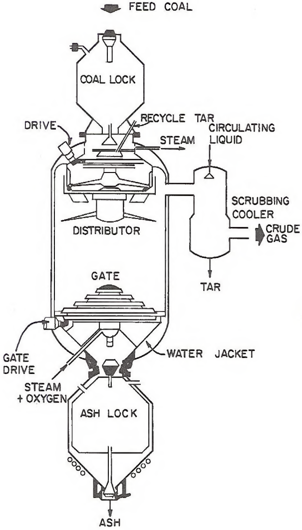


Figure 3.1-C

Lurgi Gasifier

Wyoming Coal Gas Company Project Proposal

Gas Purification - Impure gas is further cooled in this component to condense a so called gas liquor consisting of light tars, oils, phenols, dissolved ammonia, naphtha, and water. Carbon dioxide is partially removed by allowing it to be absorbed by a potassium carbonate solution. The acid sulfur gases are similarly absorbed using methanol or a similar substance later to be regenerated and treated in the sulfur treatment component. Hydrogen cyanide, if present, can be recirculated to the shift convertor and converted to ammonia and methane. Process gas leaving this unit is free of dust, heavy hydrocarbons, sulfur, ammonia, and cyanide compounds.

Catalytic Methanator - Clean gas now passes through a catalytic convertor to change the residual carbon dioxide and all of the carbon monoxide to methane. Then, if there is too much carbon dioxide left, the gas stream is again passed through a carbon dioxide absorbent.

Compression and Dehydration - The high Btu gas is compressed to meet pipeline pressures, cooled, and passed through a water absorbing agent. Water is dumped back into the plant's water system and reused. This final product is synthetic pipeline gas with a heating value of 1000 Btu's per cubic foot and of high enough quality to be sent to the consuming public.

3.1.2.2 Support components

Tar and Tar Oil Treatment - Heavy, thick coal tars are separated from lighter thinner tar oils and both are either stored or sold to industrial consumers who convert these by-products to other valuable organic based products such as plastics, etc.

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Gas Liquor Treatment - The gas liquor is treated by extraction with organic solvents that dissolve light tars and oils, phenols, and naphtha. These compounds are then chemically separated and generally passed on to the same industrial consumers who buy coal tar. The remaining water and ammonia are separated by fractionation and condensation yielding anhydrous ammonia which is marketable and water which can be returned to the plant water system.

Sulfur Treatment - Acid sulfur gas, hydrogen sulfide, can be converted to elemental sulfur by two proven methods--the Claus process and the Stretford process--which differ basically in the method of conversion. The gas leaving sulfur treatment, called tail gas, is incinerated to make sure any remaining hydrocarbons, hydrogen sulfide, and organic sulfur compounds are oxidized before venting to the atmosphere. Sometimes, depending on air quality standards, it is necessary to control this gas with the emission controls discussed later in this section.

Water Supply - Several functions are carried out in this area. Waste water from various systems in the process is cleaned and reclaimed for cooling and boiler feedwater. Raw water, from outside, is purified, if necessary, before going to the boilers. Cooling water is cycled from heat producing systems to steam generation where already heated cooling water is economically turned to steam. The remainder of the heated cooling water is cooled in evaporation towers or ponds. Environmental Protection Agency (EPA) standards require that there be no liquid effluents or waste water leaving the plant.

Power and Steam Generation - Heat, steam and electricity needs for the plant are supplied in this area. Coal that is too small to be gasified can be burned as fuel to provide process heat. Ash from coal combustion can be disposed of along with gasifier ash. Some heat from steam generation is recovered from cooling water by heat exchange. The gases yielded from coal combustion generally cause the greatest impact on air quality. Thus, they must often have emission controls on the stacks from the power and steam generation area. The emission controls are discussed in more detail later in this section.

Ash Disposal - Residual ash (inorganic residue) from coal processing is quenched in water, thickened, allowed to settle into a thick, high density slurry, and finally disposed of--generally as fill in the coal mine.

Air Separation - Oxygen is required in the gasifier to sustain the high temperatures required in the initial gasification reaction. This oxygen is supplied by cryogenic fractionation of air (separation of oxygen and nitrogen in the air by rapid cooling). The nitrogen created is vented back to the atmosphere.

Emission Control Systems - Primarily, two air quality problems are presently dealt with using emission control devices. Particulate matter or dust can be removed from stack gases leaving the plant, generally the power and steam generation area, with better than 99 percent efficiency using a device called an electrostatic precipitator. This device works by passing the gas through an electrically charged area, thereby giving the dust particles an electric charge. The particles are then attracted to charged plates inside the precipitator. When the plates are covered with dust, the electric charge is removed, the attraction stops and the dust falls to the bottom of the precipitator to be collected and disposed of. Other methods of dust collection can be used. A baghouse unit is basically a large box full of porous bags, like fine cheesecloth, which allow gas to pass through, but hold the dust. When full these bags are dumped and the dust collected. A cyclone is a cone-shaped device through which the gas is forced to swirl, much like a tornado. The dust, being heavier than the gas, is thrown to the outside of the swirling area, collected, and removed.

The other emission control problem is countered by sulfur dioxide (SO_2) scrubbing. Primary sources of SO_2 are the steam and power generation area and the incinerated tail gas from the sulfur treatment area. Sulfur dioxide is generally absorbed by a substance which has a chemical affinity, sort of a hunger, for SO_2. Commonly used substances are limestone or dolomite. The material is very finely ground, mixed with water, and sprayed into the SO_2 laden gas stream. The limestone or dolomite absorbs part of the SO_2, yielding magnesium and calcium sulfites and sulfates. These sulfates and sulfites must be either disposed of with the ash or treated to recover the sulfur and the limestone or dolomite. Other scrubbing systems are used in which the SO_2 is catalytically oxidized to SO_3 (sulfur trioxide) which reacts with water to form sulfuric acid, a saleable byproduct. Also, instead of using limestone or dolomite, sodium salt solutions are used to absorb SO_2. This solution can then be treated to recover the sulfur and the original solution.

3.1.2.3 Ancillary systems

The above mentioned systems are the principal features in a coal gasification plant. In addition, any plant will have pumps for moving liquids; valves and piping to control gas flow; fans to direct air flows and combustion areas; stacks to vent exhaust gases; tanks, ponds and silos for storage; maintenance and construction equipment; buildings for laboratories and offices; and parking lots and loading areas.

3.1.3 Material and energy balances - Raw materials and products

Using the assumption that the available water resource will be used to build two 375-million standard cubic feet per day coal gasification plants, it is possible using available technical data (see references (3.1.6) and table on following page) to estimate the amounts of various raw materials consumed by each plant and the amounts of products and by-products yielded from each plant. This is generally expressed in terms of material and energy balances, in which the total amount of what goes into the plant--coal, air, water, etc.--is exactly balanced by what comes out of the plant--synthetic gas, by-products, and wastes. If an accurate chemical analysis is known for the various raw materials going into the process, it is possible to predict the amounts of various products, by-products, wastes, emissions, and trace element dispersion.

3.1.3.1 Raw materials - 375 MMSCFD plant

Coal to gasifiers	30,680 Ton/Day
Coal to boilers	6,390 Ton/Day
Total coal	37,070 Ton/Day
Air to oxygen plant	32,190 Ton/Day
Air to boilers, etc.	85,000 Ton/Day
Air to sulfur units	2,270 Ton/Day
Total air	119,460 Ton/Day
Water	46,470 Ton/Day (12,500 acre-feet/year)
Chemicals	76 Ton/Day
Total	203,076 Ton/Day

Scale Up Factors

(from planned plant data)

Plant Name & Location	Coal Use ton/day	Water Use ton/day	SPG Produced MMSCFD*	Sulfur Produced** ton/day	Employment people
Wyoming Coal Gas Wyoming	27,192	19,860	270	62	800
El Paso Burnham I New Mexico	28,248	42,300	288	186	890
Assumed Plant Estimates	37,070	46,470	375	89	1,000
El Paso Burnham II New Mexico	76,788	114,900	785	509	1,200

*Million standard cubic feet per day.

**Sulfur variations due to sulfur analysis of differing feed coals.

Coal - As coal is processed in the plant, fixed carbon, volatiles, moisture, and sulfur are consumed and converted, eventually turning up in another form, generally as products and by-products. Residual ash is left to be disposed as a waste. Much of the mineral and trace element content is concentrated in this ash, often causing some concern with ash disposal methods. Some of the trace elements which are easily vaporized (converted to gases by heating encountered in processing) may be emitted into the air. (See coal analysis, page 3-22.)

Air - Air is a major raw material for the gasification process, providing oxygen for coal combustion and oxygen to maintain the gasification process. The air will generally contain some gases and trace elements which should be monitored to ascertain whether or not undesirable gases and traces are being built up in the airshed due to coal processing.

Water - The water, as received from the reservoir, may need to be purified to meet specifications for boiler and process water. This purification will yield approximately 40 tons per day of waste solids from the dissolved solids or sediments in the water.

No data for chemical quality of the water that would be held in the Middle Fork Reservoir has been gathered as yet. Of the several water gaging stations in the area, only one, several miles downstream is presently gathering water quality information. Because this station is downstream on the Powder River and several streams run into the river besides the Middle Fork, the data from this station is not necessarily representative. However, the total dissolved solids

Coal Analysis* - 37,070 Ton/Day Throughput

Component	% Present	Ton/Day Yielded From 37,070 T/D of Coal
Fixed carbon	33.71	12,498
Volatiles	32.71	12,123
Moisture	28.00	10,381
Sulfur	0.33	121
Ash	5.58	2,069
Ash Analysis		
Na_2O	0.12	44
K_2O	0.01	4
P_2O_5	0.06	23
SiO_2	1.76	653
Fe_2O_3	0.32	119
Al_2O_3	0.89	330
TiO_2	0.07	25
CaO	1.39	515
MgO	0.33	122
SO_3	0.61	227
Trace Elements		
Antimony	8×10^{-6}	0.003
Arsenic	5.7×10^{-5}	0.021
Beryllium	7.1×10^{-5}	0.026
Boron	3.2×10^{-3}	1.19
Cobalt	5.5×10^{-5}	0.021
Copper	8.9×10^{-4}	0.33
Chromium	4.2×10^{-4}	0.16
Fluorine	6.5×10^{-3}	2.41
Lead	5.1×10^{-5}	0.019
Mercury	1.7×10^{-5}	0.006
Nickel	1.7×10^{-3}	0.63
Vanadium	1.4×10^{-3}	0.52
Uranium	8.8×10^{-5}	0.033

*Based on coal from proposed Rochelle Mine, Wyoming. This coal is typical of coal mined in the eastern Powder River basin.

figure is included from the downstream gaging station simply to get a handle on the amount of solids expected from water purification.

Component	% present	Ton/day yielded from 46,470 ton/day water
Total dissolved solids	0.08	37.2

Chemicals - Chemicals are used throughout the process, particularly in the support components as catalysts and mediums for chemical reaction. Also, small amounts of special chemicals are used as absorbents for water and carbon dioxide, biocides, corrosion inhibitors, and pH controls. Catalysts can generally be returned to the manufacturer and regenerated. Reaction media are recovered and recycled; however, there are some loses which must continually be replaced. Other chemicals are captured by species in the process and come out incorporated in the products.

3.1.3.2 Products - 375 MMSCFD plant (Ton/Day)

Synthetic pipeline gas	9,516
S.P.G. loss	50
Sulfur	89
Tar	1,644
Tar oil	925
Naphtha	380
Ammonia (Anhydrous)	172
Phenols	208
Waste ash and dust	2,720
Sludges and spent chemicals	330
Water to atmosphere	33,503
Water entrained in solids	1,933
*Total gases	121,840
Nitrogen gas	29,041
Boiler stack gas	61,774
Superheater and incinerator stack gases	53,861
CO_2 purifier vent stack gas	3,908
Sulfur vent stack gas	2,297
Miscellaneous losses	725
Total Products	203,076

*Stack outputs vary from plant to plant due to gas routing through different stacks; however, total gas flows are similar.

3.1.3.2.1 Saleable product

Synthetic Pipeline Gas - This plant is rated to produce 375 million standard cubic feet per day or 9,516 tons per day. This is the principal product for which the plant is designed, hence there will usually be a ready market. The gas can be shipped and consumed as produced. There must be provision made for transporting the gas to points where it will be consumed. Gas is generally transported by pipeline. Feasible, though unlikely, would be a plan for onsite conversion of the S.P.G. to another form of energy using, for instance, an electric generating plant. This would lead to a whole new set of potential impacts.

Synthetic Pipeline Gas Loss - Throughout the process of conversion and beneficiation of gas there will be loss from leakage, and some may be inadvertently combusted. This loss will be minimized, ideally, for both economic and environmental considerations.

3.1.3.2.2 Saleable by-products

Sulfur - Approximately 89 ton/day of sulfur will be produced in the sulfur treatment unit. This will be liquid, until cooled, and generally of approximately 99 percent purity. At the present time, there is no great demand for sulfur, but it is a potentially valuable by-product. The sulfur must be stored on site until shipped to another industrial consumer. For sulfur, as well as other by-products, transportation to consumers will be necessary. If the sulfur were not marketable, it would likely be dispersed in the ash and handled in the ash disposal unit.

Tar - One thousand six hundred forty-four tons of crude coal tar will be produced each day in the process. This tar has considerable use in the petrochemical industry and should therefore be of value. The coal tar will have to be stored and shipped to industrial consumers. Possibly a petrochemical plant might be set up in conjunction with the gasification plant using the tar, tar oils, and other organics from the process to produce marketable organic products. If there was no market for the tar, it would have to be cleanly incinerated, and any solids remaining disposed of as ash.

Tar Oil - In the tar and tar oil treatment system, 925 tons/day of crude tar oil are separated. This by-product is also valuable to the petrochemical industry and should be readily marketable. It will have to be shipped to industrial consumers unless, as mentioned above, a petrochemical processing plant exists on site. In case there was no demand for the tar oil, it would be burned and the residual solid disposed with the ash.

Naphtha - Crude naphtha will be yielded in some processes, depending on the method used to treat the gas liquor. This by-product has industrial value and can be stored and shipped to those consumers. If no market exists, the naphtha would be burned and the solids disposed as ash.

Phenols - The 208 ton/day crude phenol production from gas liquor treatment can be stored and shipped to industrial consumers unless, again, one already exists on site. If the phenols will not sell, they can be burned and the residue wasted with the ash.

3.1.3.3 Waste solids

Ash and Dust - The solid residues from the process are quenched with water, thickened, and fed to a settling pond where some of the water is reclaimed. If the by-products are not marketable, they may be at least partially disposed of with the ash. The ash would be temporarily stored and then, in most cases, sent back to the mine to be used as fill. There is little apparent commercial value for the dust and ash, but it may be feasible to dispose of this product commercially, as a fill material.

Sludges and Spent Chemicals - Several types of solid wastes are grouped together in this category. Soluble salts from raw water treatment will be concentrated along with organic material from raw and recycle water treatment. These can either be disposed with the ash or sold if a market exists. Solids which build up in the cooling water are constantly removed and treated with the ash. Ion exchange resins (used to purify water), dessicants (used to absorb water or carbon dioxide), and spent catalysts can either be regenerated or disposed with the ash.

3.1.3.4 Waste water

Water Entrained in Solids - This 1,933 tons/day of water represents water which is left in the thick ash and sludge slurry prior to being used as mine fill. Some of this may be lost to the atmosphere during ash storage and shipment. Much of the water used in ash and sludge treatment is retained and returned to the process during the thickening and settling process, and only water which is not recovered is included as waste water. In the case where the ash and sludge were to be returned to the mine in a slurry pipeline, more water would be required and less would likely be recovered.

Water to Atmosphere - A great deal of water is lost by evaporation. Much of this is evaporation in holding and settling ponds, cooling ponds, cooling towers, and steam vents. Water vapor is also present in higher than normal concentrations in the various stack gases discussed below.

Liquid Effluents - These are not indicated in the material balance because most new plants are designed for zero discharge conditions established by the Environmental Protection Agency for the 1980's.

3.

3.1.3.5 Air emissions (See Figure 3.1-D.)

Waste Nitrogen - 29,041 tons/day of almost pure nitrogen are vented into the atmosphere. Some of this gas may be used in minor applications around the plant, and possibly some could be converted to saleable liquid nitrogen and disposed of as a by-product.

Boiler Stack Gas - This gas flow results from the burning of coal or some other similar fuel to produce process heat. Electrostatic precipitation or some other effective dust control is required as this gas has a high dust loading from coal ash. If sulfur dioxide or nitrogen oxide concentrations are above established standards, a gas scrubber system may be necessary.

Incinerated Tail Gas - This is the gas coming from the sulfur recovery and gas purification units. The gas has been incinerated or combusted to eliminate any remaining "reduced" species, such as H_2S, NH_3, HCN and CO. The gas will be fairly rich in "oxidized" species such as CO_2, H_2O, SO_2, and NO_x. Scrubbing units may be imposed if sulfur dioxide and nitrogen oxide concentrations are above acceptable standards.

Recovery Vent Gas - This is a low volume gas stream resulting from gas vented in the sulfur recovery process. The gas is enriched in carbon dioxide and water due to the flaring of methane contained in the gas but contains negligible amounts of sulfur and nitrogen oxides.

Figure 3.1-D

EXHAUST GAS COMPOSITION BY PERCENTAGE
(375 MMSCFD Plant)

Component	Boiler Flue Gas	Incinerated Tail Gas	Recovery Vent Gas	Lock and Exhaust Gas	Superheater Stack Gas	Residual CO_2 Stack	Waste Nitrogen	Total Gases
CH_4 Methane	--	--	0.003	--	--	0.43	--	0.009
CO_2 Carbon dioxide	14.17	58.75	16.70	32.05	12.39	85.67	--	24.20
H_2O Water vapor	11.50	7.38	5.54	15.11	9.38	13.90	0.49	8.09
SO_2 Sulfur dioxide	0.032	0.010	--	0.017	0.005	--	--	0.018
N_2 Nitrogen	71.10	32.61	66.99	51.41	74.85	0.004	99.51	65.77
O_2 Oxygen	3.15	1.24	10.77	1.39	3.36	--	--	1.92
NO_x Nitrogen oxides	0.044	0.024	--	0.019	0.019	--	--	0.027
Suspended particles	0.001	--	--	--	--	--	--	0.004
Flow (SCFM)	1,025,550	547,200	7,350	46,650	89,850	43,350	467,250	2,227,200
Temperature (°F)	350	350	90	350	350	130	80	290
% Total Flow	44.14	25.44	0.34	2.17	4.18	2.01	21.72	100
Control	Electrostatic Precipitator SO_2 scrubber	Incineration SO_2 scrubber	Flare	Incineration SO_2 scrubber	None	None	None	--

3.

3.

Lock and Exhaust Gas - This is process gas lost in the gasifier locks and other exhaust vents in the system. It is incinerated, and all methane and other combustibles are oxidized. Thus this gas stream is high in carbon dioxide and water vapor and also contains low levels of oxides of sulfur and nitrogen--again probably necessitating gas scrubbing before venting to the atmosphere.

Superheater Stack Gas - This flow comes from the steam superheater system and resembles the boiler flue gas flow except that it is a little higher in oxygen and nitrogen concentration. No control of this flow is generally required unless the sulfur or nitrogen oxide concentrations are unacceptable.

Residual Carbon Dioxide Stack Gas - This gas comes from the final gas purification step and is composed largely of carbon dioxide removed from the process gas. This gas also contains methane, which, in high concentration, may be controlled by some sort of incineration process. However, the necessity for methane control would be determined by standards for methane emissions.

3.1.3.6 Heat balance - 375 MMSCFD plant (Million Btu/Hour)

IN:	
Coal to gasifiers	22,222
Coal to boilers	4,365
Total Heat In	26,587
OUT:	
Synthetic pipeline gas	15,196
Various by-products	1,912
Carbon left in ash	230
Heat from stack and off gases	746
Cooling tower heat losses	1,442
Air cooling losses	6,729
Miscellaneous heat loss	336
Total Heat Out	26,587

$$\text{Thermal efficiency of gasification} = \frac{\text{Synthetic Pipeline Gas} + \text{Various By-Products}}{\text{Coal to Gasifiers}}$$

$$= .77 \text{ or } 77\%$$

$$\text{Overall thermal efficiency} = \frac{\text{Synthetic Pipeline Gas} + \text{Various By-Products}}{\text{Total Heat In}}$$

$$= .64 \text{ or } 64\%$$

$$\text{Heat Loss to surroundings} = \frac{\text{Heat Stack \& Off Gases} + \text{Cooling Tower} + \text{Air Cooling} + \text{Miscellaneous}}{\text{Total Heat Out}}$$

$$= .35 \text{ or } 35\%$$

The thermal efficiency of gasification--heat that can be derived from gasification products compared to heat that could be derived from the coal that was gasified--is about 77 percent for this plant. This means that 23 percent of the heating value is lost in this process. This heat loss by conversion is justified because pipeline gas is a much more marketable fuel than coal; it yields no ash and fewer air pollutants when burned and has more applications at the present time.

However, the overall thermal efficiency of the process is only 64 percent. The heat derivable from the products is only 64 percent of the total heat put into the process. This means that 36 percent of the heat is wasted. In this model plant, 35 percent of the heat is lost to the surroundings in the form of stack gases, and heated air and water from the cooling areas. The other one percent of the heat value remains in the ash. Since this model has no liquid effluents, the possible effects of heated water on the environment need not be considered. The average temperature of the gases leaving this plant is 290°F as compared to an annual mean of approximately 50°F.

3.1.3.7 Water balance 375 MMSCFD plant (Gallons/Minute)

IN:	
Raw water	4,486
Moisture in the coal	1,474
Miscellaneous water	106
Total Water In	6,066
OUT:	
Process consumption	1,753
Losses to atmosphere	3,892
Losses to solid waste	421
Total Water Out	6,066

$$\text{Water consumption (\%)} = \frac{\text{Raw Water}}{\text{Total Water In}} \times 100\%$$

$$= 74\%$$

$$\text{Water loss to environment} = \frac{\text{Losses to Atmosphere + Loss to Solid Waste}}{\text{Total Water Out}}$$

$$= 71.\ \text{or}\ 71\%$$

Approximately 74 percent of the water required in this process model is supplied from outside water sources, the remaining 26 percent supplied by moisture in the coal. Only 29 percent of the water used in the plant goes to the actual gasification process, the remaining 71 percent is lost to the environment. Again, there are no liquid effluents in this model, so the water is lost in the form of high density slurries and gaseous emissions. The ash and sludge are mixed with water as a high density slurry and disposed in the mine site, accounting for 10 percent of the water loss. The remaining 90 percent of the water loss is evaporation from cooling towers and various settling and holding ponds.

3.1.3.8 Sulfur balance - 375 MMSCFD plant (Tons/Day)

IN:	
Sulfur in coal to gasifiers	101.0
Sulfur in coal to boilers	19.9
Total Sulfur In	120.9
OUT:	
Elemental sulfur by-product	86.0
Gasifier ash	7.8
Boiler ash	1.0
Tar	1.7
Tar oil	0.5
Naphtha	1.0
Boiler stack	18.9
Superheater and incinerator stacks	4.0
Total Sulfur Out	120.9

$$\text{Sulfur loss to environment} = \frac{\text{Sulfur in Ashes + Sulfur in Stacks}}{\text{Total Sulfur Out}}$$

$$= .26 \text{ or } 26\%$$

This balance indicates what happens to the sulfur contained in the feed coal. Approximately 74 percent of the sulfur goes to by-products that are marketable. However, 26 percent of the sulfur is lost to the environment--chiefly in two forms. Over 7 percent of the sulfur remains trapped in the ash and is buried. Nearly 19 percent of the sulfur is emitted as gaseous sulfur dioxide, a foul smelling, noxious gas. Standards are set for sulfur dioxide emissions, and if the vent emission is too high, the gas streams are chemically scrubbed or cleaned of a part of the sulfur dioxide.

3.1.4 Physical plant

The coal gasification plant will resemble, as much as anything, a large oil refinery when finished. A perspective view of a typical plant is shown on the following page. The plant site should encompass some 1,000 acres, and the plant area would be something like two miles long and one mile wide. An idea of the plant layout--location and the major components in the process--can be gained from the figure on the second page following.

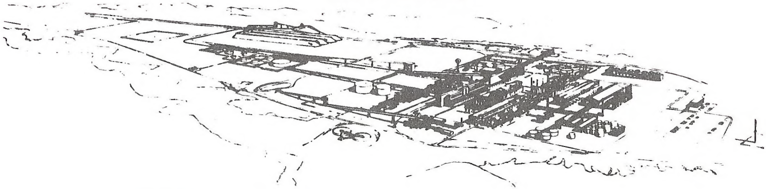
Three typical phases exist in the lifetime of any plant: plant construction, routine plant operation, and phase out-shutdown.

3.1.4.1 Plant construction

Principle plant construction considerations are plant access (for transport system), site preparation and setup, and construction labor force. The construction phase will take very roughly five years with a peak of activity of 3,000 to 3,500 employees occurring about halfway through. Most of the estimated 1,000 acres required for the plant site will likely be disturbed during this period.

<u>Figure 3.1-E</u>

PERSPECTIVE VIEW OF A COAL GASIFICATION PLANT
(288 MMSCFD plant)

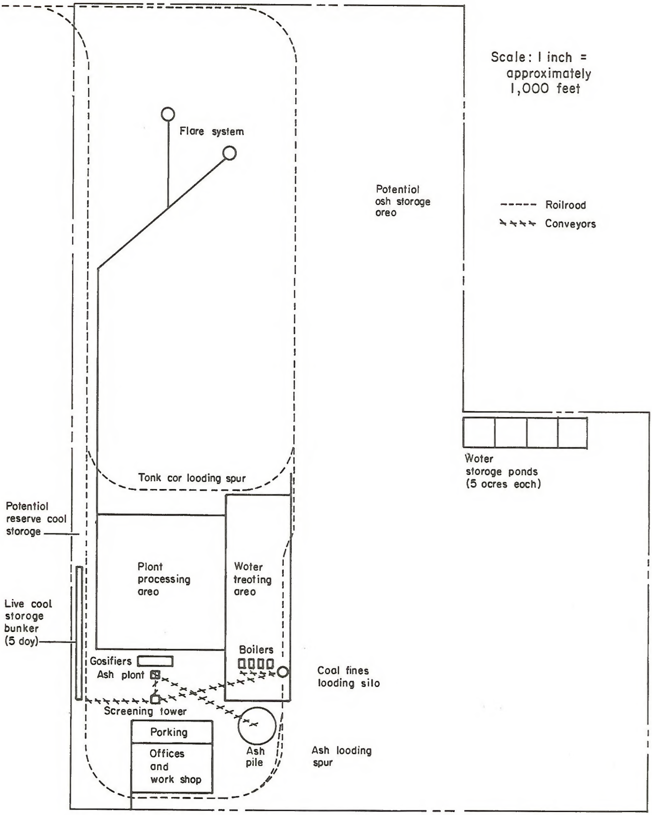


Scale - 1 inch = approximately 1,000 feet

From: El Paso Coal Gasification Project - Draft Environmental Statement

Figure 3.1-F

LAYOUT - COAL GASIFICATION PLANT



From: Wyoming Coal Gas Co. Project Proposal

Figure 3.1-G - Material Handling - Gasification Pilot Plant
Consolidation Coal Co., Rapid City, South Dakota

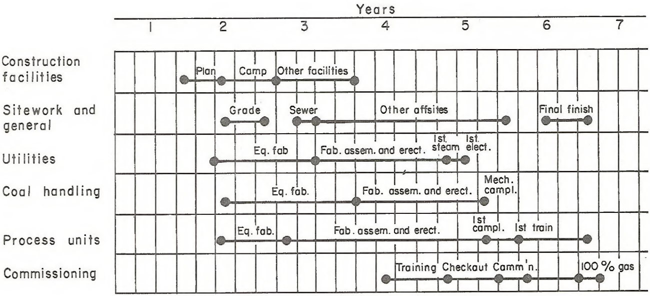
3.

Access to the plant is critical during all three phases of plant life. During construction, the site must be accessible to both equipment (caterpillars, scrapers, draglines) and labor, and provision must be made for transport of large process components (gasifiers, boilers, compressors, etc.) which cannot be assembled on site. Transport systems must be supplied for raw materials--coal, water, chemicals--as well as products, by-products, and waste products. If coal is to be shipped by rail, access must be provided, most probably, for three or four round trip, 100 car unit trains per day. Coal hauled by large, 100-ton, off-road trucks would require a road system capable of handling approximately 400 round trip truck hauls per day. Another alternative would be moving coal in a slurry pipeline. This would require approximately a 3-foot pipeline. The pipeline carrying raw water would be nearly as big as the slurry pipeline. Another 3-foot pipeline would have to be built to carry the synthetic pipeline gas to its market. Additional trains and/or trucks would need access to the plant to bring chemicals and haul away by-products and wastes. Waste ash could be hauled back to the mine in the empty unit trains or in a pipeline paralleling the slurry pipeline. The right-of-way for the access systems would have to be cleared, leveled, and finally the system itself would be built. Also, before the plant becomes operational, access must be provided for employee roads, electric transmission lines, and telephone lines. The construction activities will resemble most nearly the construction of a two lane highway. Bulldozers, scrapers, trucks, and draglines, in addition to some specialized railroad or pipeline laying equipment would generally be used. Crews should be fairly small and mobile.

During site preparation and setup, most of the 1,000-acre site would be leveled, storage and holding ponds dug, and finally buildings, storage structures, and processing equipment would be moved in and assembled. Many bulldozers, scrapers, trucks, draglines, cranes, and other vehicles would work at leveling the site.

The labor force may include 3,500 workers. During various periods during the construction schedule, the force would include, in addition to a large number of manual workers, many equipment operators, welders, masons, iron workers, and pipe fitters.

Typical Plant Construction Schedule



eg. fab. – equipment fabrication
fab. – fabrication
assem. – assembly
erect . – erection
mech. compl . – mechanical completion
compl . – completion
train . – training
comm'n – commissioning

From: Applicants' environmental assessment for a proposed coal gasification project, Wyoming Coal Gas Co. and Rochelle Coal Co.

Figure 3.1 - H

3.1.4.2 Routine plant operation

As construction of the site draws to a close, the operating crews would be trained and the plant systems would be tested and brought into production. When the plant is operating at a steady level, the labor force would stabilize. The operational phase time frame is somewhat dependent on economics and availability of raw materials, but a thirty-year life is a reasonable approximation. For the 375-MMSCFD plant, the operating crew would be approximately 1,000 workers. With the plant operational, a constant level of heavy duty commercial (rail and road) and light duty private traffic would persist.

3.1.4.3 Phase out and shutdown

Process plants are designed to run at full rated capacity or, occasionally, a bit higher and are often uneconomical to operate at reduced capacity. Thus, a plant will generally be run at as near full capacity as possible until the critical resource is depleted. When this happens, it is more economically sound to suddenly shutdown rather than gradually phase out operations. In the case of a gasification plant, product price and demand in addition to govermental policies can determine whether plant operation is economically feasible. However, this rather sudden closeout would be unlikely. More likely would be a gradual, planned phase out to lessen impacts on the community.

Unless some sort of plant deconstruction plan is implemented, the plant may be abandoned. However, some of the equipment and structures may have salvage or second-hand value. The plant site can then be cleared of any remaining structures and the site may be returned to a natural topography. This would mean a short-term, several months, period of heavy vehicular traffic somewhat similar to the construction phase. Access systems may also be removed if no longer needed for transport systems.

3.1.5 Typical Gasification Project Summary

1.	Process used Synthetic gas output Heating value of pipeline gas	Lurgi 375 million cu.ft./day (MMSCFD) 1000 Btu/cu.ft.
2.	Coal consumption	13,500,000 tons/year
3.	Coal reserves required (assumed 30-year life)	405,000,000 tons
4.	Water requirements (reservoirs, process, utilities)	12,500 ac.ft./year
5.	Land needs (plant and appurtenant facilities; does not include mine area)	1,000 acres
6.	Size of power plant (if required)	75 megawatts
7.	Employment (full employment)	1,000
8.	Construction employment (five years)	a) peak - 2,500-3,500 or more b) average - 1,500-2,000
9.	Total plant investment (order of magnitude, 1975 dollars)	$500 million
10.	By-products:	
	a) salable	sulfur - 32,000 ton/year tar oil - 335,000 ton/year tar - 600,000 ton/year ammonia - 62,000 ton/year phenols - 75,000 ton/year
	b) waste	ash - 1,000,000 ton/year sludges, garbage - 120,000 ton/year
	c) emissions	particulate matter ± 1,800 ton/year sulfur oxide ± 8,000 ton/year nitrogen oxides ± 12,000 ton/year
11.	Utilization factor	85 percent
12.	Thermal efficiency	
	a) gasification	77 percent
	b) overall process	64 percent

3.1.6 References

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11. Western Gasification Project (WESCO) Coal Gasification Project and Expansion of Navajo Mine by Utah International Inc. - Draft Environmental Statement.

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4.1 Introduction - reservoir and agricultural water use

This section describes the existing environment for the three areas specifically affected by the proposed agricultural water use and a broader geographic area for certain components.

The three specific areas are:

1) The reservoir area including the relocated paved county road.

2) The agricultural water transportation route which is basically the route of the Middle Fork of the Powder River and the Sussex Irrigation Ditch.

3) The agricultural water use area between Kaycee and Sussex.

Broader geographic treatment is given to water resources, cultural resources, and recreation.

4.2 Components

4.2.1 Climate

The following information is taken from data summarized by Kohout (1957), Banner and Associates (1970), and U.S. Bureau of Reclamation (1967). Data for the 27-year period 1941-1967 are summarized in Figure 4.2.1-A.

The weather reporting station nearest the proposed reservoir site and irrigable lands is at Kaycee, Wyoming. This is approximately twelve (12) air miles east of the reservoir site and about 18 miles west of the irrigable lands. Records have been maintained since 1941.

The climate of the area is locally influenced by the Big Horn Mountains to the west, and to a larger extent by the Rocky Mountains and coastal ranges. It can be characterized as semi-arid with low humidity and high evaporation. Winters are long with occasional severe blizzards. Summer days are warm with cool nights. Strong winds are common throughout most of the year.

Precipitation. Heaviest average precipitation generally falls in April, May, June, September, and October. Summer moisture is often in the form of widely scattered and often severe rain or hailstorms. Runoff can be locally heavy during such storms. Average accumulated precipitation during these months is about eight (8) inches, while the remainder of the year averages about 3.8 inches. Total growing season precipitation averages about 9.3 inches.

Snowfall is usually light and seldom begins before October. Total annual precipitation for a 27-year period (1941-1967) averaged 11.50 inches, ranging from 17.73 inches in 1941 to 6.80 inches in 1954.

Temperature. Average daily minimum temperatures range from 5.7 degrees in January to 50.8 in July. Average daily maximum temperatures range from 37.4 in January to 87.8 in July. Extremes ranged from -45 degrees in January of 1949 to 105 degrees in July of 1954.

The average date of the last killing frost at the Kaycee station is May 16, and that of the first killing frost is September 22. The average growing season is 122 days.

4.2.2 Air quality

General information following was taken from the Regional Analysis, EIS, Eastern Powder River Coal Basin, Volume I.

The site is within the Intrastate Air Quality Region of Wyoming, a rather heterogeneous climatic area. Climate and air quality are greatly

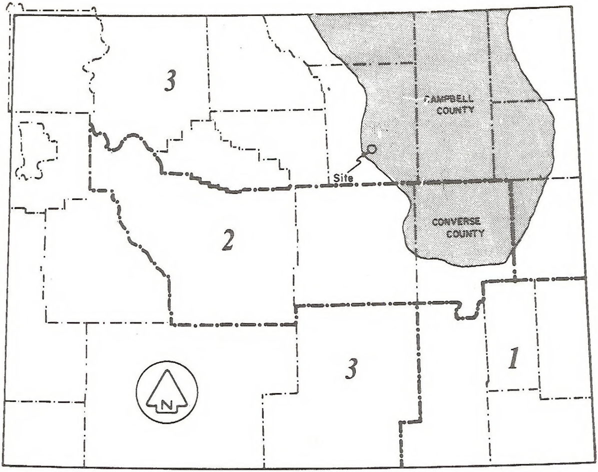
CLIMATOLO[illegible] SUMMARY
Means and Extremes [illegible] Period 1941-1967
Kaycee Weather Station

Month	TEMPERATURE (°F) Means: Daily Maximum	Means: Daily Minimum	Means: Monthly	Extremes: Record Highest	Year	Extremes: Record Lowest	Year	Mean Degree Days **	PRECIPITATION TOTALS (Inches): Mean	Greatest Daily	Year	Snow, Sleet: Mean	Maximum Monthly	Year	Greatest Daily	Year	MEAN NO. DAYS: Precip. .10 or more	Temperatures Max.: 90° and above	Max.: 32° and below	Min.: 32° and below	Min.: 0° and below	Month
Jan.	37.4	5.7	21.6	66	1953	-45	1949	1327	0.40	0.58	1967	7.0	24.2	1949	8.1	1965	1	0	10	31	10	Jan.
Feb.	41.0	11.0	26.0	71	1958	-34	1949	1109	0.32	0.40	1960	6.0	20.9	1960	8.7	1967	1	0	7	28	6	Feb.
Mar.	45.3	16.7	31.0	76	1953+	-30	1943	1042	0.61	0.56	1961	6.4	14.5	1954	5.1	1952	2	0	5	30	3	Mar.
Apr.	57.8	27.9	42.9	83	1962+	- 3	1945	681	1.56	1.52	1941	6.4	32.4	1955	22.0	1955	4	0	*	21	*	Apr.
May	67.3	37.5	52.4	92	1948	12	1950	403	1.97	1.60	1952	2.8	17.6	1950	11.7	1946	6	*	*	7	0	May
June	76.5	44.5	60.5	104	1954	25	1951	198	2.20	3.62	1964	0.1	1.4	1951	1.4	1951	6	3	0	1	0	June
July	87.8	50.8	69.3	105	1954	33	1962	37	1.01	0.92	1941	0.0	0.0		0.0		3	14	0	0	0	July
Aug.	86.6	48.4	67.5	103	1949	28	1964+	43	0.66	1.72	1941	0.0	0.0		0.0		2	13	0	*	0	Aug.
Sept.	75.3	39.1	57.2	97	1950	13	1965	261	1.09	1.19	1962	0.6	7.3	1965	4.2	1965	3	3	*	6	0	Sept.
Oct.	64.7	29.3	47.0	87	1957	- 3	1949	570	0.82	1.58	1962	2.9	8.2	1961	8.0	1967	2	0	*	22	*	Oct.
Nov.	48.1	17.2	32.7	77	1949	-37	1955	960	0.51	0.39	1942	6.0	17.2	1955	7.8	1957	2	0	4	29	3	Nov.
Dec.	40.8	10.0	25.4	66	1965+	-42	1964	1194	0.35	0.45	1953	6.3	14.5	1964	6.0	1944	1	0	7	30	7	Dec.
Year	60.7	28.2	44.5	105	July 1954	-45	Jan. 1949	7825	11.50	3.62	June 1964	44.5	32.4	Apr. 1955	22.0	Apr. 1955	33	33	33	205	29	Year

T Trace, an amount too small to measure
** Base 65° F; values computed from mean temps.
+ Also on earlier dates, months or years
* Less than one half

Source: Engineering Feasibility Report on the Hole-in-the-Wall Dam and Reservoir, J. T. Banner and Associates, Laramie, Wyoming, 1970

Figure 4.2.1-A



1 CHEYENNE INTRASTATE AIR QUALITY CONTROL REGION

2 CASPER INTRASTATE AIR QUALITY CONTROL REGION

3 WYOMING INTRASTATE AIR QUALITY CONTROL REGION

POWDER RIVER BASIN

Source: Chuck Ward, Wyoming's Air Quality Program, August 1972, Figures 1 & 2.

Figure 4.2.1-B

Wyoming Air Quality Control Regions

influenced by the Big Horn Mountains to the west and by local topography. Prevailing winds, though seasonally variable, are generally westerly down the canyon. Velocities are often high, resulting in a flushing effect.

There are no nearby sources of emission. occasional sources of air degradation may arise from several nearby bentonite operations and oil fields. Any degradation of air quality resulting from these operations would be primarily in the form of dust from the bentonite operation and an occasional sump fire at the oil fields.

Overall, air quality in the vicinity of the reservoir site exceeds Wyoming ambient air quality standards. No significant air pollution sources are listed in Johnson County (Quinn, 1974).

4.2.3 <u>Topography</u>

The Middle Fork of the Powder River drainage basin can be divided, west to east, into four topographic belts: 1) the Big Horn Mountains, 2) the mountain foothills and valleys, 3) the cuestas and plains, and 4) the rolling plains.

The Big Horn Mountains, extending from northcentral Wyoming into southcentral Montana, are a part of the Rocky Mountain system. Altitudes along the west of the mountains generally range from 8,000 to 9,000 feet, although higher summits rise 3,000 to 4,000 feet above the general level. The crest of the mountains, which has a relatively uniform altitude (8,000 to 9,000 feet) except where higher peaks rise above the general level, was called the "central plateau" by Darton (1906, p. 1). Surrounding the central plateau are scarps formed by the upturned edges of strata that dip into the adjacent structural basins. In places the scarps display cliff faces several hundred feet high. The area west of Barnum includes a small part of the eastern flank of the Big Horns, which is formed by the dip slope of the Tensleep sandstone and rocks of Permian age. Numerous streams have eroded canyons, which are as much as 400 feet deep, in the dip slopes.

The division between the main range and the foothills is marked by a long, northwest trending red shale valley west of "The Red Wall." "The Red Wall" is a resistant sandstone cliff of the upper Chugwater Formation. West of this shale valley the elevation of the land surface increases rapidly.

The reservoir and road relocation lies in the narrow band of foothills adjacent to the mountain front. The foothills are characterized by the gently sloping pediment surface that has been carved into rounded ridges and flat-topped benches and terraces by basinward-flowing streams. This topography coincides, in general, with the anticlines and synclines of the underlying geologic structure. The maximum relief of the foothill belt is about 800 feet.

The topography in the vicinity of the reservoir is largely dependent on the underlying geologic formations. Shales such as the Thermopolis erode easily and tend to form lowlands. Topography developed on shale formations is usually quite dissected and rugged. Sandstones such as the upper Chugwater and Cloverly are much more resistant to erosion and stand out in high relief forming cliffs and bluffs.

About 1 mile west of the town of Kaycee, the foothill belt is abruptly replaced by the much less rugged terrain of the plains section. Numerous cuestas, or hogbacks, are present in this area. Cuestas are formed by the differential erosion of gently inclined sandstone and shale strata; erosion of the former produces ridges, and erosion of the latter produces valleys. Most conspicuous among the cuestas is one formed, in part, by the Ft. Union Formation. It is covered with pine trees and is often referred to as the "great pine ridge."

In the vicinity of the town of Sussex, the cuestas and plains give place to the rolling plains. The valley of the Powder River broadens considerably, and the river terraces widen and become more extensive. As the gradient decreases, the river gradually becomes sluggish and sediment laden.

Through this topographic region, Powder River undergoes changes from a typical rushing mountain stream to a sluggish, meandering, sediment-laden stream in the eastern plains section. In the mountainous regions the river valley is narrow - in no place more than a quarter of a mile wide; but as the river flows through the flat plains section, its valley widens to as much as 3 miles, bordered by broad terraces.

4.2.4 Geology

4.2.4.1 Stratigraphy and geologic history

Paleozoic

From the beginning of the Paleozoic Era until Late Cretaceous time, the Powder River Basin was part of the vast foreland or stable shelf which lay along the eastern side of the main Cordilleran geosyncline.

Transgression and regression of marine seas resulted in widespread unconformities and changes in patterns of sedimentation. Sediment deposition took place mainly in shallow seas during the transgressive cycle. Withdrawal of the seas or regression resulted in widespread erosion. Early Paleozoic deposits are primarily fine grained clastics and carbonate rocks. During the upper Paleozoic, non-marine rocks were more prevalent.

Mesozoic

Triassic system

Chugwater Formation

The Chugwater formation is exposed in the western part of the area in a strip about two to three miles wide along the foot of the Big Horn Mountains. It is exposed also on the Red Fork anticline. The upper and middle parts of this formation form respectively, "The Red Wall," and the valley west of "The Red Wall." The Chugwater Formation in this area is about 1,000 feet thick.

The lowermost member consists of a soft sequence of interbedded moderate reddish-brown siltstone, shale, and silty fine-grained sandstone. The unit weathers to soft reddish slopes. The topmost unit of the Chugwater formation is a salmon-pink fine-grained massive sandstone ranging in thickness from 45 to more than 100 feet. This unit is called "The Red Wall."

Jurassic system

Gypsum Spring Formation

The Gypsum Spring Formation unconformably overlies the Chugwater Formation and is unconformably overlain by the Sundance Formation. Due to post-Gypsum Spring and pre-Sundance upwarping and erosion in the southern part of the Powder River Basin, this formation is absent.

Sundance Formation

The Sundance Formation outcrops a short distance east of the Red Wall in a belt one fourth to three fourths of a mile wide. It is exposed also on the flanks of the Red Fork anticline. The Sundance Formation has an average thickness of about 260 feet. The upper part of the Sundance Formation is light gray to greenish gray glauconitic shale containing a hard limestone layer at the top. The lower part of the formation is slabby sandstone interbedded with shale, and contains yellow sandstone at the base. The Sundance Formation was deposited in a marine environment, and is characterized by a high content of glauconitite and by an abundance of fossil remains of Belemenites throughout the formation. At the close of Sundance deposition the Jurassic sea rapidly retreated from the basin area, and the continental sediments of the Morrison were deposited.

Morrison Formation

The Morrison Formation, which overlies the Sundance Formation, outcrops about one mile west of the junction of the Middle Fork of Powder River and Beaver Creek. Although the stratigraphic thickness of the Morrison Formation is about 200 feet, the stress of folding in the Red Fork anticline has been great enough to squeeze the sediments to almost one half their original thickness.

The Morrison Formation is of continental origin and contains many dinosaur bones, gastroliths, and other reptilian remains. It is composed of poorly cemented lenticular beds of fine-to-medium-grained sandstone and shale and is characterized by streaks grading from light and medium gray to purple, red, brown, and white. The formation is dominantly sandstone in the lower part and claystone in the upper part.

Cretaceous

During Early Cretaceous the Arctic sea again invaded the area. Rock strata deposited by the invasion of the Cretaceous sea can be divided on the basis of five regressive cycles. During the regressive cycles, coarse clastic sediments were deposited, separating the primarily shale sediments of the major Cretaceous transgressions.

The repeated transgressions and regressions of the sea during Late Cretaceous time apparently are related to the beginning of the Laramide orogeny. Growth of Laramide mountains and basins, as well as minor tectonic features, influenced depositional patterns.

Cloverly Formation

The Cloverly Formation, which rests on the Morrison Formation, is about 30 feet thick in the Kaycee area. Because of its resistance to erosion, it is well exposed along the flanks of all the anticlines and domes in the area.

The Cloverly Formation consists of massive, ledge-forming white to light-cream medium-grained friable sandstone that weathers to light brown or pink. It is composed chiefly of clear quartz sand cut contains some feldspar and some thin lenses of small pebble conglomerate.

The Cloverly Formation was deposited in a fluviatile and lacustrine environment.

Thermopolis shale

The Thermopolis shale generally is divided into three parts: the lower part consists of soft, thin-bedded shales that weather dark brownish-gray. The middle part is the Muddy sandstone member which lies about 40 feet below the top of the formation. It is a well-indurated drab buff to brown medium-grained sandstone 5-30 feet thick. The third, or upper part of the Thermopolis shale consists of dark gray shale and lenticular beds of bentonite.

Quaternary (recent deposits)

The surficial overburden deposits in the vicinity of the damsite are of three principal types: the ancient flood plain deposits which remain as terraces of silt, sand, and gravel in the valley above the existing flood plain; the slope-wash material derived from recent weathering and erosion of outcrops; and the material in the bottom of the valley in the present flood plain.

The terrace deposits occur as nearly flat, unconsolidated, and generally stratified deposits of silt, sand, and gravel, covered with a variable thickness of topsoil. Deposit thickness varies from 6 to 235 feet. The coarser materials are generally concentrated on or near the eroded surface of bedrock. The gravel contains well rounded pebbles and cobbles of quartsite and igneous rocks.

The slope-wash materials occur as an accumulation of soil and rock debris on or at the base of sidehill slopes. They consist of a heterogenous mass of clay, silty sand and rock fragments, with little or no grading of materials. These colluvial deposits range in thickness from about 60 feet to a featheredge.

Alluvial deposits in the area are of recent age and are present only beneath the flood plains of the principal stream valleys. The width of the alluvium ranges from a few feet in the mountainous region to as much as a mile in the eastern part of the area.

The alluvial deposits consist chiefly of gravel and other materials derived from erosion of the drainage area of the streams. Across the flood plains, these sediments average about 12 feet in depth with a maximum reported depth of 41.5 feet.

Summary

The reservoir and proposed road relocation are underlain by a sequence of Paleozoic, sandstones, shales, and limestones. Mesozoic units exposed in the vicinity consist of the Chugwater, Sundance, Morrison, Cloverly, and Thermopolis Formations. Recent deposits in the area are valley fill materials, terrace materials, and slope deposits.

4.2.4.2 Geologic structure

The Kaycee area lies at the western edge of the Powder River Basin which is bordered by the Black Hills on the east, the Casper Mountains and the Hartville uplift on the south and southeast, and the Big Horn Mountains on the west. Wegemann (1917) states,

> "The Big Horn Mountains are flanked on the southeast by several anticlines, inches of strata that rise like a series of waves, each higher than the last, toward the major arch that forms the mountains themselves."

Five asymmetrical anticlines with adjacent synclines have been mapped in the area. These features have been designated Freeman, Red

Fork, and Kirtley anticlines and Middle Fork and Kaycee domes. In general, the axes of the anticlines parallel the northwest-trending axis of the Big Horn Mountains.

The damsite lies in the west of an anticlinal upwarp (Middle Fork dome). The rock strata are essentially horizontal in the foundation area. Gentle dips on the flanks of the geologic structure are apparent a short distance both upstream and downstream from the proposed dam.

In the immediate vicinity of the dam no surface evidence of faulting was observed. The nearest fault on the geologic map is two miles to the south at the southern end of Middle Fork dome in Section 9, T. 42 N., R. 83 W. It is concluded that faults crossing the axis of the dam site, if any exist, are minor in character.

4.2.5 Mineral resources

The proportion of Federal mineral ownership is significantly high in the area. Land involving Federal surface and Federal minerals runs approximately 50 percent, and, of the remainder, approximately 50 percent involves private surface and Federal minerals. However, the land to be occupied by the reservoir or relocated road or to be disturbed in construction only involves the 141 acres of Federal surface and Federal minerals and approximately 40 acres of private surface with Federal minerals.

There are six mining claims of record in the general reservoir area. Two are uranium claims and four are for bentonite. However, none are located on any of the land to be occupied by the reservoir or the relocated road or to be disturbed during construction.

EXPLANATION

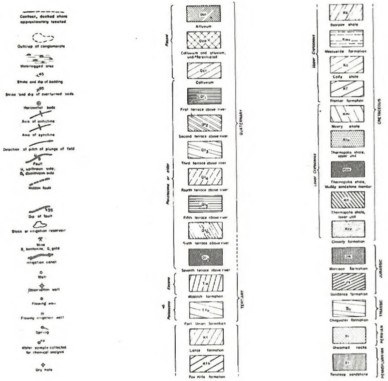


Figure 4.2.4-A

BED ROCK GEOLOGY
in the vicinity of
THE MIDDLE FORK RESERVOIR SITE

Source: Taken from U.S.G.S. water-supply paper 1360-E by F. A. Kohout, 1957.

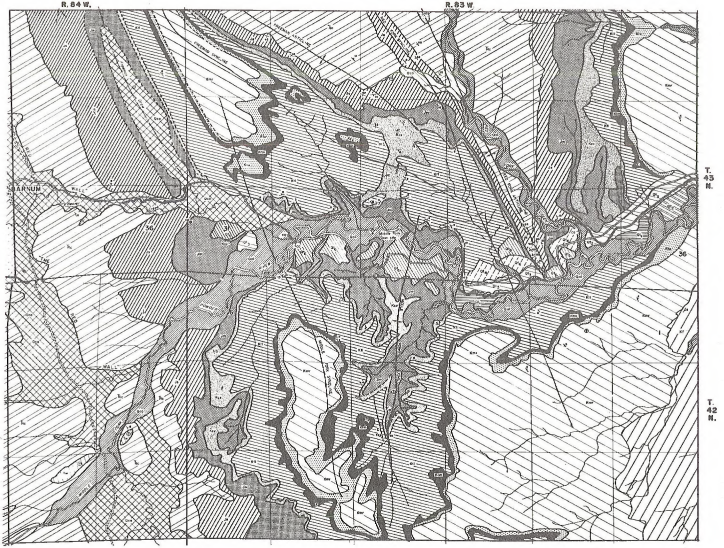

R. 84 W.
R. 83 W.
T. 43 N.
T. 42 N.
BARNUM
FREEMAN ANTICLINE
FREEMAN SYNCLINE
MIDDLE FORK SYNCLINE
RED WALL
THE
POWDER
RIVER
MIDDLE
36
31
36

Figure 4.2.4-A

4.2.5.1 Bentonite

The source material of bentonite is primarily volcanic ash. This ash was transported by winds and deposited in marine seas. Alteration of ash to bentonite is a complex chemical reaction dependent on an aqueous environment.

Bentonite occurs in the Thermopolis, Mowry, and Frontier Formations. Only the Thermopolis shale outcrops in the vicinity of the reservoir and road sites.

A field traverse along the proposed road relocation revealed three bentonite horizons in the Thermopolis shale. Each horizon contained multiple beds; thickness of each bed varied from 1/2" to 8". Samples were collected and tested at the BLM bentonite laboratory at Worland, Wyoming. Laboratory results indicated that the bentonite was marginal for commercial purposes. Thin beds and poor quality indicate this bentonite may never be mined.

It is concluded no commercial deposits of bentonite exist on the reservoir site or along the proposed road relocation.

4.2.5.2 Oil and gas

A report by the U.S. Geological Survey indicates the area in the vicinity of the reservoir site may be valuable for oil and gas. There are no oil and gas leases covering the reservoir site and along the proposed road relocation. The nearest oil production is about 18 miles northeast (North Fork field) and 14 miles southeast (Tisdale field).

Oil and gas exploration potential does not appear to be favorable. USGS records were examined to determine past drilling activity. Two dry holes were drilled in Section 4, T. 42 N., R. 83 W. Negative production was obtained from tests of the Madison limestone and the Tensleep sandstone. There have been no wildcat wells drilled in T. 43 N., R. 83 W. Ward (1966) states that regional structures appear unfavorable for oil and/or gas accumulation at the site.

Lack of oil and gas lease activity, past exploration history, and distance from producing fields indicate minor oil and gas potential.

4.2.5.3 Sand and gravel

Potential sources of sand and gravel may be stream terraces and alluvial deposits found in the vicinity of the reservoir site. Extensive testing is required to determine if sand and gravel deposits are suitable for concrete aggregate. Many of these deposits in the vicinity of the reservoir may not be suitable for use as concrete aggregate (Kepler, 11-7-74). Ward (1966) states that the quality of gravel is poor; oversized material is predominant.

Extensive material is available in the vicinity of the reservoir for use as embankment material. This "borrow" material consists of clean clay to sand with excessive clay overlaying a variable amount of gravel, sand, silt, and clay.

4.2.6 Soils

Soils along Middle Fork have developed in alluvial material from redbed shales, sandstone, siltstone and bentonite outcrops. The arid climate has limited soil development and effective root depth. Many soils are calcareous throughout and influenced by parent materials of alkaline sediments as evidenced by high reactions.

The criteria used to describe the soils and make predictions about their potential was taken from a finished, yet unpublished, report by the Soil Conservation Service, USDA, covering the south half of Johnson County. Both the Soil taxonomy and capability groupings are part of a National Classification System that shows how the proposed reservoir and supplemental water areas compare, not only statewide but on a national basis. See Figures 4.2.6-A, B and C showing land areas by Roman numerals that fit the capability groupings.

Class I soils have few limitations that restrict their use. (None in Johnson County, southern part.)

Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. (None in Johnson County, southern part.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to pasture, range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or aesthetic purposes.

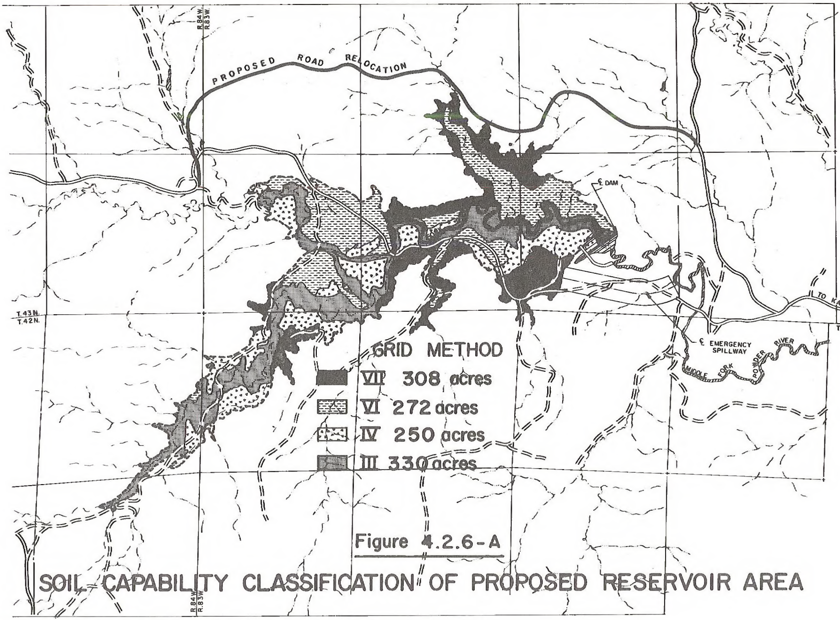


Figure 4.2.6-A

SOIL CAPABILITY CLASSIFICATION OF PROPOSED RESERVOIR AREA

Source: S.C.S. Unpublished Soil Survey Report of Johnson County.

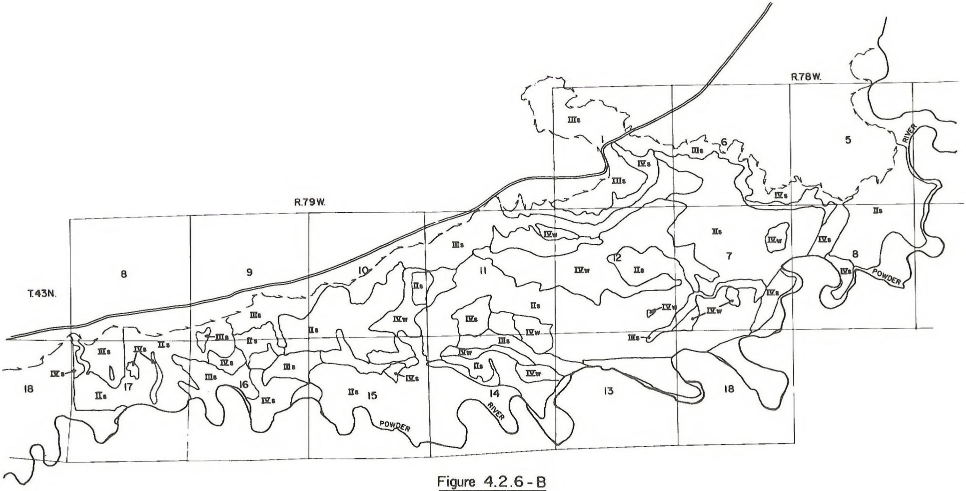


Figure 4.2.6-B

SOIL CAPABILITY CLASSIFICATION OF IRRIGATED LAND AREA

Source: S.C.S. Unpublished Soil Survey Report of Johnson County

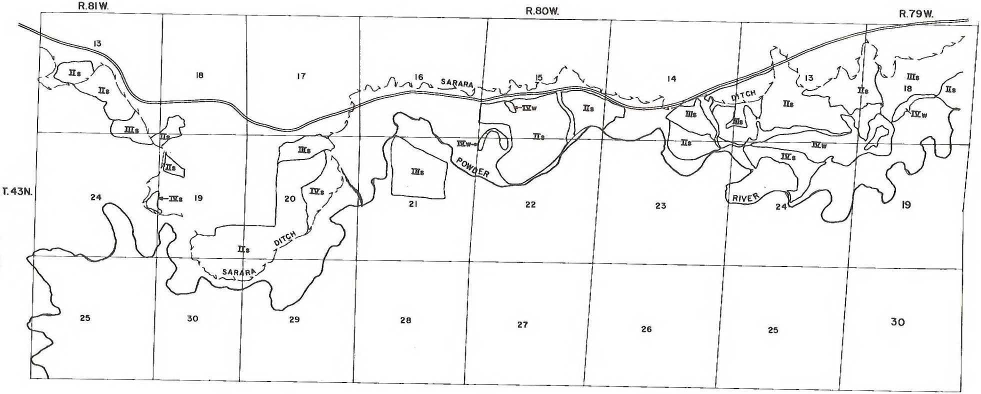


Figure 4.2.6-C

SOIL CAPABILITY CLASSIFICATION OF IRRIGATED LAND AREA

Source: S.C.S. Unpublished Soil Survey Report of Johnson County

Capability grouping. Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects.

4.2.6.1 Proposed reservoir site

Within this site, below the high water line, there are approximately 1,160 acres of land which are categorized according to the capability classification: Class IIIw, 330 acres; Class IV, 250 acres; Class VI, 272 acres, and Class VII, 308 acres. (See Figure 4.2.6-A for their location.)

IIIw. Soils have severe limitations for cultivation because of poor drainage. They occupy nearly level to gently undulating alluvial bottoms dissected by the meandering Middle Fork stream channel. Some areas include cutbanks of side drainages and small alluvial fans at the mouth of tributary drainages. The over-all areas occupy first bottom position and are subject to flooding during high water. The stream channels are included in the landscapes. Some small areas have a beneficial water table.

Soils. The principal soils are of the Barnum and Redbanks series. These soils are reddish colored alluvial soils, silty and moderately sandy, respectively, and formed on alluvial bottoms. The soils formed in reddish brown calcareous sediments of low aggregate stability derived principally from redbed shales and sandstones. These soils are usually calcareous throughout but less than 1 to about 5 percent calcium carbonate equivalent. They are moderately alkaline (pH 8.0 to 8.4) with stratified lower horizons.

Vegetation. Cottonwood trees, brush, western wheatgrass, cactus, sage and phragmites.

IV. Soils have very severe limitations which restrict choice of plants for cultivation and require very careful management, or both because of slope. They occur on nearly level to strongly sloping valley fill landscapes.

Soils. The principal soils are the Harlan, Conner, and Barnum series. They are well drained, dark colored, moderately fine textured soils. Typical profile is upper subsoil 5 to 8 inches are composed of dark reddish-brown, prismatic and blocky clay loam. From 8 to 20 inches the subsoil is a clay loam and below 20 inches the substrata is a calcareous loam to clay loam.

Vegetation. Big sagebrush, western wheatgrass, blue grama, needle and thread, and cacti.

VI. Soils have severe limitations which make them generally unsuitable for cultivation and which limit their use largely to pasture or range, recreation, or wildlife food and cover. It is practical to apply improvement practices and management. Because of one or more limitations, however, the soils are not generally suited to cultivated crops.

Soils. The principal soils are Arndt, Arvada, and Pike series. They are developing from mixed sediments, locally transported from nearby shales and sandstones of the Frontier Formation. Included in the parent materials are alkaline sediments from sodic shales as evidenced by high reactions typical of the Arvada and Pike series. Other series include Key, mantled complex which have extremely hard columnar B horizons with reaction of pH to 9.2.

Vegetation. Key-cactus, big sagebrush, blue grama greasewood, Pike-Barren slickspots.

VII. Areas of barren rock outcrops of the Morrison Formation, consisting of sandstone and varicolored claystone. Areas of steeply sloping hillsides and canyon walls. Soils are developed from sandstone and from alkaline shales. They have very severe limitations that make them unsuited to cultivation.

4.2.6.2 Agricultural water use area

See Figures 4.2.6-B and C, showing the location of the following classified land: Class II, 3,039 acres; Class III, 982 acres; Class IV, 207 acres; and Class IVw, 888 acres.

II. Soils have a surface layer of loam or silt loam and a subsoil or underlying material of loam to clay loam. Slopes are 0 to 3 percent. Runoff is slow, and the hazard of erosion is slight. Permeability is moderate. The effective rooting depth is 60 inches or more.

These soils are used for hay, pasture, and small grain.

Practices that are applicable in conserving the soils of this unit are using a suitable cropping system, land leveling, and managing irrigation water.

Soils. The principal soils are of the Haverson, Kim, Stoneham, and Barnum series. See attached soil series descriptions for additional information.

III. Soils are the same as the above Class II except they are on a slope of 3 to 6 percent. Soils require uniform distribution of irrigation water to control erosion.

IV. Soils have a surface layer of loam and a subsoil or underlying layer of loam to clay loam. Slopes are 6 to 10 percent. Consists of well drained soils. Runoff is medium to rapid, and the hazard of erosion is moderate to high. Permeability is moderate, and the available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for hay, pasture, and small grain.

Practices that are applicable in conserving the soils are using a suitable cropping system, land smoothing, and managing irrigation water. Uniform distribution of irrigation water through a properly designed system is essential for control of erosion. Small grain should be grown where the soil is being prepared for reestablishment of hay or pasture.

Soils. The principal soils are of the Kim and Stoneham series. See soil series descriptions of additional information.

IVw. Soil consists only of Haverson silt loam, wet subsoil phase. This is a poorly drained, saline soil. Slopes are 0 to 3 percent. Runoff is slow, and the hazard of erosion is slight. Permeability is moderate, and the available water capacity is moderate. This soil has a fluctuating water table that is near the surface during most of the growing season. It has moderate salinity.

This soil is used for irrigated pasture. Practices that are applicable in conserving the soil are managing pasture, land smoothing, managing irrigation water, and draining and reducing salt. Unless this soil is drained and the content of salts reduced, only salt-tolerant crops can be grown. Light, frequent applications of irrigation water help in establishing the stand.

Descriptions of soil series in the previous capability classification are in the Appendix.

4.2.7 Water resources

Much of the data used in compiling the following discussion of water resources were obtained from reports from the U.S. Geological Survey, Wyoming State Engineer's Office, U.S. Bureau of Reclamation, and J. T. Banner and Associates.

4.2.7.1 Surface water resources

4.2.7.1.1 Water supplies and streamflow characteristics

4.2.7.1.1.1 Regional

The Powder River Basin in Wyoming, as shown in Figure 4.2.7-A includes practically all of Johnson County, and parts of Campbell, Natrona, Sheridan, and Washakie Counties (Wyoming State Engineer's Office, 1974). This drainage area is approximately 9,200 square miles in size. The mainstem Powder River is formed by North, Middle, and South Forks of Powder River near Kaycee, Wyoming. These streams, except for the South Fork which has its headwaters in the Rattle Snake Range, originate in the Big Horn Mountains and join the mainstem Powder River as it flows parallel to the Big Horn Mountains northward toward Montana.

Some major streams such as Powder River drain both mountain and plains areas. The resulting streamflows are therefore a combination of perennial and ephemeral types.

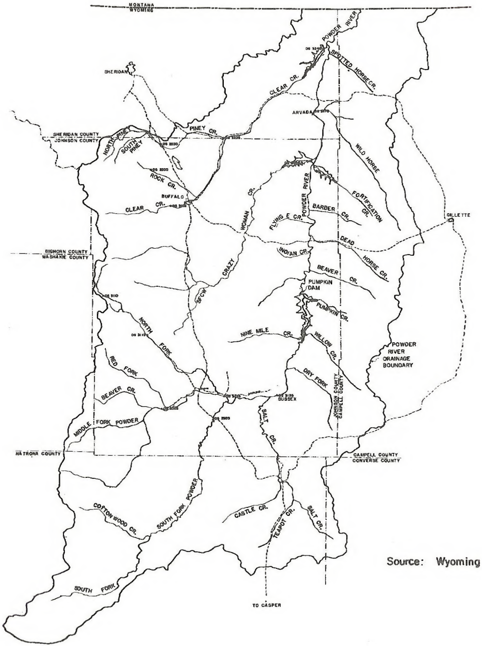
Streamflow in tributaries rising in the Big Horn Mountains is mainly perennial, with sustained base flow occurring from ground water inflow. The major portion, approximately 70 percent, is derived from snowmelt runoff during the months of April, May, June, and July (Wyoming State Engineer's Office, 1973). Spring and summer rainstorms, at times quite intense, contribute large but erratic and unpredictable amounts of water. In Wyoming, streamflows in the mainstem Powder River are influenced greatest by tributary snowmelt runoff. With present use of water for irrigation along the upper reaches of Powder River and tributaries, late summer flows diminish to almost negligible amounts in dry years.

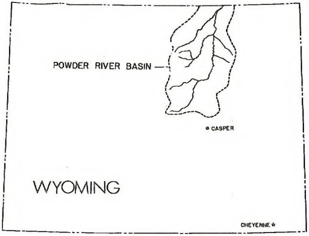
4.2.7.1.1.2 Reservoir area

Water for the area is available principally from flows of the Middle Fork Powder River. A small amount of water for irrigation is available from flows of the Red Fork and the North Fork tributaries of Powder River entering downstream from the damsite. The period for analyzing the water supply available to the proposed reservoir extends from September 1948 to September 1969 (from a gaging station immediately below the damsite, near Red Fork tributary). It was necessary to extend several of the station records to cover this period, see Figure 4.2.7-B (Banner, 1970).

Average annual streamflows of Powder River and tributaries are listed below:

STREAM	ANNUAL FLOW - ACRE-FEET
Middle Fork Powder River at damsite (1948-69)	50,414
Red Fork Powder River at mouth (1951-63)	23,100
North Fork Powder River at mouth (1940-69)	23,623
Powder River near Kaycee (1940-69)	93,639
South Fork Powder River near Kaycee (1951-1969)	25,900





LEGEND

- STREAMS
- DRAINAGE BOUNDARIES
- ROADS
- COUNTY LINES

Figure 4.2.7-A

POWDER RIVER BASIN

Source: Wyoming State Engineer's Office, 1974.

4.2.7.1.2 Present uses of surface water

Irrigation is by far the largest consumptive water use in Wyoming, amounting to over 82 percent of the 2,601,300 acre-feet of streamflow depletions given in Figure 4.2.7-C. The table indicates man's consumptive uses (depletions) in each river basin in the State.

4.2.7.1.2.1 Regional

Water supplies in the Powder River Basin depend upon the local availability of water and its quality. The following tabulation presents the average annual streamflow and water uses of Powder River in Wyoming (Wyoming State Engineer's Office, 1974).

		ACRE-FEET PER YEAR
State live streamflow under natural conditions		419,100
Man's depletions of streamflow in Wyoming:		
Irrigation	66,100	
Municipal, domestic, and stock	2,100	
Industrial	700	
Reservoir evaporation	27,600	-96,500
Depleted streamflow leaving Wyoming		322,600

About 93% of the streamflow and 94% of the water uses occur from the mainstem Powder River and its tributaries with the remainder occurring in Little Powder River. Most of the irrigation occurs along the base of the Big Horn Mountains where numerous ranch operations rely on hay production for a winter feed base. The limited and variable precipitation of the area requires irrigation for dependable crop production. The average acres irrigated on Powder River are approximately 16,200. As can be seen from the above tabulation, industrial companies are presently using relatively minor quantities of surface water as most of their needs are being met by ground water supplies. Another major use of the area's surface waters is for recreational purposes, e.g. hunting and fishing.

STATION LOCATION SW$\frac{1}{4}$ Sec 34, T43N, R83W
DRAINAGE AREA 450 sq. mi.
QUANTITIES IN Acre-feet

NAME OF STATION: Middle Fork Powder River above Kaycee

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL	
1948-49	a 3020	a 2800	a 2570	a 2370	a 2890	a 3540	5360	11740	6530	2380	1950	2440	47,590	
1949-50	2990	2750	2130	2110	2370	3010	5380	15880	6430	2430	1910	2290	49,680	
1950-51	2920	2660	2580	2200	2210	2510	4000	11240	3930	2150	1630	2030	40,060	
51-52	2700	2530	2570	2710	2760	2710	6450	10530	3620	1720	1510	2010	41,820	
52-53	2120	2090	2270	2560	2020	2770	3000	8570	6180	1810	1260	1320	35,970	
53-54	1900	2550	2580	2560	2430	3040	4650	9420	2820	1250	1300	1140	35,640	
1954-55	1950	2050	2170	2030	1980	2740	4000	19660	12280	3430	1820	1960	56,070	
1955-56	2740	3010	2940	2600	2590	3340	4750	7610	2610	1770	1570	1360	36,890	
56-57	1770	2350	2490	2040	2760	2440	3110	11970	9410	4320	2180	1870	46,710	
57-58	2690	2840	2830	2520	1970	2610	3380	16110	4510	4050	1800	1590	46,900	
58-59	2310	2550	2720	2560	2360	2700	3630	18410	9210	3090	1860	1760	53,160	
1959-60	2620	2670	2670	2330	1980	3030	5590	5970	2510	1530	1430	1600	33,930	
1960-61	2100	2360	2310	2510	2230	2500	2560	11530	4290	1850	1590	1880	37,710	
61-62	2920	2900	2740	2430	4220	2720	10490	13710	9620	4510	2510	2400	61,170	
62-63	2740	2690	2690	2210	3050	2820	4490	16220	8880	3370	1940	2480	53,580	
63-64	2290	2350	2140	2290	2220	2490	3420	19720	25030	6100	2400	2310	72,760	
1964-65	2970	3070	2780	2540	2340	2880	3870	16840	13520	4120	2810	2960	60,700	
1965-66	3090	2790	2700	2010	3190	3040	3670	12160	3620	1750	1420	2120	41,560	
66-67	2650	2630	2190	2460	2480	2730	3790	19170	23620	7680	3230	3570	76,190	
67-68	3160	3080	2960	2570	2720	3020	3710	19840	22580	5520	3530	3490	76,180	
68-69	3340	2990	3240	3270	2780	2960	9800	12590	5290	3980	2070	2130	54,420	
1969-70														

a - Obtained by correlation of monthly flows of Middle Fork of Powder River above Kaycee with monthly flows of Powder River near Kaycee.

Figure 4.2.7-B

Wyoming Average Annual Streamflows and Water Uses
Streamflow Base Period 1948-1968
(Figures in Acre-Feet)

River Basin & Subdrainage (1)	Streamflow Into Wyoming From Other States (2)	Water Yield Within Wyoming (3)	State Line Outflow-Natural Conditions (4)=(2)+(3)	Man's Depletions of Streamflow in Wyoming					Depleted Streamflow Leaving Wyoming (10)=(4)-(9)
				Irrigation (5)	Municipal, Domestic, & Stock (6)	Industrial (7)	Reservoir Evaporation (8)	Total (9)	
Missouri River Basin									
Yellowstone River	298,700	2,407,300	2,706,000	---	---	---	---	---	2,706,000
Clarks Fork	146,800	564,600	711,400	21,100	200	---	500	21,800	689,600
Bighorn River	---	3,676,100	3,676,100	1,007,400	5,700	2,200	104,500	1,119,800	2,556,300
Tongue River	---	386,300	386,300	77,100	2,400	1,000	3,100	83,600	302,700
Powder River	---	419,100	419,100	66,100	2,100	700	27,600	96,500	322,600
Little Missouri River	---	35,400	35,400	1,800	100	---	2,100	4,000	31,400
Belle Fourche River	---	96,700	96,700	1,500	1,000	1,000	16,800	20,300	76,400
Cheyenne River	---	85,700	85,700	4,500	600	1,700	14,100	20,900	64,800
Niobrara River	---	7,300	7,300	3,000	---	---	1,100	4,100	3,200
North Platte River	529,900	1,215,800	1,745,700	573,600	7,300	9,000	176,500	766,400	979,300
So. Platte River Basin	---	19,200	19,200	3,500	3,000	800	3,000	10,300	8,900
SUBTOTALS	975,400	8,913,500	9,888,900	1,759,600	22,400	16,400	349,300	2,147,700	7,741,200
Colorado River Basin									
Green River Basin	391,400	1,926,600	2,318,000	241,600	12,000	16,200	26,300	296,100	2,021,900
Great Basin									
Bear River	139,600	273,400	413,000	60,600	800	---	7,000	68,400	344,600
Columbia River Basin									
Snake River Basin	---	4,721,600	4,721,600	83,700	700	---	4,700	89,100	4,632,500
TOTALS	1,506,400	15,835,100	17,341,500	2,145,500	35,900	32,600	387,300	2,601,300	14,740,200

Source: Wyoming State Engineer's Office, 1973.

Figure 4.2.7-C

There are four reservoirs currently in existence on Powder River and its tributaries. Of the four, only one, Lake DeSmet, has a large storage capacity. The number of potential reservoirs on Powder River and its tributaries is relatively large. Of these, several have relatively large storage capacities. The currently existing and potential reservoirs, with their capacities, uses, and sources of water, have been presented in Figure 4.2.7-D.

Several small reservoirs for which applications have been received by the Wyoming State Engineer's Office were excluded from the table because the storage was transferred to Lake DeSmet.

Wyoming's share of the average unused and unappropriated annual Powder River flow is estimated to be approximately 121,000 acre-feet (Wyoming State Engineer's Office, 1972). Comparison with the reservoir capacities in Figure 4.2.7-D indicates that a few of the potential reservoirs would use the unappropriated flow of Powder River. Since most of the storage capacity of the Middle Fork Reservoir has a filing date prior to 1950, it is not included in the 121,000 acre-feet of unappropriated flow.

4.2.7.1.2.2 Reservoir area

Most current water use in the reservoir area is for irrigation. Lesser amounts are used for livestock, domestic, and municipal purposes. Kaycee, with a population of less than 500, is the only town in the area that obtains its domestic water supply from Powder River. Its water uses are probably no more than 100 acre-feet a year, a negligible amount compared to the irrigation requirements.

Figure 4.2.7-D

A. Existing Reservoirs, Powder River and Tributaries*

Reservoir	Capacity, Acre-Feet	Source	Use**
Dull Knife	4,345	North Fork Powder River	I
Lake DeSmet	239,243	Piney Creek	I, D, S
Lower Salt	2,708	Salt Creek	D, Oil
Wallows Creek	1,194	Buffalo Wallows Creek	I, S

B. Potential Reservoirs, Powder River and Tributaries*
(Indicated by Wyoming State Engineer Records)

Reservoirs	Priority	Capacity	Source	Use
Little Sour Dough	10/18/33	1,642	Little Sour Dough Cr.	I
Camp Comfort	8/16/39	11,640	Clear Cr.	I, S, D
Reynolds Shell Cr.	3/ 8/55	1,369	Shell Cr.	Ind
Healy	4/15/57	5,140	Clear Cr.	I, Ind, P, D
(41,974 minus 36,834 transferred to Lake DeSmet)				
4th Enlargement Lake DeSmet	1/26/70	23,513	Piney, Rock, and Clear Creeks	I, Ind, Pwr, R
(Brings Lake DeSmet capacity up to 239,243 acre-feet)				
Reynolds Piney Cr.	1/26/70	12,660	Piney Cr.	I, Ind, Pwr, R
Lower Clear Cr. Reservoir Co. Boxelder Reservoir	2/21/68	20,000	Piney Cr.	I, Ind, R
B.C.L. Co.	3/16/71	19,126	Clear Cr.	I, Ind, P
Enlargement Negro Cr.	9/19/56	13,911	Clear and Negro Creeks	I, S, Pwr, Ind
Crazy Woman	7/ 5/67	64,300	Crazy Woman Cr.	I, D, Ind
North Fork Powder River	10/12/71	2,759	North Fork Crazy Woman Cr.	I, S, F
Middle Fork Powder River	3/ 7/40	41,075	Middle Fork Powder River	I, S, D, Pwr, M
Pumpkin	2/ 3/62	206,985	Powder River	M, Ind, Mfg, R, I, Pwr, S, F, Mech
Bass Industrial Enlargement	5/ 1/68	123,380	Powder River	Ind, I, R
Pumpkin Enlargement	7/24/70	71,938	Powder River	Same as Pumpkin
Middle Fork Powder River	12/29/70	8,474	Middle Fork Powder River	I, Ind

Figure 4.2.7-D (continued)

C. Potential Reservoirs, Powder River and Tributaries*
(Indicated From Investigations)

Reservoir	Capacity	Source
Hazelton Watershed Site "A"	2,700	SCS
Hazelton Watershed Site "B"	9,000	SCS
Moorhead	1,150,000	USBR
Clear Creek	602,000	WWPP
Arvada	1,309,000	WWPP
Crazy Woman		
Beaver Creek	35,000	WWPP

* Table compiled from: Wyoming State Engineer's Office, Wyoming Water Planning Program Report No. 10, April, 1972.

** I, Irrigation; D, Domestic; S, Livestock; Ind, Industry; Pwr, Power generation; Oil, Oil recovery; M, Municipal; R, Recreation; P, Steam power; Mfg, Manufacturing; Mech, Mechnical.

Adjudicated water rights exist for 15,363 acres along the Middle Fork, lower North Fork, and along the main Powder River in the reservoir area. The irrigation water requirements for each month of the irrigation season have been summarized and placed in Figure 4.2.7-E. The individual water rights have priority dates extending from 1884 to 1959. During years of low runoff and late in the summer of many years, the water requirements for later priorities may not be fulfilled. The following diversion requirements were assumed in the figure (Banner, 1970):

May	- 0.5 acre-foot/acre
June	- 0.8 acre-foot/acre
July	- 1.0 acre-foot/acre
August	- 1.0 acre-foot/acre
September	- 0.5 acre-foot/acre

Figure 4.2.7-E

Irrigation Water Requirements in the Vicinity of the Proposed
Middle Fork Powder River Reservoir

Irrigation Area	Irrigation Requirement (Acre-Feet)					
	Acreage	May	June	July	Aug.	Sept.
Sahara Ditch	4,618	2,311	3,694	4,618	4,618	2,311
Middle Fork Powder River	2,922	1,462	2,338	2,922	2,922	1,462
Powder River above Sussex	1,113	557	890	1,113	1,113	557
Powder River below Sussex	404	203	323	404	404	203
North Fork Powder River	6,306	3,154	5,046	6,306	6,306	3,154
TOTALS	15,363	7,687	12,291	15,363	15,363	7,687

All of the irrigation areas in Figure 4.2.7-E, except the North Fork, withdraw water from the Middle or mainstem Powder River. The North Fork area is located below the stream gage at Mayoworth and thus represents water withdrawal below the gage and above the confluence with the Middle Fork.

In addition to the Sahara Ditch, the irrigation withdrawals are made through several private ditches from the North Fork, Middle Fork, and mainstem Powder River.

In spite of irrigation return flows, the water that is consumptively used is large enough in volume to be detectable in the streamflow records of Powder River near Kaycee and of Powder River at Arvada (where months of no flow have been recorded). The monthly records of these stations have been presented in Figures 4.2.7-F through 4.2.7-J.

In order to compare the effects of irrigation upon Powder River flows, the historical minimum and maximum flows for the irrigation season (May through September) for the Middle Fork Powder River above Kaycee were extracted from Figure 4.2.7-B. The total flows for the same months for the Powder River near Kaycee and the Powder River at Arvada were extracted from Figures 4.2.7-G and 4.2.7-J. These data are presented below.

Minimum and Maximum Monthly Irrigation Season Flows for Middle Fork Powder River above Kaycee, Powder River Near Kaycee, and Powder River at Arvada

Middle Fork Powder River	- Minimum:	September, 1954	- 1,140 AF
	Maximum:	June, 1964	- 25,030 AF
Powder River near Kaycee	- Minimum:	September, 1954	- 10 AF
	Maximum:	June, 1964	- 43,140 AF
Powder River at Arvada	- Minimum:	September, 1954	- 0 AF
	Maximum:	June, 1964	- 103,600 AF

In spite of tributary flows from the Red Fork, North Fork, South Fork, and Salt Creek as well as irrigation return, the flows downstream were considerably diminished during September, 1954. The probable effects of irrigation upon the flow is not obvious for the month of maximum observed flows. However, inspection of the monthly flow records reveals flow patterns similar to that observed for September, 1954 Figures 4.2.7-F through 4.2.7-J).

The current aquatic biology is described in section 4.2.9, while the vegetation along the agricultural water transportation route (Middle Fork streambed) and water use area (Sahara Ditch) is covered in section 9.2.8.

4.2.7.1.3 Water quality

4.2.7.1.3.1 Chemical quality

Chemical quality in a stream continually changes. Water in shallow aquifers generally has higher dissolved solids concentration than the runoff from precipitation. Lower dissolved solids concentrations occur during periods of higher streamflow when the larger portion is surface runoff. At lower streamflows when the larger portion of the water is from ground water discharge, higher dissolved solids concentrations generally occur and often exceed that of the aquifer source, due to the evaporative concentration in the stream channels. Salts are deposited by the evaporation of water in the stream channels and by the evaporation of ground water discharge that never reaches the stream.

Concentrations of individual constituents in the water very widely, but sodium, calcium, magnesium, sulfate and bicarbonate are the major

North Fork Powder River near Mayoworth

NAME OF STATION

STATION LOCATION Sec. 6,T 45 N, R 83 W - 2 mi. down stream from Pass Creek.

DRAINAGE AREA 106 sq. mi.

QUANTITIES IN Acre feet

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL
1940-41	a 1410	a 1260	1200	a 1170	a 1060	a 1230	2390	8890	2930	1820	1880	1730	a 26,970
41-42	1590	a 1220	a 1230	a 1170	a 1000	a 1210	4540	4780	2820	1420	1060	1020	a 23,070
42-43	1270	1120	1110	1110	1040	1120	4280	7840	10050	2710	1270	1190	34,110
43-44	1190	1210	1150	1110	1050	1150	1220	8860	7930	2590	1300	1090	29,830
1944-45	1440	1260	1150	1160	1060	1210	1260	6140	7320	3300	1750	1670	28,720
1945-46	1570	1410	1310	1270	1060	1250	5290	5790	4080	1910	1220	1360	27,520
46-47	1440	1210	1170	1190	992	1090	1800	14150	5410	2760	1320	992	33,520
47-48	1330	1260	1250	1180	1060	1090	1500	6070	3460	1900	1170	1020	22,280
48-49	1270	1200	1160	1100	976	1110	1910	5310	5510	1830	1100	1040	23,520
1949-50	1270	1180	1150	1100	928	1140	1530	6090	4640	2250	910	1130	23,320
1950-51	1180	1070	1190	1110	918	1110	1200	4440	2550	1680	1020	1190	18,660
51-52	1260	1160	1060	1060	1070	1060	3950	6100	3140	1590	1170	817	23,440
52-53	887	704	1040	1110	992	1120	1150	3420	5880	1670	1310	901	20,180
53-54	743	934	1180	1040	918	1170	1490	3380	1710	1340	1010	861	15,780
1954-55	952	560	878	865	803	1030	1260	5550	5150	1800	1210	1090	21,150
1955-56	966	1030	1160	1100	958	1050	1360	5560	2790	1200	1070	952	19,200
56-57	643	872	1040	889	839	978	1040	4950	5840	2010	1210	1220	21,530
57-58	1220	1180	1140	1080	940	970	1400	6200	2090	1480	1050	851	19,600
58-59	916	910	988	914	785	867	938	3930	4200	1900	906	797	18,050
1959-60	1020	966	887	829	716	938	2430	2080	1450	885	688	708	13,600
1960-61	754	766	729	829	799	803	881	3250	1730	897	722	807	12,970
61-62	1030	922	908	861	799	928	4540	8350	6400	2380	1270	1110	29,500
62-63	1120	1010	934	902	815	910	1150	6930	6200	1610	1150	1090	23,820
63-64	1040	1080	952	932	863	930	998	7690	7590	2360	1080	1000	26,520
1964-65	1230	1160	1110	1150	950	1050	1100	4430	8590	2960	1660	1300	26,690
1965-66	1310	1180	1150	1060	899	1210	1420	4080	1490	1080	1000	926	16,800
66-67	926	1050	1030	1040	877	952	912	2430	14670	3990	2290	1650	31,820
67-68	1140	1110	1090	1070	948	1070	1080	4430	13710	2920	2710	2080	33,360
68-69	1620	1370	1270	1300	1070	1140	1690	2840	1620	2550	1950	1110	19,530

a - Partly estimated by USGS

Figure 4.2.7-F

450'
from H G

STATION LOCATION Sec 13, T43N, R81W - Sahara Canal
DRAINAGE AREA 980 sq. mi.
QUANTITIES IN Acre-feet

Powder River near Kaycee
NAME OF STATION

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL	
1933-34		7030					10100	1140	3830	1580				
1934-35		a 5060						a17530						
1937-38								27900	9830	2570	25	1220		
38-39	3170	4400	4600	4580	3480	6690	9530	14130	9110	463	7	6	60,120	
1939-40	2600	4030	4250	3100	4290	4870	8970	14420	2360					
1940-41	6980	5550	4740	4300	4360	6310	15280	56140	7310	7600	18160	7150	143,900	
41-42	7780	7520	6120	5060	5530	8360	26720	28640	5960	52	1480	2940	106,200	
42-43	5650	5470	4600	4560	5340	8050	23670	24290	25560	2680	537	2820	113,200	
43-44	5320	5840	5840	5330	5150	6930	10480	61530	37420	10390	909	2550	157,700	
1944-45	5760	6370	5780	6070	5960	8220	9210	28300	23300	8870	2590	5140	115,600	
1945-46	7280	7290	5880	6070	5600	7660	27560	27040	14380	5320	824	4150	119,100	
46-47	6600	6780	6040	4320	6410	11380	11830	61560	22950	8210	1270	3340	150,700	
47-48	6530	6690	6510	6290	9590	10460	9420	26400	10560	3110	1340	1410	98,310	
48-49	6100	6140	5780	4990	7100	11590	10570	23020	13950	954	89	1320	91,600	
1949-50	5940	6320	5780	6250	6190	7200	13070	32010	11390	722	149	2060	97,080	
1950-51	6380	6060	5710	4050	6000	6790	6370	16010	2280	497	46	4610	64,800	
51-52	5800	6120	4860	4710	5190	6360	13060	18860	3930	132	127	84	69,230	
52-53	2120	4200	4800	5730	4620	5840	5410	10210	11110	285	13	17	54,340	
53-54	1020	4330	5130	4760	5880	5880	9520	12530	358	27	29	10	49,470	
1954-55	1060	3880	5630	4060	3030	7300	7690	30440	19270	1610	990	1210	86,170	
1955-56	1100	4780	6560	7710	4880	8710	10080	12090	1150	220	110	24	57,410	
56-57	337	5390	5410	4550	5590	6690	5170	16310	16790	3850	123	1610	71,820	
57-58	4110	6080	6660	6100	6080	5800	6210	22720	4360	3800	689	141	72,750	
58-59	2010	4770	4930	5140	4640	7730	6300	26120	12010	2520	420	396	76,990	
1959-60	3060	5490	4610	3770	5050	7670	8300	3240	272	104	195	97	41,860	
1960-61	705	4520	5460	5690	4780	5360	2160	11250	2410	48	52	638	43,070	
61-62	4590	6190	3260	3620	10680	6930	22110	28410	26800	9670	1120	1550	124,900	
62-63	4870	5490	5710	4100	4180	6000	9180	24930	17010	1840	668	1700	85,680	
63-64	1660	5430	4070	3670	3330	5010	7160	32380	43140	7850	404	478	114,600	
1964-65	2120	5720	6290	6230	6720	6880	7660	30260	25340	2790	1390	2680	104,100	

Figure 4.2.7-G

STATION LOCATION
DRAINAGE AREA 980 sq. mi.
QUANTITIES IN Acre-feet

Powder River near Kaycee
NAME OF STATION

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL	
1965-66	4880	5620	5580	4360	5710	6800	6180	13780	584	22	6	129	53,650	
66-67	2130	4690	4750	6060	5410	6750	5310	30640	52030	16070	461	4090	138,400	
67-68	4960	6670	6060	5950	6800	7130	7420	32870	45180	6120	3470	5460	138,100	
68-69	5430	5530	5660	5550	5490	6460	18310	16120	3950	2000	132	176	74,800	

Figure 4.2.7G (cont.)

800' upstream

Red Fork near Barnum

NAME OF STATION

STATION LOCATION Sec 35,T43N,R83W - from mouth

DRAINAGE AREA 142 sq. mi.

QUANTITIES IN Acre-feet

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL	
1929-30	1510	2430	a 2150	a 1540	a 1670	2240	5530	5960	2470	1540	2120	1160	a 30,300	
30-31	2750	2500	1840	1540	1650	1870	4170	3810	2610	295	799	577		
31-32	1300	1510	1050	922	1440	1590	3750	13300	3110					
1948-49								b 6000	b 2900	b 1050	b 750	b 1000		
1949-50						1930	4460	7840	3040	956	643	1050		
1950-51	1800	1670	1560	1410	1450	1640	1960	5390	1580	906	694	1380		
51-52	1570	1520	940	862	1510	1630	4270	5660	1650	641	384	916		
52-53	1270	1190	1580	1550	1380	1580	1830	4240	2540	609	884	714		
53-54								b 4600	b 1200	b 300	b 350	b 250		
1954-55								b 9000	b 5600	b 1700	b 700	b 750		
1955-56								b 3600	b 1100	b 650	b 500	b 400		
56-57								b 6000	b 4300	b 2000	b 900	b 750		
57-58								b 8300	b 2000	b 2000	b 650	b 550		
58-59								b 9000	b 4200	b 1500	b 700	b 650		
1959-60								b 2800	b 1000	b 500	b 400	b 550		
1960-61								b 5800	b 1850	b 700	b 550	b 750		
61-62								b 7000	b 4500	b 2000	b 950	b 1050		
62-63								b 8400	b 4100	b 1500	b 750	b 1100		
63-64								b 9000	b 6000	b 2000	b 1050	b 1000		
1964-65								b 8800	b 6000	b 2000	b 1300	b 1400		
1965-66								b 6200	b 1500	b 650	b 450	b 850		
66-67								b 9000	b 6000	b 2000	b 1550	b 1800		
67-68								b 9000	b 6000	b 2000	b 1750	b 1750		
68-69								b 6400	b 2400	b 2000	b 850	b 900		

a - Partly estimated by USGS

b - Estimated by correlation with flows of Middle Fork of Powder River above Kaycee.

Figure 4.2.7-H

South Fork Powder River near Kaycee
NAME OF STATION

STATION LOCATION SE$\frac{1}{4}$ Sec 9, T42N, R81W 7 mi. upstream from confluence with Mid. F
DRAINAGE AREA 1150 sq. mi.
QUANTITIES IN Acre-feet

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL
1937-38								1360	4190	14380	639	1270	
38-39	1240	1240	1010	1120	466	13060	1970	3690	6670	795	262	635	32,160
1939-40	2060	996	1260	1030	2970	2160	10250	836	1190				
1949-50								12230	789	878	302	827	
1950-51	1310	1790	1600	851	1880	3160	1710	1110	687	1060	572	3640	19,370
51-52	1210	1020	738	735	1190	2750	1560	16840	1270	1790	805	389	30,300
52-53	556	911	1090	1390	1650	4750	1910	1230	2850	3330	661	476	20,800
53-54	676	924	914	764	1620	4010	4260	1170	530	5450	445	338	21,100
1954-55	1220	994	926	595	823	11020	7190	1050	4720	3250	339	926	33,050
1955-56	1100	890	1930	1330	1450	5340	2690	3990	821	759	796	366	21,460
56-57	814	955	1530	583	1790	1840	4150	4970	4890	1420	535	839	24,320
57-58	1510	982	955	820	983	2040	3220	1370	1590	4850	1030	1250	20,600
58-59	550	641	690	781	795	6420	1470	1320	2450	964	958	1430	18,470
1959-60	643	984	1340	635	900	3480	1060	821	607	246	295	234	11,250
1960-61	428	888	853	966	1180	2220	1140	1420	1030	3370	100	1670	15,220
61-62	2920	776	351	383	9070	2290	1600	40530	12590	5420	1080	1600	78,560
62-63	10100	799	682	585	954	1320	2850	2210	2880	337	649	8750	32,120
63-64	467	511	522	397	337	2210	9020	3900	6010	368	151	105	24,000
1964-65	159	347	351	541	1530	3830	2610	6820	2710	1630	245	478	21,250
1965-66	678	522	420	399	323	3600	2980	1130	2870	977	43	3580	17,520
66-67	827	440	454	510	859	4760	877	2880	31160	3340	439	1840	48,390
67-68	616	617	268	368	2120	2090	2070	4480	10720	1530	1080	754	26,710
68-69	253	327	278	337	367	1310	2860	747	690	432	0	0	7,600

Figure 4.2.7-I

Station Location	$NE\frac{1}{4}NW\frac{1}{4}$ Sec 21, T54N, R77W
Drainage Area	6050 sq. mi.
Quantities In	Acre-feet

Powder River at Arvada
NAME OF STATION

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Total	
1930-31	16200	6490	5880	6150	7780	15300	13400	41500	28600	9650	12200	2670	166,000	
31-32	3910	5860	3690	3380	24900	38400	24700	93500	70200	9780	0	0	278,000	
32-33	2610	8270	4000	922	555	25300	38400	126000	57500	2760	29900	18500	315,000	
33-34	7290	10600	--	--	--	--	23360	7140	17870	16140	2100	4020	--	
1934-35	3970	4960	2460	1840	11220	15650	13410	29230	6690	8240	7480	835	166,000	
1935-36	381	678	6320	3350	11590	54150	7930	3150	39540	18990	395	0	146,500	
36-37	4250	8010	4550	1600	2780	32330	30670	23140	66410	104700	3140	11210	292,800	
37-38	11310	4300	4300	5840	6940	21720	19100	53770	25990	31420	1270	4480	190,400	
38-39	1970	4970	8460	7880	4470	30750	12200	24110	23860	1520	14	341	120,500	
1939-40	4880	4560	7030	3850	9170	19350	21240	16300	23770	7300	70	1620	119,100	
1940-41	25490	4060	5760	5360	7100	12080	65870	81330	26520	50520	52920	13550	350,600	
41-42	16910	13360	11500	4980	7180	17350	31580	47310	18450	4950	8480	567	182,600	
42-43	6410	7550	5650	6710	9390	39740	42690	40130	58010	11380	274	350	228,300	
43-44	3170	5210	4260	2590	3800	9850	34280	99090	93960	24360	3620	185	284,400	
1944-45	6480	7150	6940	6030	8890	32620	39590	38390	65310	25190	11050	6650	254,300	
1945-46	9500	10540	6130	9100	12470	19560	24580	29310	36270	22350	280	9440	189,500	
46-47	8910	9530	7600	5480	10240	58380	19910	86380	46080	20760	448	1110	274,800	
47-48	5290	8560	6630	5040	12770	53010	14870	32600	77920	24540	4540	3090	248,900	
48-49	8020	7560	5220	3620	4290	54140	19510	33800	39660	7780	8	366	184,000	
1949-50	5570	5320	1410	1800	3510	13610	22480	53880	19450	3900	494	280	131,700	
1950-51	6260	6510	2390	3880	4850	14770	10070	19160	6020	1730	4110	18020	97,770	
51-52	7190	6190	4590	2160	5760	15210	22460	73860	15540	11110	2280	158	166,500	
52-53	1570	3950	2950	4890	6590	18550	10710	10150	37420	4260	13630	12	114,700	
53-54	194	2920	3460	3430	11940	14350	16370	16300	1820	4580	8350	0	83,710	
1954-55	536	3570	2090	2170	3570	43990	30750	30550	43460	9230	11830	570	182,300	
1955-56	1470	2420	12490	5780	7200	37340	15180	21690	15470	6040	3990	66	129,100	
56-57	8	2190	4430	3460	2310	13790	13890	29820	65080	14640	2460	3150	155,200	
57-58	5990	7900	6800	5180	4930	12580	16140	29950	22250	28270	4010	15	144,000	
58-59	1210	4960	4090	3750	3910	22050	11070	30180	24770	12270	139	315	118,700	
1959-60	2170	2350	4230	2840	5410	37210	14750	8230	6120	2580	1180	0	87,060	

Figure 4.2.7-J

Powder River at Arvada
NAME OF STATION

STATION LOCATION
DRAINAGE AREA 6050 sq. mi.
QUANTITIES IN Acre-feet

YEAR	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL
1960-61	0	1680	1840	2310	3230	8860	5890	15970	6040	3600	694	756	50,870
61-62	9750	5960	2350	1990	25890	15540	24740	124800	197500	49150	14640	11530	483,800
62-63	23390	10330	8690	7280	15050	14120	14080	34810	54610	10760	1580	10950	205,600
63-64	3990	6590	4800	5510	4680	12970	27660	39610	103600	20150	1350	140	231,050
1964-65	2750	6500	5950	8770	13710	29550	40710	47780	65680	28760	9360	5350	264,900
1965-66	8710	7870	5140	4540	5910	21090	16310	18490	7420	2000	3	7050	104,500
66-67	2990	6240	3680	4640	6800	13140	10780	31090	161200	47880	5530	7610	301,500
67-68	8500	9200	4680	4580	7910	21790	13710	45190	127900	20910	12140	11350	287,900
68-69	10440	8640	7040	8710	7260	19210	15100	18780	16130	10320	308	28	122,000

Figure 4.2.7-J(cont.)

ion species in the Middle Fork at the reservoir site. Calcium and magnesium concentrations generally increase in comparison to the sodium concentration during high runoff periods.

4.2.7.1.3.1.1 Region

Water quality data have been collected on Powder River at Arvada intermittently from 1946 to 1967 and continuously from 1967 through 1974. In samples collected, dissolved solids concentrations ranged from about 700 to 4,500 milligrams per liter with a corresponding range in streamflow of 725 to 3 cfs (Department of Interior, 1974).

The quality of irrigation return may be affected by numerous organic and inorganic compounds. Many of these would be reflected in the total dissolved solids measurement. Most fertilizers have a high nitrogen content, usually as nitrates. A high nitrate content may therefore indicate high fertilizer content in the irrigation return. A measure of the alkali hazard of irrigation water is provided by the sodium adsorption ratio. An indication of the change in these parameters is obtainable by considering mean values and ranges of nitrate, total dissolved solids and the sodium adsorption ratios in a reach of a stream. The annual means and ranges for the Powder River near Kaycee and the Powder River at Arvada are presented in the following table for the water years 1969 through 1973:

GAGE	NITRATE (Milligrams per liter) MEAN	RANGE	TOTAL DISSOLVED SOLIDS (Milligrams per liter) MEAN	RANGE	SODIUM ADSORPTION RATIO MEAN	RANGE
Powder River near Kaycee (06312500)	1.27	0-4.4	809	252-1,600	1.85	0.5- 4.0
Powder River at Arvada (06317000)	1.45	0.2-3.3	2,069	737-4,480	3.99	2.2-13

The change in these water quality parameters between the upstream and downstream gages is primarily due to the lower quality of the South Fork and Salt Creek inflows. Mean annual nitrate concentration increases slightly downstream, but is still far below the maximum allowable concentration of 45 milligrams per liter (U.S. Public Health Service, 1962). Although total dissolved solids concentration more than doubles in the reach, it should be pointed out that at the upstream end of the reach, the mean concentration already exceeds acceptable limits for potable water (500 milligrams per liter; U.S. Public Health Service, 1962). However, water with a concentration less than 3,000 mg/l is classified as only slightly saline (Hem, 1970). The sodium adsorption ratio increases downstream, but the sodium hazard would be considered low. A sodium adsorption ratio less than 10 is usually considered as a low sodium hazard (Powell, 1964).

Some indication of the relative importance of these changes can be obtained by looking at the changes in the same parameters along the Shoshone River between Buffalo Bill Dam (06282000) and Lovell, Wyoming (06285100). Along this river reach, approximately 116,800 acres are under cultivation. Unlike the Powder River, along which forage production predominates, a large portion of this cultivated acreage is used for the production of irrigated row crops. Large volumes of irrigation water are used as well as larger quantities of fertilizer. Despite this, the mean annual nitrate concentration increases from 0.19 to only 2.43 milligrams per liter. Total dissolved solids increase from 247 to 450 milligrams per liter and the sodium adsorption ratio increases from 0.56 to 2.15. That natural runoff contributes more to salinity than does irrigation in the Powder River Basin was also noted by the Wyoming State Engineer's Office (1972).

4.2.7.1.3.1.2 Reservoir area

Compared to the water quality discussed above, salinity of the water to be diverted for irrigation in the proposed project is higher than is expected in irrigation water, but the water can be used with minimum harmful effects if drainage is adequate. The sodium adsorption ratio is relatively low and the concentration of dissolved solids is not excessively high.

4.2.7.1.3.2 Sediment

Sediment may be defined as fragmented material that is transported by, suspended in, or deposited by a fluid medium. Sediment quality of streamflow is the result of erosion and sedimentation processes. The highest sediment concentrations occur during flood periods, because of the available amount of high energy produced.

4.2.7.1.3.2.1 Regional

The topography of the upper Powder River Basin ranges from rugged mountains to semi-arid plains. Pre-Cambrian and Paleozoic rocks, which are very resistant to erosion, underlie the mountainous area in the vicinity of the Big Horn Mountains which produce only a small part of the sediment transported by Powder River. Rocks underlying the plains area are mainly Mesozoic and Tertiary in age and are mostly composed of erodible shales, siltstones, and sandstones. The plains area streams have valleys composed of alluvial fills which are quite susceptible to erosion. The plains area, therefore, produces the highest sediment yield to Powder River, most of which is geologic erosion.

Most of the sediment contributed to the main Powder River enters below the dam site, from the South Fork and Salt Creek, with lesser amounts from the Red Fork and North Fork. The following summarizes the sediment production, from which the relative effects of tributaries arising on the plains and in the Big Horn Mountains can be assessed.

Suspended Sediment as a Function of Streamflow
of Powder River and Tributaries
(Bureau of Reclamation, 1967)

Location	Sediment Tons/Acre-Foot of Runoff
Middle Fork Powder River above Red Fork	1.1
Middle Fork Powder River near Kaycee	3.4
South Fork Powder River near Kaycee	4.7
Powder River at Sussex	2.5
Powder River near Arvada	3.3

Most of the sediment is relatively fine and is transported in suspension. Based upon earlier studies, the Wyoming State Engineer's Office (1974) estimated that 80 percent of the suspended sediment samples were smaller than sand size (0.062 mm) in Powder River at Arvada. The median suspended particle size was 0.057 mm, and the size distribution was 37 percent clay, 43 percent silt, and 20 percent sand. The median size of bed load particles was 0.228 mm.

In laminar flow such as would be expected under low flow conditions in low gradient streams or in reservoirs, the settling velocity of particles with an effective diamater of 0.057 mm (corresponding to the median particle size of suspended sediment in Powder River) is approximately 0.001 foot/second (Einstein in Chow, 1964). This indicates that a large fraction of the particles (all sand and most silt) would settle out in a relatively short time. The Bureau of Reclamation (1967) reported that much of the silt load of Powder River was lost as the result of settling action by the time it reached the Yellowstone River.

Records of daily suspended sediment discharge have been collected by the U. S. Geological Survey at eight gaging stations on Powder River and its tributaries. These records date back to 1946 but are not continuous from that time. A summary of the records for the gaging stations of interest is shown in Figure 4.2.7-K.

4.2.7.1.3.2.2 Reservoir area

The Middle Fork Powder River drains an area of about 460 square miles, 380 square miles of which is in the Big Horn Mountains, contributing very little sediment to the mainstem Powder River. A sediment study of the proposed reservoir, completed in December 1963, showed that the 100-year sediment inflow volume to the reservoir would be about 4,000 acre-feet (Bureau of Reclamation, 1967). Primarily, the tributaries Buffalo and Beaver Creeks, which traverse the easily eroded Chugwater formation along part of their lengths, contribute the majority of the estimated sediment inflow volume. Sediment concentrations are not considered a problem in water diverted into the Sahara Canal.

4.2.7.1.4 Floods

Flooding has resulted in damage to the town of Kaycee and agricultural properties in the area. In 1964, the largest flood of record on the Middle Fork occurred. It was reported that about 25 percent of the homes in Kaycee were flooded above the first floor, while foundation damage occurred in 60 percent of the buildings (Wyoming State Engineer's Office, 1972).

Although based on a relatively short period of record, a flood flow analysis by the U. S. Geological Survey (1972) indicates probable future flood flows at gaging stations in the vicinity of the reservoir site. Inspection of Figure 4.2.7-L reveals that high flood flow peaks on the Upper Middle Fork are rather quickly attenuated. For example, the 100-year flood at Barnum is 15,566 cubic feet per second, while the 100-year flood at the reservoir site (Middle Fork Powder River above Kaycee) is only 2,375 cubic feet per second, a much lower peak flow (a reduction of 85 percent). A similar attenuation of flood peaks occur on the main-stem, Powder River. The 100-year flood at Sussex is 84,520 cubic feet per second but is attenuated to 68,816 cubic feet per second at Arvada (a reduction of 19 percent).

The flood peaks occurring on the South Fork Powder River near Kaycee are much greater than on the Middle Fork, even though the mean annual flows of the Middle Fork are greater. This is at least in part a reflection of the tributary source. The South Fork arises on the plains

Suspended Sediment Data

Station Number	Station Name	Period of Record	Observed Daily Values					
			Date	Flow (cfs)	Maximum Concentration (mg/l)	Date	Flow (cfs)	Maximum Load (tons/day)
06309500	Middle Fork Powder River above Kaycee	1949-53, 1965-68, 1970	7/29/53	55	25,900	6/8/68	877	69,000
06312500	Middle Fork Powder River near Kaycee	1950-53	9/7/51	728	37,300	9/7/51	728	82,700
06313100	South Fork Powder River near Kaycee	1950-53	9/7/51	852	94,800	5/22/52	4,260	1,270,000
06313500	Powder River at Sussex	1950-53	8/3/53	1,090	87,500	5/23/52	14,100	2,850,000
06315000	North Fork Crazy Woman Creek near Greub	1965-68	9/3/66	35	30,600	6/9/68	950	34,900
06316500	Crazy Woman Creek near Arvada	1950-53	6/15/53	822	48,200	6/15/63	1,170	127,000
06317000	Powder River at Arvada	1947-57, 1968	7/19/54	792	113,000	5/24/52	12,500	2,340,000
06324000	Clear Creek near Arvada	1950-53	5/28/53	498	17,800	7/30/53	475	25,800
06334000	Little Missouri River near Alzada, Mont.	1949-52	5/21/49	57	20,300	5/10/50	1,180	17,600
06386000	Lance Creek near Spencer	1950-54, 1957-59	7/19/54	74	57,700	6/27/52	3,620	281,000
06394000	Beaver Creek near Newcastle	1949-57	5/22/57	134	36,000	5/25/57	780	90,800
06426500	Belle Fourche River below Moorcroft	1947-52	--	--	--	9/5/51	710	12,400

Figure 4.2.7-K

while the Middle Fork arises as the slopes of the Big Horn Mountains. Even though the total volume may be less on plains streams, instantaneous flood peaks may be greater.

Potentially, the contribution to flood flows on the mainstem Powder River by South Fork may be large.

4.2.7.2 Ground water resources

4.2.7.2.1 Occurrence

Precipitation and infiltration of surface water are the primary sources of ground water. Ground water usually occurs as fluid filling the very small pore spaces in sediment or rock. Sometimes it occurs as large pools enclosed in solution cavities in limestone. If enough of the water-filled pores or cavities are interconnected, then the saturated portion of the rock or sediment is called an aquifer. The amount of underground storage space (porosity), the ability of the rock formation to transmit water (permeability), the depth to water, and the hydraulic gradient are characteristics which for the large part have been determined by past geologic environment. Figure 4.2.7-M is a generalized geologic section across Powder River Basin and shows the position of these rocks in the subsurface.

4.2.7.2.2 Availability of ground water

The volume of water in storage is not an indication of its availability. Also, the absolute volume is not a reliable indication of how much and at what rate ground water might be produced.

Figure 4.2.7-L

Flood Flows at Selected Sites
in the Upper Powder River Basin

Flood Recurrence Interval (years)	Flood Peak Flows (Cubic Feet per Second)				
	Middle Fork Near Barnum	Middle Fork Above Kaycee	South Fork Near Kaycee	Powder River at Sussex	Powder River at Arvada
5	1,320	978	8,147	10,371	14,470
10	2,308	1,246	14,885	18,162	21,918
25	4,899	1,645	28,574	34,921	35,624
50	8,715	1,988	43,775	54,984	49,946
100	15,566	2,375	64,475	84,520	68,816

Approximately 10,000,000 acre-feet of ground water storage volume has been estimated available to wells in alluvial aquifers (Wyoming State Engineer's Office, 1973). However, the annual or regulatory volume which might be withdrawn would be limited to approximately the amount of annual recharge to the alluvial aquifers; this volume has been estimated at 1,250,000 acre-feet.

Most of the ground water available to wells is from bedrock formations. Considering the approximately 200,000 cubic miles of rock formations present in Wyoming's basins, the total amount of ground water must be extremely large. The State Engineer reported in The Wyoming Framework Water Plan that about 3 billion acre-feet of ground water is stored in consolidated formations. The most widely used bedrock aquifers are the Tertiary sandstones, some of which outcrop in each of the major geologic basins (Figure 4.2.7-N). The potential annual recharge to consolidated formations from precipitation is estimated to be about 4,000,000 acre-feet, only 0.1 percent of the recoverable storage.

4.2.7.2.2.1 Regional

As with the rest of Wyoming, most of the ground water available to wells in the Powder River Basin is in bedrock formations. Even though much more ground water is stored in bedrock than in unconsolidated material, the unconsolidated material usually yields water at a greater rate and accepts recharge faster. Figure 4.2.7-O compares the relative availability of alluvial ground water to wells by study area, and the availability of ground water in the terrace gravels. The table gives a rough estimate of quantities of water in storage and an estimate of

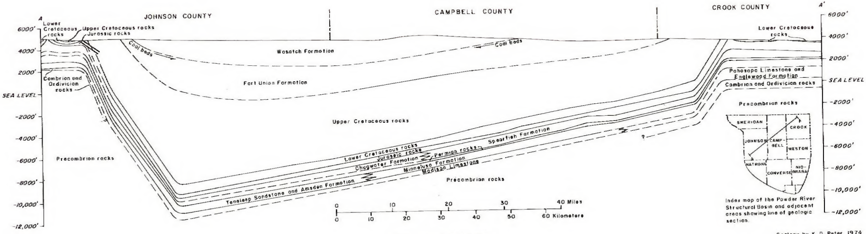


Figure 4.2.7-M

Generalized Geologic Section of the Powder River Structural Basin and Adjacent Areas, Northeastern Wyoming.

Source: Department of the Interior, 1974.

annual recharge (natural). From this figure a summary of magnitudes of the ground water resource in alluvial aquifers in northeastern Wyoming can be estimated as follows:

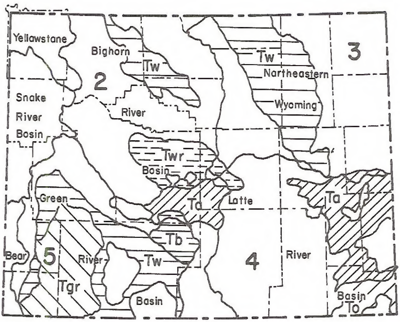
	WATER IN STORAGE AVAILABLE THROUGH WELLS (acre-feet)	EFFECTIVE ANNUAL RECHARGE (acre-feet)
Flood plain alluvium	559,325	114,199
Terrace gravels	210,000	7,000
TOTAL unconsolidated aquifers	769,325	121,199

An enormous quantity of water is available in shallow storage underground (within 1,000 feet of the surface) in the Powder River Basin. In the Wasatch-Fort Union formation alone, an estimated 85,000,000 acre-feet of ground water is available to wells. This large quantity of water is due to the great areal extent of the Tertiary aquifer material and the thick aquifer interval below the water table. Older bedrock aquifers (mostly below 1,000 feet) also have tremendous amounts of water in storage. The largest yields generally come from wells penetrating aquifers of the Mississipian and Pennsylvanian ages.

4.2.7.2.2.2 Reservoir area

Ground water resources in the area have been evaluated by the U.S. Geological Survey in Water Supply Paper 1360-E. This report shows the ground water potential to be practically negligible compared to the quantity of water required for irrigation and other purposes.

The amount of water obtainable by pumping from wells ranges up to a maximum rate of about 1 cubic foot per second.



WYOMING

Ta - Arikaree
To - Ogallala
Tb - Battle Spring
Tw - Wasatch
Twr - Wind River
Tgr - Green River and younger Tertiary formations. (groundwater potential is fair to poor; TDS usually is high.)

Assuming that the first 200 feet of saturated aquifer below the water table hold water under predominantly water table conditions, this interval in the major Tertiary sandstone aquifers contains an estimated 180,000,000 acre-feet of groundwater available to wells, as shown below:

Aquifer (first 200 feet of saturation)	Area	Groundwater in storage Available to Wells (Acre-Feet)
Arikaree	4	80,000,000
Ogallala	4	10,000,000
Battle Spring / Wasatch	5	30,000,000
Wasatch	2	17,000,000
Wasatch	3	30,000,000
Wind River	2	13,000,000
Total		180,000,000

Figure 4.2.7-N

MAJOR TERTIARY SANDSTONE AQUIFERS

Source: Wyoming State Engineers office, 1973.

Estimates of Ground Water in Storage and Annual Recharge, in Unconsolidated Aquifers

Study Area	Drainage Area	Extent of Alluvium in Acres[1]	Average Saturated Thickness in Feet[2]	Volume of Saturated Aquifer in Acre-Feet	Yield Factor in Percent[3]	Water in Storage Available Through Wells in Acre-Feet	Average Fluctuation in Ground Water Level in Feet[2]	Recharge Factor in Percent[3]	Effective Annual Recharge in Acre-Feet[4]
1	Tongue River and tributaries above Goose Creek	16,700	20	334,000	10	33,400	5	10	8,350
	Goose Creek and tributaries above Little Goose	6,350	20	127,000	10	12,700	5	10	3,175
	Little Goose Creek	4,850	20	97,000	10	9,700	5	10	2,425
	Other tributaries	1,250	15	18,750	10	1,875	5	10	625
	Prairie Dog Creek and tributaries[5]	30,400 / 800	15 / 50	496,000	10	49,600	5	10	15,200
	Other tributaries	11,600	15	174,000	10	17,400	5	10	5,800
	Total Study Area 1	71,150		1,246,750		124,675			35,575
2	Clear Creek and tributaries	39,100	17.5	684,250	10	68,425	5	10	19,550
3	Crazy Woman Creek and tributaries	25,150	20	503,000	10	50,300	5	10	12,575
4	Powder River (and tributaries in study area)	45,550	11	501,050	10	50,105	4	10	18,220

This table continued on following page.

Figure 4.2.7-0

Estimates of Ground Water in Storage and Annual Recharge, in Unconsolidated Aquifers

Study Area	Drainage Area	Extent of Alluvium in Acres[1]	Average Saturated Thickness in Feet[2]	Volume of Saturated Aquifer in Acre-Feet	Yield Factor in Percent[3]	Water in Storage Available Through Wells in Acre-Feet	Average Fluctuation in Ground Water Level in Feet[2]	Recharge Factor in Percent[3]	Effective Annual Recharge in Acre-Feet[4]
5	Little Powder River and tributaries	20,250	7	141,750	10	14,175	1.5	10	3,038
6	Little Missouri River and tributaries[6]	51,850	7	362,950	5	36,295	1.5	5	3,889
7	Belle Fourche River and tributaries[7]	56,900 / 22,250	20 / 10		10		1.5	10	
	Total Study Area 7	79,150		1,360,500		136,050			11,872
8	Cheyenne River and tributaries[8]	15,500 / 16,100	20 / 30		10		3	10	
	Total Study Area 8	31,600		793,000		79,300			9,480
	Total Floodplain Alluvium					559,325			114,199
	Terrace gravels[9]	70,000	30	2,100,000	10	210,000			7,000
	Total Unconsolidated Aquifers					769,325			121,199

(Note: Data subject to revision and modification.)

This table continued on following page.

Figure 4.2.7-0

Estimates of Ground Water in Storage and Annual Recharge, in Unconsolidated Aquifers

1. Measured on available maps and adjusted to exclude areas judged to be above the normal water table.

2. Estimated from available data.

3. Not to be confused with specific yield; as used here, the yield factor is based on cumulative effects of natural and artificial influences; in any local area, the yield factor could be greater for some wells. Similarly, the local recharge factor could be greater than the figures given.

4. Does not include an estimate of recharge due to irrigation.

5. Subsurface investigations have indicated the presence of a buried channel in the valley of Dutch Creek, which is a tributary of Prairie Dog Creek. The number 800 refers to the estimated known areal extent of this buried channel, and 50 refers to its average saturated thickness. Since it is a buried channel, it underlies the floodplain alluvium and is not added to the total of the extent of the alluvium.

6. The alluvium in the valley of the Little Missouri River is mostly fine grained and very fine grained material; this is reflected in yield and recharge factors of only 5 percent.

7. The numbers 56,900 acres and 20 feet refer to Donkey Creek and the upper reach of the Belle Fourche River.

8. The numbers 16,100 acres and 30 feet refer only to Lance Creek.

9. Terrace gravels are found throughout the area. About 35,000 acres of terrace gravels are in Study Area 1. Some of the gravel deposits in Study Area 1 are extensive and might be developed as sources of ground water. The recharge figure given is an amount due to the direct precipitation. Recharge due to irrigation is much greater than recharge due to precipitation; however, the effects of irrigation may be detrimental to water quality.

Source: Wyoming State Engineer's Office, 1973.

Figure 4.2.7-0

4.2.7.2.3 <u>Quality of ground water</u>

Ground water quality (chemical) is generally classified by the amount of total dissolved solids in milligrams per liter mg/l. According to the U.S. Public Health Service standards (1962) water for human use should have no more than 1,000 mg/l total dissolved solids (TDS) and preferably no more than 500 mg/l.

Animals can become accustomed to higher TDS concentrations. Water with less than 1,000 mg/l total dissolved solids is considered good for livestock; 1,000 to 3,000 mg/l is fair; 3,000 to 5,000 mg/l is poor but usable; 5,000 to 7,000 mg/l is very poor and of questionable use; and more than 7,000 mg/l is not advisable (Wyoming State Engineer's Office, 1972).

Quality requirements vary widely for industrial use; in general, water that meets standards set for domestic use is suitable.

The median TDS concentration of groundwater in gravel and sandstone above the depth of 1,000 feet in Wyoming is about 500 mg/l. In deeper aquifers (to a depth of 8,000 feet) the median TDS concentration is 2,000+ mg/l (Wyoming State Engineer's Office, 1973). Also, they report that concentration in waters produced from clays and shales commonly is in the 2,000 to 10,000 mg/l range. A maximum concentration of 200,000 mg/l in water associated with accumulations of petroleum has been reported in Powder River Basin.

Hardness is caused principally by high concentrations of calcium and magnesium. The aquifers that are most widely used provide primarily hard water. Ground water in the alluvium generally is moderately hard

(60 to 120 mg/l) to very hard (200+ mg/l). In consolidated aquifers, water is generally soft (0 to 60 mg/l) to very hard, with extreme variations commonly occurring within the same aquifer. Water in Cretaceous and Jurassic sandstones usually is not as hard as in younger (Tertiary) and older (Triassic through Cambrian) aquifers.

4.2.7.2.3.1 Regional

Water quality is better near the recharge areas and deteriorates toward the centers of the geologic basins. Ground water in the geologic Powder River Basin commonly can be expected to have TDS contents ranging from 500 to 2,500 mg/l, hardness greater than 200 mg/l, iron in excess of 0.2 mg/l, and sulfate in excess of 500 mg/l. Also, it is not uncommon to find fluoride in excess of 1.5 mg/l (Wyoming State Engineer's Office, 1972).

4.2.7.2.3.2 Reservoir area

Samples of water from alluvium of Powder River and its tributaries and from several bedrock formations were analyzed by the U.S. Geological Survey (Figure 4.2.7-P). The Tensleep sandstone and the Lance, Fort Union, and Wasatch formations are the principal aquifers; water derived from these formations generally is useable for domestic purposes.

4.2.7.2.4 Use of ground water

Ground water is used for domestic, stock, municipal, industrial, irrigation, and other purposes. By far the predominant and most widespread use of ground water is for livestock and domestic purposes.

4.2.7.2.4.1 Regional

Most of the permits issued by the State Engineer are for domestic and stock wells, however a relatively large number of permits have been issued for industrial wells, most of which are for the purpose of water flood operations (exclusive of oil produced water) in secondary recovery of crude oil.

Only about 2 percent of the total municipal population use a combination of ground water and surface water; 51 percent depend entirely upon ground water (Wyoming State Engineer's Office, 1972).

There are approximately 546 acres of land in Powder River Basin presently being irrigated by original supply and none being irrigated by supplemental supply. Within Powder River Basin then, based on an average consumptive use of 1.77 acre-feet per acre, approximately 970 acre-feet of ground water is used. However, since the amount of water actually applied to the land is greater than the amount consumptively used and depends largely on climatic factors and methods of application, an estimated amount of total annual withdrawal in the basin is 1,800 acre-feet (Wyoming State Engineer's Office, 1972).

4.2.7.2.4.2 Reservoir area

Present use of ground water in the area is limited, primarily to stock water and domestic uses.

4.2.8 Vegetation

4.2.8.1 Reservoir area

The vegetation present at the reservoir site consists of many gradations and variations of typical compositions found on four basic land types and in the stream itself. These five categories are: a) badlands, b) hillsides, c) stream bottoms without subirrigation, d) subirrigated stream bottom areas, and e) the area traversed by the stream which is continually under water (see Figures 4.2.8-A through -D). No endangered plant species are involved on the site.

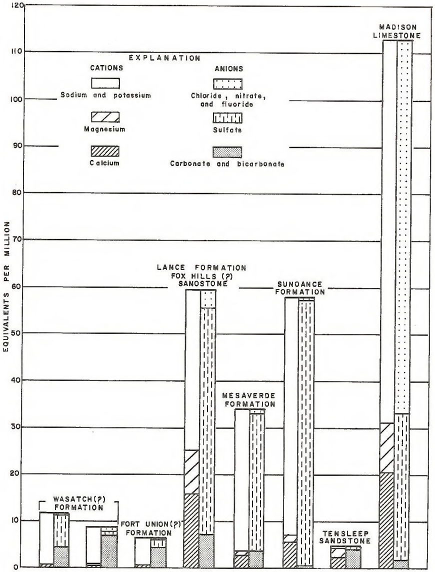


Figure 4.2.7-P

CHEMICAL QUALITY OF WATER FROM CONSOLIDATED ROCKS IN PROPOSED PROJECT AREA

Source: Kohout, 1957.

The badland areas "a)" are mainly in the uplands and are characterized by extremely rough terrain and many barren areas devoid of vegetation. A few of these areas extend into the reservoir basin and exist along the north shore of the proposed reservoir. The major vegetation involved is sagebrush, mountain mahogany, greasewood, rubber rabbitbrush, and mid and shortgrasses such as bluebunch wheatgrass, blue grama grass, junegrass, and needle and thread grass. This type also supports scattered stands of scrub ponderosa pine and juniper.

The hillside type "b)" is an intermediate type with smoother terrain but with many steep slopes and ravines. General vegetation density is greater on this type and the proportion of grass is greater. Pine and juniper are also present in certain areas.

A few areas near the stream are considered of a transitional type "c)" which have some of the added moisture from the stream and are periodically flooded, but are not characterized by the drastic change in vegetation type typical of full subirrigation. These transitional areas support a few of the moisture tolerant species present on the subirrigation type but are mainly characterized by some of the same vegetation as on the hillsides with a much higher proportion of greasewood, inland saltgrass, and western wheatgrass.

The remaining land type "d)" is located on the stream bottom areas where soil and subsoil properties have created a subirrigation condition, i.e., the ground water level periodically rises sufficiently to furnish water to the root zone of the plants present. This type supports midgrasses, a high proportion of forbs, and many areas of brush and

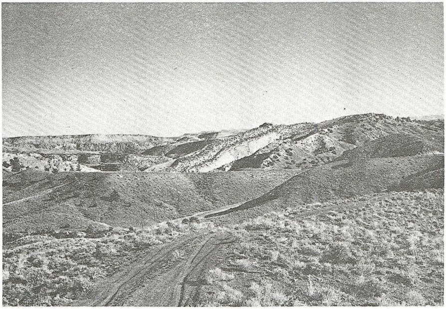


Figure 4.2.8-A
Badlands vegetation type (background)

Figure 4.2.8-B
Hillside vegetation type (foreground)

Figure 4.2.8-C
Stream bottom without subirrigation.

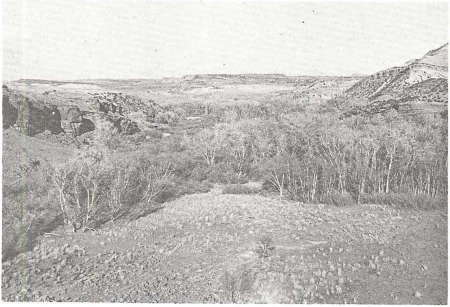


Figure 4.2.8-D
Subirrigated vegetation type.

willows, sometimes dense enough to be termed thickets. There are a few areas where dense groves of mature cottonwoods are present such as in the area to be inundated along the Middle Fork above the confluence of Beaver Creek. Small portions of the flat subirrigated areas have been cultivated, planted to alfalfa and tame grasses and are being surface irrigated to produce hay (about 60 acres).

Aquatic vegetation "e)" is present in the stream consisting of plants such as mosses and algae. This subject is also discussed under the Wildlife and Fish section.

4.2.8.1.1 Inundation and embankment area

Terrestrial vegetation on the inundation and embankment area was further broken down into subtypes and mapped (see Figure 4.2.8-E).

Figure 4.2.8-F is a vegetation description and species list by subtype of major vegetation species found in the area to be inundated by the reservoir.

4.2.8.1.2 Proposed relocated road

The relocated road would be an estimated six miles long and, at a right-of-way width of 100 feet, would occupy 70 acres of land. The route traverses 18 acres of the hillside vegetation type. The major species involved are sagebrush, blue grama grass, junegrass, bluebunch wheatgrass, and scrub ponderosa pine and juniper.

The remaining 52 acres would be through a type considered to be a gradation between the badlands and hillside types. The major vegetative species on this type are sagebrush, rubber rabbitbrush, blue grama grass, bluebunch wheatgrass, and some scrub ponderosa pine and juniper.

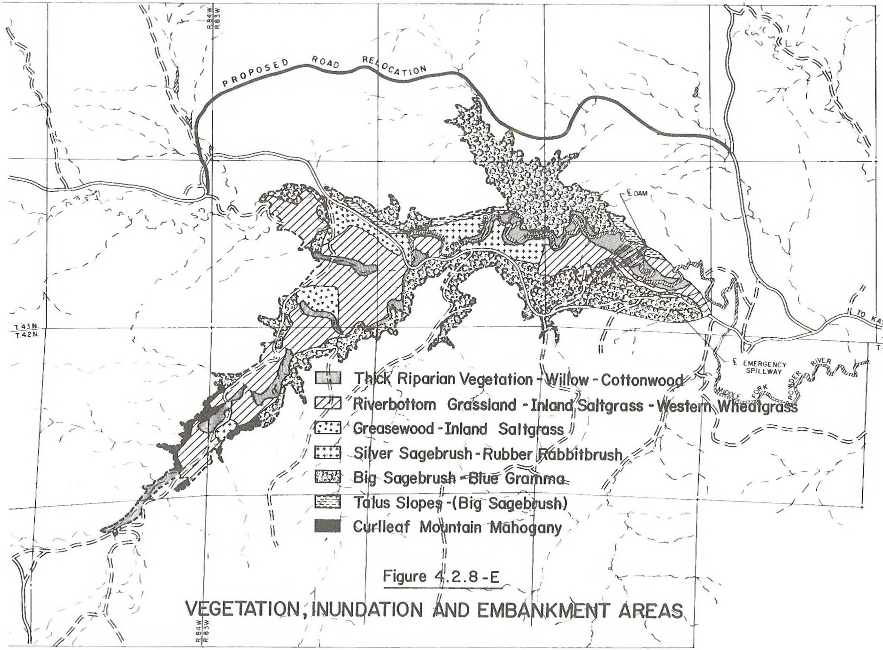


Figure 4.2.8-E

VEGETATION, INUNDATION AND EMBANKMENT AREAS

Figure 4.2.8-F

MAJOR VEGETATIVE SPECIES BY PLANT COMMUNITY FOUND IN THE INUNDATION AND EMBANKMENT AREAS

1) Willow-cottonwood

Grasses

Agrostis alba	- red top
Distichlis stricta	- inland saltgrass
Elymus cinereus	- wildrye
Poa secunda	- Sandberg bluegrass
Palypogon monspeliensis	- rabbitfoot grass
Spartina gracilis	- alkali chordgrass
Phleum pratense	- timothy
Carex (spp.)	- sedges
Carex filifolia	- threadleaf sedge

Shrubs and trees

Rosa (spp.)	- rose bushes
Salix (spp.)	- willow
Populus angustifolia	- narrowleaf cottonwood
Populus sargentii	- river cottonwood

Also some unidentifiable vines growing among trees and willows.

The dominant grasses within this plant community are inland saltgrass and timothy. There are many rose bushes growing among the willows along the streambank.

2) Inland saltgrass-western wheatgrass

Agropyron smithii	- western wheatgrass
Bromus tectorum	- cheatgrass
Distichlis stricta	- inland saltgrass
Hordeum nososum	- meadow barley (domestic)
Phleum pratense	- timothy
	- cocklebur
Taraxacum officinale	- common dandelion
Artemesia cana	- silver sagebrush
Artemesia frigida	- fringed sagebrush
Chrysothamnus nauseosus	- rubber rabbitbrush
Rosa (spp.)	- rose
Sarcobatus vermiculatus	- black greasewood
Salix (spp.)	- willows

The dominant grass species in this plant community are inland saltgrass, western wheatgrass, cheatgrass, and meadow barley. All the brush species mentioned are sparsely scattered throughout the area.

Figure 4.2.8-F (continued)

3) Greasewood-inland saltgrass

This plant community is almost a pure stand of black greasewood with an understory dominated by inland saltgrass. Other species of grass are present but not identifiable due to intense grazing pressure.

4) Silver sagebrush-rubber rabbitbrush

This plant community is characterized by dense stands of 5' tall silver sagebrush and rubber rabbitbrush plants. The understory is composed mainly of inland saltgrass and various other grasses mentioned previously.

5) Big sagebrush-blue grama

Agropyron spicatum	- bluebunch wheatgrass
Bouteloua gracilis	- blue grama
Bromus tectorum	- cheatgrass
Koeleria cristata	- prairie junegrass
Stipa comata	- needle and thread
Carex filifolia	- threadleaf sedge
Phlox	- phlox
Opuntia polyacantha	- plains pricklypear
Artemesia frigida	- fringed sagebrush
Artemesia tridentata	- big sagebrush
Chrysothamnus nauseosus	- rubber rabbitbrush
Cercoparpus ledifolius	- curlleaf mountain mahogany
Juniperus scopulorum	- Rocky Mountain juniper
Yucca	- yucca

This plant community is dominated by big sagebrush and blue grama grass and occurs along the hills above the river bottom. Needle and thread, cheatgrass, bluebunch wheatgrass, sedges, and prickly pear are also very abundant.

6) Talus slopes

The vegetation found on the talus slopes is the same as found in the big sagebrush-blue grama community; however, the amount of vegetation is greatly reduced with bare rock being the dominant feature.

7) Curlleaf mountain mahogany

Where curlleaf mountain mahogany is the dominant vegetation there is little other vegetation present. This occurs mainly in areas of red soil and the aspect is one of mountain mahogany and bare soil.

4.2.8.2 Agricultural water transportation route

This route consists of the Middle Fork of Powder River between the damsite and the Sahara Ditch diversion and also would include the length of the Sahara ditch. Vegetation found along this route is similar to that of the reservoir basin with a preponderance of the subirrigation type present. Subtypes found most commonly along the stream are those of riparian vegetation and river bottom grassland. Stream volume is increased with the addition of Red Fork after 4 miles and North Fork after 19 miles of the estimated 20-mile stream length. The added volume tends to increase riparian vegetation growth. Cottonwoods and willows become progressively more plentiful. The flood plain widens out somewhat and the above subtypes are larger per unit of stream distance. More irrigated land is present than in the reservoir basin. Substantially more acreage has been cultivated and although some small grain is raised the majority of land under cultivation raises alfalfa and tame grass hay. The water temperature increases, enabling a greater amount of aquatic vegetation to grow. Mosses and algae increase in volume gradually.

The Sahara ditch would be used to transport the bulk of the agricultural water to the irrigation areas. The length is estimated at 15 miles. Water is diverted to the south of the stream for two miles and then is siphoned back under the stream to the north side and runs within 1/4 mile of the stream for another two miles. At this point the ditch begins to depart from the stream bottom area and was constructed on grade outward in such a manner as to facilitate irrigation of the remaining land in the irrigation district, most of which is situated on a fairly flat area between the highway and the stream.

Where the ditch is situated within a short distance of the river the vegetation involved is largely riparian trees and shrubs and river bottom grassland. As it moves into the upland areas, surrounding vegetation changes to sagebrush and short and mid grasses. However, the presence of the ditch has altered natural vegetation due to construction and the presence of additional water. Introduced vegetation is present, such as tame grasses, sweet clover, and weeds and other forbs. This unnatural vegetation extends a considerable distance from the ditch in some areas where seepage has occurred and in areas of extensive seepage, wetland vegetation is present, such as sedges and rushes. In the irrigated areas, cropland is present immediately below the ditch and in some cases on both sides.

4.2.8.3 Agricultural water use area

A wide variety of vegetation is present in the irrigated land areas where the water would be used. Four basic situations are present influencing vegetation: a) irrigable areas which have not been developed for agriculture but are intended for development, b) areas subjected to land preparation but which have not raised a crop due to insufficient irrigation water, c) areas which have been irrigated and cultivated for many years, and d) areas below the ditch which are not irrigated due to rough terrain or flooding potential.

Those lands under the "a)" category contain largely sagebrush and short and mid grasses typical of the native vegetation in the surrounding area.

The areas in the "b)" category currently contain either stubble remains of the attempted crop (usually corn or grain) or are largely barren due to the land preparation activities.

The "c)" category involves a wide variety of vegetative types including: regularly plowed cropland; hayland including alfalfa and grass, irrigated pasture with topographical limitations; and irrigated pasture with limitations such as from poor drainage and alkali deposits. The vegetation of this category is discussed more thoroughly in connection with its primary significance under the Agriculture section.

The "d)" category supports typical riparian vegetation such as cottonwoods, willows, other brush species, and in some areas wetland vegetation such as cattails and rushes.

4.2.9 Wildlife and fish

4.2.9.1 Habitat description

4.2.9.1.1 Reservoir site

The reservoir site offers a variety of excellent wildlife habitat. Thickets of cottonwoods, willows, boxelders, and wild roses are abundant in the river bottom. Native hay, alfalfa, and grains are grown on the irrigable river bottom lands. Unfarmed lands are typified by sagebrush, greasewood, rabbitbrush, grasses, and weeds. The hillsides and draws on the adjacent watershed are typically vegetated by juniper, some sparse ponderosa pine, mountain mahogany, sagebrush, and grass.

Grazing by domestic livestock has been very heavy. Trampled hillsides, over-utilized streambank vegetation and trampled and sloughing streambanks are common sights.

4.2.9.1.2 Agricultural water use area

These lands are similar to the river bottom lands at the reservoir site. Cover, except on the parcels cultivated for crops, is abundant in the form of cottonwoods, willows, etc. Cultivated areas produce hay, corn, alfalfa, wheat, and sorghum, i.e., supplemental livestock feeds. Wildlife cover is lacking in these areas except for some ditchbank cover. These areas retain green and succulent feed for wildlife late in the year when native range has dried.

4.2.9.1.3 Mammals

Game. Game species found in the project area include mule and white tail deer, antelope, and rabbits.

Antelope are absent from the reservoir site but are common on the irrigated land east of Kaycee. An aerial count by Wyoming Game and Fish in August of 1972 revealed 300 animals from Kaycee to Sussex, a distance of about 20 miles. Estimates are that about 40 inhabit the lands to be irrigated (Roger Wilson, Wyo. Game & Fish, 1974, pers. comm.).

Mule and white tail deer inhabit both the reservoir site and irrigated lands, and are considered resident. Some mule deer inhabit the brushy bottoms almost exclusively while others inhabit the adjacent hills and draws, feeding in the irrigated lands during the night. A recent winter count by Wyoming Game and Fish put the number of mule deer on the reservoir site at 100. Summer populations are believed to be about one third higher. About 30 white tails inhabit the reservoir site. Numbers in the irrigated areas are estimated at about 15 deer/section, or about 300-400 animals (Wilson, op. cit.).

Cottontail rabbits are widespread and abundant. No population data are available.

Non-game mammals. A list of non-game mammals (excluding furbearers) would include a long series of "probables," because no definite information exists. A list would include shrews, bats, hares, rodents, weasels, and skunks. Prairie dogs are reported in the project area (Wilson, op. cit.), making it potential habitat for the endangered black-footed ferret.

Furbearers. Inhabiting the reservoir area and irrigated lands are raccoons, badgers, weasels, beavers, muskrats, minks, bobcats, coyotes, foxes, and perhaps very rarely a transient mountain lion. Some of these animals are classified under Wyoming game laws as predators. Beavers and muskrats are the most commonly trapped animals (Wilson, op. cit.).

Threatened or endangered mammals. The spotted bat and the black-footed ferret are possible inhabitants of the reservoir or irrigated land areas, but no known observations have been made.

4.2.9.1.4 Birds

Game. Game birds inhabiting the project area include the chukar partridge, turkeys, sage grouse, Hungarian partridges, pheasants, mourning doves, and several species of waterfowl.

Chukars are probably the most numerous of the resident species. The reservoir site supported an estimated 300-400 birds in 1967, but current levels are much lower (R. Williams, Wyo. Game & Fish, 1974, pers. comm.). Habitat is marginal and winters may be limiting.

Turkeys are found in both the reservoir area and on the irrigated lands. The brushy bottoms offer good cover for this much sought bird. Wyoming Game and Fish biologists estimate the population at the reservoir site at 30-plus birds, primarily upstream from the confluence with Beaver Creek (R. Williams, op. cit.). No data are available for the irrigated lands.

Pheasant, sage grouse, and Hungarian partridge populations are low due to marginal habitat. No population data are available.

Doves are seasonally abundant.

Waterfowl habitat and numbers are limited. A few ducks nest along the river and cultivated lands are used for feeding by ducks and geese.

Non-game birds. The Casper District Bird List, compiled by the Casper BLM District in 1973, lists 282 species of birds known or thought to occur in the District. Of this number, more than 200 non-game birds are possible residents or visitors to the project area. No attempt will be made to enumerate them here, as no definite knowledge exists of their occurrence at the reservoir or irrigable land sites.

Raptors frequenting the project area include wintering populations of bald and golden eagles; the latter probably is a resident. The "threatened" prairie falcon and the "endangered" American and Arctic peregrine falcons probably pass through the area. The prairie falcon quite likely nests in the cliffs overlooking the reservoir site.

4.2.9.1.5 Reptiles and amphibians

No site-specific studies have been made, either qualitatively or quantitatively, regarding reptile and amphibian populations. It is reasonable to assume that at least some of the species listed as possible inhabitants in the Eastern Powder River Coal Basin EIS (Appendix C, Table 30) also occur at the reservoir site and in the irrigated land area. None of these species is listed as endangered or threatened.

4.2.9.1.6 Invertebrates

Data on aquatic invertebrate life are almost non-existent. Wyoming Game and Fish personnel sampled stream bottoms in 1955 at the mouth of Beaver Creek. The usual complement of mayflies, etc., were found but no quantitative data are available (J. Mueller, Wyo. G&F, 1974, pers. comm.).

4.2.9.1.7 Fish

The Middle Fork within the project area is known to contain rainbow trout, brown trout, longnose sucker, mountain sucker, white sucker, flathead chub, and longnose dace.

The Middle Fork supports little fishing between the damsite and the mouth of Beaver Creek, about 3 miles upstream.

Beaver Creek drains a watershed containing an erosive red soil, and heavy loads of red sediment are carried into the Middle Fork. Warm water temperatures and heavy sedimentation make this stretch undesirable game fish habitat. After the spring runoff, and between rain showers, both Beaver Creek and Middle Fork waters become fairly clear and some trout are taken in the Middle Fork below Beaver Creek when water conditions are rights.

The latest electro-fishing data collected in July 1974 at a station about one third mile below the mouth of Beaver Creek revealed brown trout 8-14 inches in length, and rainbows 9-12 inches long. There are an estimated 200 trout per mile in this section of the Middle Fork.

From the mouth of Beaver Creek and upstream for 17 miles there is a substantial population of trout, with an estimated 12 fishermen per mile per year. Electro-fishing data collected in July 1974 at a station where the county road crosses Beaver Creek near Barnum, about 2 miles above the backwaters of the proposed reservoir, indicated that brown trout from 6-12 inches in length were present. An estimated 800 trout per mile inhabit this stretch of Beaver Creek. There is a 20 foot vertical falls about one half mile above the mouth of Beaver Creek which provides a barrier to fish migration from the Middle Fork. This limits the species of non-game fish that occur in Beaver Creek upstream from these falls to the mountain sucker and longnose dace.

From Beaver Creek upstream to the mouth of Buffalo Creek the Middle Fork receives most of its fishing pressure. This stretch of stream has been planted with trout in the past by the Wyoming Game and Fish Commission. Up until 1964 plants of catchable rainbow trout were made but due to reduced fishing pressure this was discontinued and plants of sub-catchable browns were made instead. This program continued for five years, but there was insufficient fishing pressure to justify it, so all plantings of trout in this area were discontinued. The last planting of sub-catchable brown trout was made in 1969.

In July 1974, data were collected from an electro-fishing station about 1-1/4 miles upstream from the mouth of Beaver Creek, about equidistant from the mouth of Beaver Creek and the backwaters of the southwest arm of the proposed reservoir. Rainbow trout of 8-14 inches and browns from 6-12 inches were observed. It is estimated that about 240 trout per mile inhabit this stretch of the Middle Fork of Powder River. Somewhat lower water temperatures and less sedimentation make this section of stream better fish habitat than the section below Beaver Creek, although this portion of the Middle Fork at times receives quantities of red semiment from Buffalo Creek.

Above the mouth of Buffalo Creek the stream fishery of the Middle Fork is excellent. Buffalo Creek is the uppermost stream to carry red sediment into the Middle Fork. Above this point the character of the soil is different, and even during spring runoff the river runs fairly clear. The Middle Fork upstream 1-1/2 miles from the mouth of Buffalo Creek runs on the deeded lands of the Bar C ranch, and is often closed or severely restricted to public fishing.

The latest data collected from an electro-fishing station just upstream from the confluence of Buffalo Creek and Middle Fork in July 1971 show that rainbows and browns of up to 18 inches were present with the average length being about 10 inches. An estimated 1900 trout per mile inhabit the Middle Fork upstream from the mouth of Buffalo Creek.

Powder River along the boundaries of the irrigated land in the Kaycee Unit is very shallow, warm and turbid with a high sediment load. Because of the warm, shallow water and high natural suspended sediment this reach of Powder River is not considered to be important game fish habitat. The only game fish species present are bullheads and stonecats. The area is such poor game fish habitat that the Wyoming Game and

Fish Commission has never conducted an inventory nearby. The shovelnose sturgeon and sturgeon chub are known to inhabit the silty currents of the lower Powder River. The nearest electro-fishing station to report these species was under the Interstate 90 bridge over Powder River, about 33 miles downstream from the irrigated lands. (All above information on fisheries was supplied by personal communications with John Mueller, Fisheries Biologist, Wyoming Game and Fish Commission, Buffalo, Wyoming.)

4.2.9.1.8 Summary

The land to be inundated by the proposed reservoir is excellent riparian habitat for a variety of game and non-game terrestrial wildlife. No sightings of endangered species are known, but peregrine falcons, prairie falcons and spotted bats may occur.

That portion of the Middle Fork to be inundated is a mediocre fishery due to poor habitat conditions. Problems are low winter and late summer flows, high summer water temperatures, and siltation.

The lands to be irrigated are occupied by a similar complement of wildlife, with the notable addition of pronghorn antelope. The Middle Fork of Powder River at this point is inhabited almost exclusively by non-game fish able to tolerate the warm, silty, slow waters.

4.2.10 Cultural resources

All cultural resources (paleontological, prehistorical, and historical) constitute integral and non-renewable portions of the human environment: fragile and limited remains of past life forms or human activity. These resources consist of physical remains, areas where significant human events occurred even though no evidence of the event remains, and the natural environment surrounding the actual resource.

4.2.10.1 Paleontological resources

4.2.10.1.1 Reservoir area

Theodore E. White of the Smithsonian Institution made a preliminary appraisal of the paleontological resources within the proposed reservoir in 1948. This field reconnaissance located fragments of fossil bone in all exposures of the Morrison Formation examined, including a skull and portion of dinosaur vertebral column, which were sent to the U.S. National Museum. The Morrison Formation examined by White is a formation of continental deposits of the Upper Jurassic epoch which contains many dinosaur bones, gastroliths, and other reptilian remains. John Jameson of the University of Wyoming reported observing marine fossils in outcroppings of the Sundance Formation within the area of the proposed reservoir. The Sundance Formation is stratigraphically below and older than the Morrison Formation; both are part of the Upper Jurassic epoch. The Sundance Formation contains marine deposits which include abundant fossil remains of Belemenites.

4.2.10.1.2 Agricultural water use area

Horace E. Wood, II and Florence D. Wood collected an assemblage of fossil mammals and other vertebrates from Eocene deposits in the Sussex area during field work conducted in 1938, 1941, 1951, 1952, and 1953. Eric Delson returned to the area during his study of the Wood collection; the results of Delson's field work and study of the Wood collection was published in 1971. The assemblage of fossils studied were located as surface finds and do not represent a complete study of the paleontological resources of the area. This preliminary work indicates a large variety of species are represented in the Eocene deposits which are within the irrigation district.

4.2.10.2 Prehistoric values

4.2.10.2.1 Regional

The Middle Fork Region, which includes the Middle and Red Fork of Powder River and their tributaries, is a transitional zone between the Big Horn Mountains and the Powder River Basin. Located in this transitional zone are protected wooded valley bottoms and broken mountainous areas which have provided favorable environments for hunting and gathering peoples since man's first arrival on the North American Continent. Dr. George Frison, Wyoming State Archeologist has stated:

> "There are many problems in plains archeology. One of these concerns the nature of prehistoric occupations along the mountain-plains borders. The Big Horn Mountains present an especially rich area for this kind of archeological study. Ecologically, it is a significant area. One side borders the arid Big Horn Basin and the other side borders the more favorable area of the Great Plains." (Frison, 1974)

Neither northeastern Wyoming nor the Middle Fork Region have been systematically inventoried for prehistoric values. It has been estimated that less than one percent of northeastern Wyoming, including the Middle Fork region, has been systematically inventoried. The current available information on the Middle Fork region has been recovered from widely scattered sites located in non-systematic reconnaissances (usually first reported by local amateur archeologists) or in systematic studies of very limited areas. The conclusion which can be drawn from these studies and the investigations done by the Bureau of Land Management Casper district archeologist is the Middle Fork region is a key area in Wyoming prehistory. Evidence from the reported sites within the Middle Fork region and adjoining areas of the Big Horn Mountains indicate that all known cultural stages for the Northwestern Plains may be represented in yet undiscovered sites in the Middle Fork region.

Important to the archeologist of today, transitional zones are areas of alluvial deposition. The factors of long-term intensive occupation and alluvial deposition increases the liklihood of good cultural preservation.

There have been several reports of "surface finds" of clovis points (11,500 BP to 11,000 BP, Before Present) along the Big Horn Mountains; however, only one site has been investigated by a professional archeologist. This site is on the western edge of the Big Horn Mountains and has been partially excavated by Dr. George Frison and field crews from the University of Wyoming; more excavations are planned.

Scattered "surface finds" of Folsom points (11,000 BP to 10,000 BP) have been reported from the Big Horn Mountains. The only reported Folsom site with stratigraphic context along the Big Horn Mountains has been vandalized to the extent that very little scientific information is available.

"Surface finds" also indicate that all cultural elements of the Plano Complex (10,000 BP to 7,000 BP) made some contact with the Big Horn Mountains.

There is evidence that one projectile point style (and cultural group) of the Plano Complex, the Pryor-stemed, developed in the Big Horn Mountains and adjacent areas of northern Wyoming.

Several sites on the eastern side of the Big Horn Mountains have been excavated which provided information on this cultural unit. The first, 48 JO 303, is located a few miles west of the proposed reservoir; another site (Schiffer Cave 48 JO 319) is located on the North Fork of Powder River north of the proposed reservoir.

The Early Middle Prehistoric period is represented by the McKean Complex (4,500 BP to 2,000 BP). Sites of this age have been found throughout the Big Horn Mountains and adjoining plains. There are three excavated sites near the Middle Fork of Powder River which contained McKean occupational levels (Sween Taylor 48 JO 301, Grey Taylor, and Blue Creeksite). There are indications of intensive occupation of the Big Horn Mountains during this period. The Big Horn Mountains and adjoining areas were intensively occupied during the Late Middle Prehistoric period (2,000 BP to 1,500 BP) and many excavated sites contained this age. Several sites within the area of the proposed Middle Fork reservoir can preliminarily be dated to this period.

The late Prehistoric Period (1,500 BP to 250 BP) is also represented at sites in the Middle Fork region as are sites of the historic period.

4.2.10.2.2 Reservoir site

The valley which would be inundated by the proposed Middle Fork Reservoir has been the subject of two preliminary archeological reconnaissances. The first of these was conducted in August and September,

100 BP 300 BP		Historic Period-Native Americans	Nomadic Bison Hunters
1,500 BP		Late Prehistoric Period	
2,500 BP	Late Middle		Archaic
4,500 BP	Early Middle	Middle Prehistoric Period	Wyoming Basin Foragers
5,000 BP			
7,000 BP		Altithermal	
10,000 BP		Plano	
11,000 BP	Folsom		Big Game Hunters
11,500 BP	Clovis	Paleo Indian	
12,000 BP			

Figure 4.2.10-A

PREHISTORIC CULTURAL OUTLINE - NORTHEASTERN WYOMING

1950 by Robert L. Shalkop, Archeologist with the Missouri River Basin Project. The second was conducted between June and November, 1974 by John Jameson, graduate student of archeology at the University of Wyoming, under the direction of Dr. George Frison.

There is a danger in overusing the preliminary data from the reservoir site in projecting settlement patterns, numbers, or varieties of unknown cultural resources. Another site with the same information (age, type occupation, etc.) may not be found. Each site is a unique occurrence and should be judged as such until a full regional inventory and evaluation has been completed. Sites reported by preliminary research in the reservoir area could be one of a kind, the only site where valuable scientific information can be found.

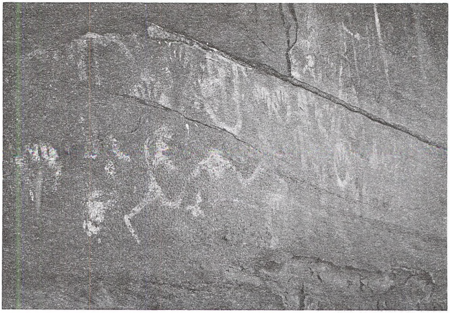
Fifty-six prehistorical occupation sites have been identified by preliminary reconnaissance within the area which would be inundated by the proposed reservoir. For reference in this report these sites will be identified by Bureau of Land Management antiquities site inventory numbers; however, final records of site locations and materials recovered will be kept at the University of Wyoming, Laramie, and the Smithsonian Institution, Washington, D.C., filed under the Smithsonian archeological site numbering system. Each site will not be individually described, nor will exact locations be published in this report to protect the scientific values from vandalism.

Two sites have been identified as eligible for nomination to the National Register of Historic Places (Middle Fork Pictograph-Petroglyph Panels and Castle Rock Archeological Site).

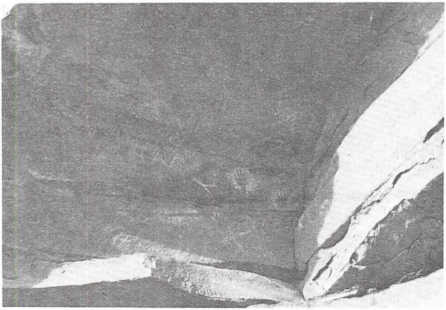
The Middle Fork Pictograph-Petroglyph Panels are situated on private land along the Middle Fork of Powder River, west of Kaycee, Wyoming. There are three large panels along the northwest bank of Middle Fork of Powder River on a red sandstone cliff. The panels have a southeastern exposure. Small overhangs have protected the panels from natural erosion, and at present they have suffered very little from vandalism.

The designs included on these panels are hands, arms, spears, arrows, bear feet, mountain sheep, V-neck human figures, lizard or insect motifs, bear motifs, circles, shields, series of incised lines, squares, and crosses, and other presently nondescript designs. The methods used in making the drawings have not been fully studied; however, preliminary indications are that they include incising, pecking, use of natural paint, and the use of splatterings of mud. Several of the panels have deposits of sand and gravel at the base of the rock wall, and in one case these deposits cover a portion of the panel. Many of the figures appear to have been purposely covered with red mud or partially scratched out.

The Middle Fork Pictograph-Petroglyph Panels are significant and unique examples of prehistoric and native American art forms, which will yield information important to the scientific study and understanding of the prehistoric cultures of the region. These panels also have aesthetic, symbolic, recreation, and human interest value of significance to native Americans and other members of the American public. Dr. George Frison, Wyoming State Archeologist, states: "Many of the figures do appear unique as far as my own experience along these lines can determine. I would recommend that they be nominated to the National Register and some efforts made to protect them."



AR-49-06-28 Pictographs
Figure 4.2.10-B



AR-49-06-28 Pictographs
Figure 4.2.10-C

The significance of these panels not only lies in the number and variety of drawings but also in the uniqueness of many of the individual figures. The hand motif which forms a portion of the panels are of particular significance, for while the hand motif is a standard design in many areas of North America, the use of splattered mud in the motif and the inclusion of the arm seems to be very limited. The current level of study indicates that these hand designs may be unique to this site. Another particular significant figure is a pictograph of a bear over two feet tall, made using a blue paint; the source of the paint material has not been determined at this time. Many of the designs have been covered with mud or scratched out either by the artist or other persons at time of drawing or shortly afterward. This practice may have symbolic or religious significance for the cultural groups or individuals who made the drawings.

The individual figures appear to differ in artistic form and style and may represent several time periods or cultural groups. One portion of the panels contain several square boxes with crosses on top which may represent historic contact with missionaries (a mission was started on Powder River near Dry Fork in 1860). No horse designs have been identified at this time, which indicates a prehistoric age for the panels. The panels contain what appears to be atlatls and others which represent the bow and arrow. The bow and arrow replaced the atlatl on the Great Plains approximately 1,500 years before present. These designs may indicate the age of portions of the panels. The deposits along the base of the panels show some evidence of cultural materials, and scientific excavations may provide information important to the study of the prehistoric cultures which produced these significant examples of rock art.

The Castle Rock Archeological Site is located along the talus slope and old terrace of the Middle Fork at the base of Castle Rock. The site has an eastern exposure and excellent protection from the west. Extending 300 meters along this terrace, which is 30 meters wide, are deposits over 50 centimeters deep containing evidence of two prehistorical occupations. In the bank of one of a series of small arroyos, which cut through the site, a level of bone has been exposed 30 centimeters below the surface. Several fire pits have been identified on the surface.

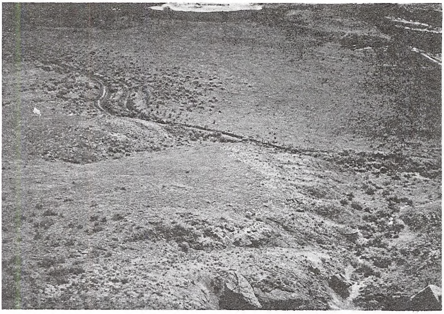
The preliminary archeological studies which have been conducted indicate this site will yield information important in prehistory.

Evidence on this site shows two occupations, one during the Late Middle Prehistoric Period and one during the Late Prehistoric Period. There is a possibility of older remains in stratigraphic context within the alluvial deposits. From the evidence of several firepits there is the possibility of obtaining carbon-14 dates for one or more of the cultural stages represented. One of the projectile points recovered from this site is made of obsidian, which does not occur naturally in the area. This find provides good evidence for prehistoric trade networks between the Middle Fork region and the sources of obsidian (most likely Yellowstone Park or Teton Pass).

The majority of sites (49) reported within the impact area of the proposed reservoir are camp sites on the open terraces of the Middle Fork of Powder River and its tributaries. This relatively high concentration of camp sites indicates how well suited this sheltered valley was to prehistoric occupation. The Middle Fork region has long been known by artifact hunters; preliminary studies of artifacts remaining in local collections denote that large numbers of artifacts were located on the surface of these camp sites. During the reconnaissance of the reservoir area, however, only a few diagnostic artifacts were recovered. Many of these camp sites are so situated that buried cultural deposits are likely.

The oldest evidence recovered on the reconnaissance of the proposed reservoir was from a large camp site (AR-49-209) which contained abundant evidence of prehistoric occupation and a possibility of deposits in good stratigraphic context. One of several projectile points recovered from the site is very similar to a McKean varient (5,000 BP to 3000 BP) found at the Dead Indian Creek site in the Sunlight Basin, northwestern Wyoming. Other projectile points indicate another occupation during the Late Prehistoric Period. Chipped stone tools, including end-scrapers, side-scrapers, choppers, knives, and a few multipurpose tools, accounted for the cultural remains recovered.

Another large camp site (AR-49-26) is even more spectacular and significant than AR-49-06-209. Even though surface indications do not place this site as early, it is larger -- over 300 meters long and 30 meters wide. Evidence on this site shows two occupations, one during the Late Middle Prehistoric Period and one during the Late Prehistoric Period. There is a possibility of older remains in stratigraphic context within the alluvial deposits. In the bank of a small arroyo on the site a level of bone has been exposed 30 centimeters below the surface. From the evidence of several firepits there is the possibility of obtaining carbon-14 dates for one or more of the cultural stages represented at this site. One of the projectile points recovered from this site is made of obsidian, which does not occur naturally in the area. This find provides good evidence for prehistoric trade networks between the Middle Fork Region and the sources of obsidian (most likely Yellowstone Park or Teton Pass).



AR-49-06-26 Prehistoric Camp Site
Figure 4.2.10-D

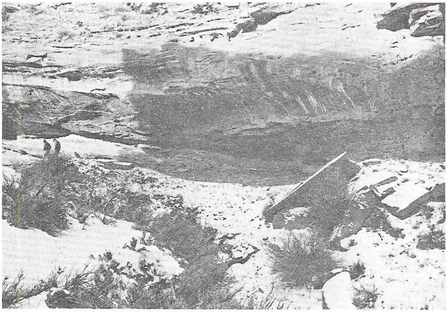
Near the confluence of the Middle Fork and one of its tributaries is another large camp site (AR-49-06-36). A small test trench was excavated in the north end of the site; no cultural materials were recovered below the surface. This may be a fragile surface site or buried deposits may be located in other areas of the site which were not tested. Mitch Johnson (a local rancher) reported seeing "Indians"

(Shoshone) camped on this site during the early 1900's. One obsidian flake located on this site may show association between it and AR-49-06-26.

The preliminary study of these camp sites indicates the valley has been occupied since the Early Middle Prehistoric period, or for over 5,000 years. Evidence from other areas near the reservoir site suggest a possibility of locating older remains. Many of these camp sites are large sites with possible stratigraphic context and more than one occupation. Others represent one age and possibly one short-term camp. These camp sites represent the only known occurrence in the Middle Fork region of Middle Prehistoric Period cultural materials in open sites. Most other Middle Period sites which have been studied are located in rock shelters.

Another type of site represented within the proposed pool area is a rock shelter (AR-49-06-29) located in a small side canyon. The sheltered area is 30 meters long and 3 to 5 meters deep. The ceiling is from 3 to 4 meters high. Under a level of recently deposited animal dung a test excavation revealed a stratified deposit containing fire-cracked rock, charcoal, and Late Middle Prehistoric Period cultural remains.

Located along the red sandstone canyon walls are several spectacular panels of pictographs and petroglyphs (AR-49-06-28, AR-49-06-30, and AR-49-06-43). The designs include hands, arms, spears, arrows, bear feet, mountain sheep, V-neck human figures, lizard or insect motifs, circles, shields, series of incised lines, and other presently nondescript designs. Methods of making the drawings have not been fully



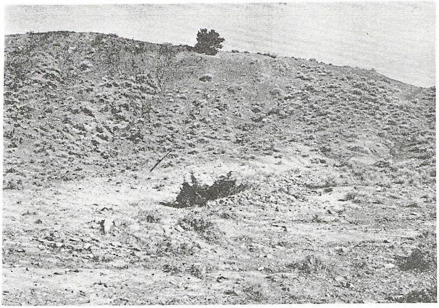
AR-49-06-29 Rock Shelter
Figure 4.2.10-E

studied; however, preliminary indications are that they include incising, pecking, use of paint, and a splattering of mud. (The paint is natural prehistoric paint, not historical.)

A common feature of prehistorical sites in northeastern Wyoming are "tipi rings;" however, on a continental scale they are very limited in distribution, mostly in northeastern Wyoming. Current information indicates that most of these circular stone alignments, 7 to 20 feet in diameter, are associated with camp sites and most likely used to hold the edges of skin or brush shelters. The tipi became a common element of Plains Indian life during the prehistoric period, and studies indicate stones were used for weights during this period. Two individual tipi rings have been located within the reservoir area (AR-49-06-31 and

AR-49-06-216). The exact function of these rings is unknown; however, their use as supports for tipi structures seems most likely.

Another type of stone construction located in the reservoir area are the series of rock cairns at site AR-49-06-215. This type of alignment is restricted in distribution to the Northwestern Plains and adjoining mountains. The exact function of these alignments is unknown; however, the series of cairns at this site and other longer alignments in the Middle Fork region may mark prehistoric trails used for seasonal migrations or trade routes.



AR-49-06-215 Alignment of Rock Cairns

Figure 4.2.10-F

4.2.10.2.3 Road relocation

As stated previously, the Middle Fork region above the proposed high water line has not been systematically inventoried for prehistoric sites. The possible new road locations have not been systematically inventoried; however, there are four known sites (AR-49-06-200, AR-49-06-201, AR-49-06-202, and AR-49-06-203) in the broken hills north of the proposed reservoir. These sites and other reported surface indications from the broken hills indicate that areas above the valley bottoms were occupied, although not as intensively. A systematic inventory of the Middle Fork region above the proposed high water line would most likely locate many more sites of archeological value representing a long timespan of occupation.

4.2.10.2.4 Agricultural water use area

The land which would be irrigated by the Middle Fork Reservoir has not been systematically inventoried. A very limited inventory on a section along Dry Creek north of Kaycee located several sites and indicates further possible sites along Powder River and its tributaries east of Kaycee. In November, 1960, Glenn Sweem and Don Grey of the Wyoming Archeological Society conducted a two-day reconnaissance in the Sussex area; they observed evidence of prehistoric occupation throughout the last 11,000 years. Their reconnaissance consisted of both field reconnaissance and studies of local "point collections." Powder River is the major drainage in northeastern Wyoming and would have provided a watering, hunting, and camping location throughout the Powder River Basin. Although the Powder River Basin has not been systematically inventoried, a few known sites indicate the possibility that sites

Figure 4.2.10-G

HISTORICAL SITES AND THEIR SIGNIFICANCE

Aiken's Cabin	HS-49-06-44	Local
Barnum	HS-49-06-54	Local
Bozeman Trail	HS-49-06-24	National
Cantonment Reno	HS-49-06-06	National Register Site
Champion Cabin	HS-49-06-55	Local
Dull Knife Battle Field	HS-49-06-07	National Register Site
DeSmet Expedition	HS-49-06-56	National
Emergency Landing Strip	HS-49-06-57	Local
Fort Reno (Connor)	HS-49-06-43	National Register Site
Hole-in-the-Wall	HS-49-06-47	National
Homesteads	HS-49-06-58	Local
Lutheran Mission	HS-49-06-49	State
Outlaw Cave	HS-49-06-52	Local
Peters and Alston Ranch	HS-49-06-59	Local
Peters and Alston Cow Camp	HS-49-06-60	Local
Portuguese Houses	HS-49-06-42	National Register Site
Powder River Crossing	HS-49-06-17	State
Sussex	HS-49-06-62	Local
Wagon Roads into Hole-in-the-Wall Country	HS-49-06-63	State
Windsor Cobb and Plunkett Ranch	HS-49-06-64	State

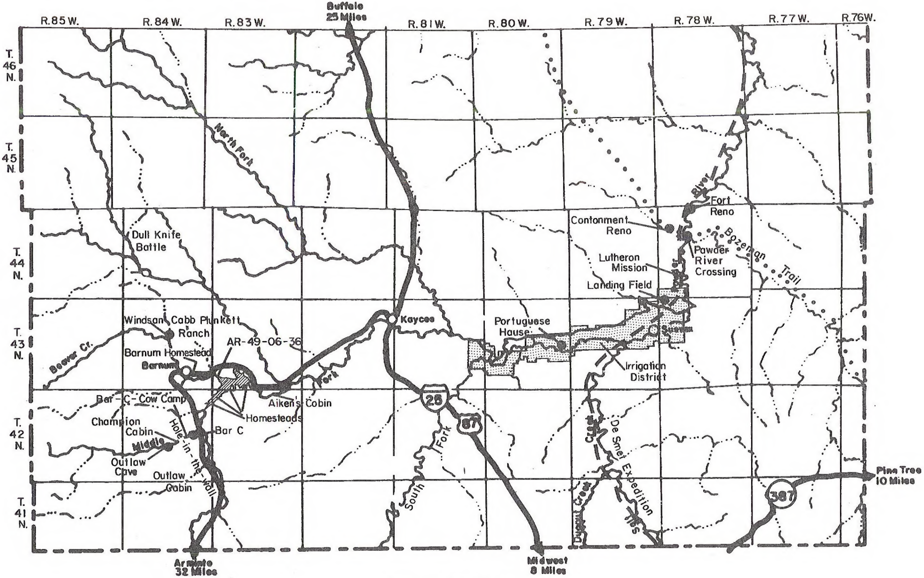


Figure 4.2.10-H

HISTORIC SITES AND TRAILS

representing the full range of human occupation could be found by systematic inventories. This same full range of human occupation may also be found within the irrigated lands of the project.

4.2.10.3 Historic values

4.2.10.3.1 Regional

The Middle Fork region is rich in historic information; sites representing several historic themes and events have been identified by a literature search conducted in preparation for this document. A detailed regional field study has not been conducted and there could be an unknown number of additional historic sites which have not been identified.

During the historic period (1680-1880) the region was occupied at various times by several native American groups including the Arapahoe, Black Feet, Cheyenne, Crow, Shoshone, and Sioux. Many of the known sites which have been studied by archeologists have shown evidence of historic occupation. The last eighty years of Plains Indian occupation was a period of conflict and war.

One of the sharpest engagements of the Indian wars was the Dull Knife Battle (HS-49-06-07) which took place on November 25, 1876, when Col. R. S. Mackenzie attacked the camp of Dull Knife (Cheyenne) along the banks of Red Fork. Several historians and archeologists have found evidence of positions occupied during the battle and the site has changed little from its original appearance. This site has been identified as eligible for nomination to the National Register of Historic Places.

In November 1876, scouts sent out by General Crook discovered a band of about 1400 Cheyenne under chiefs Dull Knife and Little Wolf camped in the upper valley of the Red Fork, one of the headwater streams of Powder River. Crook was searching for the Sioux village of Crazy Horse; however, learning of the Dull Knife band, Crook decided to attack it. General Ranald S. Mackenzie, in command of the Indian scouts and all cavalry except for one company, was sent into the Big Horn Mountains. Mackenzie's effective force was over 1183 men, of whom almost one third were Pawnee, Shoshone, Sioux, Arapaho and Cheyenne scouts.

At daybreak on November 25, troops and scouts attacked the unprepared village of Cheyennes. The Cheyennes, aroused from their beds following celebration of a successful raid against the Shoshones, raced west for cover, ascending the branches of the Red Fork and the slopes of Fraker Mountain. During a hand-to-hand engagement, the heaviest losses of the battle were sustained for both sides, including at least one son of Chief Dull Knife, and Lieutenant John A. McKinney of Mackenzie's force.

For the army the Dull Knife Battle was a significant step in forcing Plains Indian bands to live on reservations, and thereby clear their land for white settlement. For the Northern Cheyenne band under Dull Knife and Little Wolf the battle was a terrible defeat that left them unprepared to face a cold winter, and forced them to seek out others for subsistence. It was an important event that helped bring about the end of a way of life that was known to the Cheyennes along with the Sioux, since some of the defeated Cheyenne joined the army offensive against the Sioux.

HS-49-06-07 Dull Knife Battle Field
Figure 4.2.10-I

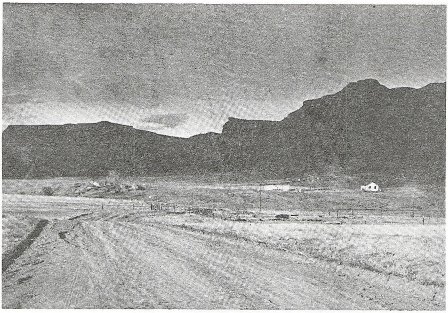
Two open range cattle operations were headquartered in the valley west of the Red Wall. T. W. Peters, an Englishman, was half owner of the Peters and Alston Bar C Ranch (HS-49-06-59) located at the confluence of Middle Fork and Buffalo Creek. The Bar C had a small enclosure around the ranch buildings and a cow camp (HS-49-06-60) one mile to the west. The Bar C is an operating ranch today. Horace C. Plunkett formed a ranch for the Anglo-American Cattle Company in 1879. This ranch, known as the Windsor Cobb and Plunkett Ranch (EK) (HS-49-06-64), was located north of present-day Barnum.

A survey of the region in 1884 to set stone monuments also reported the Aiken's Cabin (HS-49-06-44). The only known information on this site is that it's located below the reservoir site on the present Harlen Ranch.

The location and dates of early homesteads in the region has not been researched; however, some of the earliest were made by ranch hands from the large open-range outfits. Several of these early homesteads were located along Red Fork.

The Johnson County War, 1892, developed out of conflicts of interests between the open-range cattle barons and small homestead ranchers. One early incident involved an attack on Nate Champion (homesteader and ranch hand) at his cabin (HS-49-06-55) west of the Bar C. The two attackers were driven off. Nate Champion was killed in April of 1892 when attacked at the KC Ranch near Kaycee, Wyoming.

The Hole-in-the-Wall country (HS-49-06-47) recently made famous again by a popular movie as an outlaw hideout, consists of a valley approximately 45 miles long and 2 miles wide, bounded on the east side by the Red Wall, a continuous line of red cliffs 100 to 200 feet high. Along the Red Wall there are only four gaps for access into the valley from the east. Groups such as Butch Cassidy, the Currys, the Bassetts, Teton Jackson, the Blackburns, the McCarthys, Robber's Roost gang operated in the area from 1882 until the early 1900's. West of the Red Wall in the bottom of the Middle Fork Canyon is Outlaw Cave which was used at times for outlaw concealment. The entrance to the cave was boarded and reinforced with rock and a fireplace built inside. Vandalism in the last 50 years has removed most evidence of these structures. South along Buffalo Creek from the Bar C is Outlaw Cabin which folklore has identified with the outlaw activities.



Red Wall at Barnum

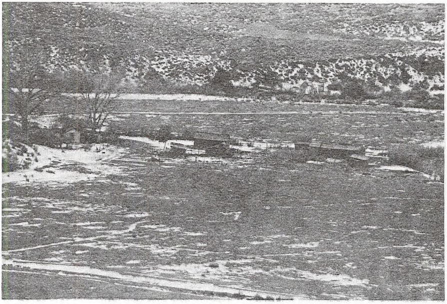
Figure 4.2.10-J

On August 31, 1893, Guy P. Barnum of Riverside (post office in the Hole-in-the-Wall area) filed on the land where the settlement bearing his name is now located. His patent was confirmed January 17, 1902. As the number of people in the region grew the settlement established a post office, school, and community building for dances, parties, sociables, known as the Barnum Dance Hall. Today only the school is in operation.

4.2.10.3.2 Reservoir area

There have not been any historical studies completed specifically covering the proposed reservoir area. Preliminary literature search conducted in preparation for this statement indicates historical values are located in the area.

There are four ranch headquarters started by homesteads in the area, two abandoned, and two currently occupied. The age of existing buildings or locations of other abandoned homestead structures has not been researched. The first homestead was filed for July 29, 1897, and canceled June 30, 1902. Several homesteads were filed and canceled one or more times before final patents were issued between 1900 and 1906. Some of the structures and associated dumps may provide archeological information on the life style of early homesteaders in this area.



Homestead
Figure 4.2.10-K

One of four gaps through the Red Wall is along the Middle Fork of Powder River. A wagon road (HS-49-06-63), which forked at Beaver Creek, was established through this gap to serve the open-range ranch headquarters in the valley to the west. This road was also used by several outlaw groups between 1882 and 1910 as an access route into the famous Hole-in-the-Wall country. This is not the gap which folklore has established as "The Hole-in-the-Wall;" however, it was the major wagon route used. This road continued in use during homesteading days and is currently followed in part by a county road.

This area was utilized for thousands of years as covered in section 4.2.10.2 (prehistory). The area was also utilized by Native Americans through the historic period. As late as the early 1900's, a group of Shoshone Indians camped at site AR-49-06-36 in their travels. Preliminary archeological investigations did not recover any historic cultural materials.

4.2.10.3.3 Agricultural water use area

A detailed historic field search for historic values has not been conducted for the agricultural water use area. Preliminary literature research has identified a rich historic resource in the area and surrounding region.

Antonio Montero established "Portuguese Houses" (HS-49-06-42) on the north bank of Powder River in 1834 while employed by Captain L. E. Bonneville to conduct trade in Crow Indian territory. The site has been identified as eligible for nomination to the National Register of Historic Places.

Very little information is presently available pertaining to the physical nature of the "Portuguese Houses." No part of the original structure remains standing at the site, but surface evidence indicates the presence of a stockaded structure over 100 feet square with buildings placed inside against the stockade wall. Archeological investigation could reveal the general outline and construction of the "Houses."

Except for a few faint depressions and scattered rocks, the site of the "Portuguese Houses" is level field covered with vegetation. A marker has been placed at the site with inscription: "And he took his journey into a far country. St. Luke XV. To mark the site of Portuguese Houses, the first buildings in the State of Wyoming. Antonio Mateo - 1830 - unsuccessfully besieged for forty days by Indians."

The "Portuguese Houses" were not built as a temporary winter quarters but constructed with some thought of permanence. Captain W. F. Raynolds, accompanied by Jim Bridger, visited the site in September of 1859, some twenty-one years after its abandonment. The post was badly dilapidated, and only one side of the pickets remained standing. However, Raynolds commented that the structures consisted of hewn logs, and from their character it was "evident that the structures were originally very strongly built."

The establishment of the "Portuguese Houses" represents one of the earliest attempts in the Rocky Mountain West to develop Indian trade from a fixed post. The date of establishment is generally accepted as being 1834, the same year as Fort William (Laramie) located some 150 miles to the southeast.

Various references, pieced together, provide some general information concerning Montero's activity. He first shows up at the Green River Rendezvous, July 20, 1833, as an associate of the American Fur

Company. The following year Montero was employed by Captain Benjamin L. E. Bonneville to lead a brigade of trappers into Crow Indian territory. Bonneville instructed him to trap in the Crow country, after which he was to winter on the Arkansas River. Striking up a friendship with the Crows, Montero decided to winter on Powder River. A winter cantonment was constructed in the autumn of 1834 about a quarter of a mile from the north bank (left) of the river. The small fort became known as "The Portuguese Houses," allegedly in reference to Montero's nationality. "Fort Antonio" may also have been a designation used at one time.

For approximately four years Montero operated from his post on Powder River, bartering beaver pelts and other furs from the Indians. Fifty or so men in his charge went into the field from the post to trap during the winter seasons.

Throughout its existence, the Montero trading post was subjected to Indian harassment, thievery, low morale, winter hardships, and the injurious competition characteristic of the latter days of the fur trade. According to an account given by Jim Bridger, the fort was held under seige for forty days at one time by the Sioux Indians. The Blackfeet ran off a number of horses during the winter of 1834-35, and the same winter a number of Montero's beaver pelts were stolen. Considerable property came up missing again during the winter of 1836-37, the result of mischief instigated by a large force of Bridger's trappers, assisted by the Crows. By the spring of '37, Montero had very little remaining of the property belonging to the fort, nor anything to show for it. This mischievous war was prompted primarily by the desire of older interests in the fur trade trying to cripple a rival trader.

It is unlikely that the Post saw usage after 1838, although Montero appears to have remained on the frontier for a few more years before finally dropping out of sight.

In 1851, Father DeSmet (HS-49-06-56) traveled down Powder River to Salt Creek and then south on his way to the Horse Creek Treaty negotiations at Fort Laramie. This party traveled relatively light and fast, leaving no identifiable camp sites.

Captain W. F. Reynolds, accompanied by Jim Bridger, visited the ruins of "Portuguese Houses" during September of 1859.

The land within the agricultural water use area was originally homesteaded in the late 1800's and early 1900's. The location and age of homestead structures has not been researched.

Sussex (HS-49-06-62) is a discontinued post office within the agricultural water use area. One report stated Sussex was named by a rancher's wife, Mrs. H. W. Davis who came from Sussex County, Delaware. Others say it was named in honor of the country in which Moreton Frewen was born.

In the region surrounding the agricultural water use are are other sites of historic value which were identified in preliminary literature research.

Moritz Brauninger and three other Lutheran missionaries founded a mission (HS-49-06-49) on the left bank of Powder River near Dry Fork in 1860. This mission was abandoned the same year. The exact site of the mission has never been established.

The Bozeman Trail (HS-49-06-24) or Bloody Bozeman, pioneered by John M. Bozeman and John Jacobs in 1863 followed known Indian, trapper, and explorer trails along the eastern edge of the Big Horn Mountains, crossing Powder River near Dry Fork.

Three miles downstream from Dry Fork is Fort Reno (originally Fort Connor) (HS-49-06-43) established in 1865. Only artifactual debris and archeological remnants remain on the site, which was abandoned in 1868. The site has been listed in the National Register.

The site of Fort Reno is on a high bench located on the left bank of Powder River. Only artifactual debris remains at the site relative to the physical structure of the Fort. The grounds that comprise the Fort site have generally returned to a natural prairie sod cover.

A granite monument marks the site with the inscription "Fort Reno, U.S. Military Post - Established August 28, 1865, abandoned August 18, 1868 - This monument erected by State of Wyoming and the citizens of Johnson County 1914."

Throughout its existence Fort Reno experienced numerous additions, improvements and modifications in its physical layout. Connor's men first built a small stockade of cottonwood logs about 120 feet square. The eight to ten inch logs were set four feet deep in a trench leaving a wall about eight feet high. Inside the stockade was built a quartermaster's and commissary storehouse. Other buildings put up outside the stockade during the fall of 1865 included two barracks, two officers' quarters, a post hospital, shops, teamsters' quarters, and two sutlers' buildings. Under Carrington's command in 1866 a log stockade was placed around the unprotected garrison buildings complete with log bastions on the "northwest" and "southeast" corners. A sturdy adobe commander's quarters was also built during 1866. In 1867 Commander Van Voast relocated the entire west stockade line, tore down the old bastions, and built three new hexagonal blockhouses, a new square bastion, and relocated several of the gates. The construction of a guardhouse, additional warehouses, and the completion of new sinks rounded out the improvements. Apparently no further building was done at Fort Reno prior to abandonment in 1868.

Fort Connor was established on August 14, 1865 by General Patrick Connor during the Powder River Expedition of that summer. November 11, 1865 the Fort's name was changed from Connor to Reno in honor of General Jesse L. Reno, killed September 14, 1862 at the Battle of South Mountain.

The troops from Fort Reno were engaging in the routine duties of garrison life interspersed with more exciting moments involving Indian warfare. The Fort never came under direct attack from the Indians but encounters with them occurred regularly throughout the area and along the trail to the north and south. The Indians frequently ran off stock, both civilian and military, harassed the emigrant trains, and killed a number of individuals who had wandered from the safety of their respective groups.

In accordance with the Fort Laramie Treaty of 1868, Fort Reno was abandoned in August of the same year. Shortly after the military left, the entire post was destroyed by fire. Bodies buried in the post cemetery were later reinterred and placed at the Custer Battlefield National Cemetery during the 1880's.

On the west bank of Powder River opposite Dry Fork Cantonment Reno (Fort McKinney) (HS-49-06-06) was established in 1876. Cantonment Reno has been identified as eligible for nomination to the National Register of Historic Places.

Today no structure remains of the cantonment that was important for a period of two years during the last quarter of the nineteenth century. From 1876 to 1878 Cantonment Reno served the United States Army as a supply post in a campaign against the Sioux, Cheyenne, and Arapaho. Close to the eastern foothills of the Big Horn Mountains and on the western fringe of the Powder River Basin, it was purposely located within the Indian hunting grounds, along a major north-south line of transportation and communication called the Bozeman Trail.

The post had no stockade to enclose it, but rather was spread across a wide, slightly elevated, alluvial terrace. Available nearby was wood for fuel and building construction, water and forage for stock, food in the form of game, and water--although often sour. Situated above the river's immediate flood plain, the terrace afforded a generally dry, level site for the large supply depot. That sage-covered terrace contained the cantonment's main complex of structures and is historically the most significant portion of the mile-wide military reservation.

Although no physical structures remain of the once expansive supply depot, numerous, shallow depressions in the ground are evidence of their former existence. It is known that over 40 major log structures were built at Cantonment Reno during just the first period of construction.

Storehouses, a hospital, huts for officers and enlisted men, outbuildings, stables and corrals were built of logs hewn from cottonwood trees that grow in a belt along the bottomland of Powder River.

Cantonment Reno was established by Captain Edwin Pollock of the Ninth Infantry. Pollock was following orders to select a site on Powder River in the vicinity of the former Fort Reno.

Cantonment Reno played a role in the army's winter campaign of 1876-1877, the high point of which was the defeat of a Cheyenne band under chiefs Dull Knife and Little Wolf on the headwaters of Powder River in the Big Horn Mountains.

In the fall of 1877 a new period of construction was begun at the cantonment with the arrival of three companies of the Fifth Cavalry from the campaign field. Erection of a pine flagstaff on February 1, 1878 completed the construction of Cantonment Reno or Fort McKinney. At peak strength the post contained 358 men, a large garrison by Wyoming military post standards.

The ultimate dissatisfaction of Pollock and his troops with their earthroofed huts led to eventual abandonment of the post and establishment of what is today known as Fort McKinney, located on the Clear Fork. By July 15, 1878 most of Pollock's men had left Powder River for the site of the new post. Meanwhile Cantonment Reno or Fort McKinney was given another designation, "Depot McKinney" as the new post was named Fort McKinney. Except for a small detail which remained to take care of the depot and repair the telegraph line from there, the army had vacated the Powder River post by the end of 1878.

The role of Cantonment Reno in the history of the West is limited mainly to the period 1876-1878, although life at the post did not cease to exist in the latter year. Civilian occupation at this significant crossing on the Bozeman Trail continued until the 1890's, and the general area today still contains a scattered population.

On the east bank of Powder River at Dry Fork, the Rock Creek Stage Company established "Powder River Crossing (HS-49-06-17) 1878 to 1892." In addition to the station, there was a store, hotel, and post office, all partially built of materials salvaged from abandoned Cantonment Reno.

During World War II, an emergency landing strip (HS-49-06-57) was constructed on the northwest bank of Powder River east of Sussex to support the Air Force training in northeastern Wyoming. This field contained lighting but no buildings. No present use is being made of this field.

4.2.11 Aesthetics

4.2.11.1 Reservoir area

The proposed reservoir would be located in an area of high scenic quality but where scenic value would not necessarily be the dominant factor when determining what land management practices or projects should be allowed. Lying in the foothills of the southern Big Horn Mountains and just east of the Red Wall, a major scenic feature of the area, the views from various locations within the proposed reservoir site are of high scenic quality. The east slope of the South Big Horn Mountains is visible in low profile in the background and Castle Rock, a part of the Red Wall, is a prominent foreground-middleground feature at the southwest extremity of the proposed reservoir. Interior views within the reservoir boundaries are the most striking and noticed because of their close proximity to the existing state secondary road. The Middle Fork of Powder River meanders through lush bottom lands and interspersed irrigated farm and pasture land, where in spring and summer the rich green bottomland vegetation contrasted against the flowing water and rock outcrops of the surrounding hills provides a pleasant variety of color, form, line, and texture. Color contrast is also heightened during spring runoff or after heavy rains when the river carries a heavy load of red sediments. Where the river flows through the gap in the Red Wall near Castle Rock, the river bottoms are heavily vegetated with dense growths of willows and cottonwoods. This vegetative pattern continues from the Castle Rock area for approximately two miles downstream where the river flows out of the Red Wall into more open country near the Austin ranch. Various forms of animal life enhance the scenic qualities of the area. Domestic livestock and scattered groups of ranch buildings contribute a pastoral mood while deer, smaller mammals, upland game, raptors, and songbirds provide the wildland scenic resource.

Figure 4.2.11-A
Reservoir site looking west to South Big Horn Mountains

As a person travels the existing highway through the proposed reservoir site, the observer position in relation to the foreground-middleground scene presented is normally either superior (above the surrounding landscape) or normal (at generally the same level as the surrounding landscape). As the observer travels from the west, his position is superior to the river bottom thus providing excellent views of the river meanders and the associated thick willow growth for a distance of just less than two miles between the two points where the highway crosses the river. It is within this area (within which the dam would be built) that the best views of the river bottom are available. The observer's attention is drawn to the river bottom due to the enclosed aspect at this location; the river bottom is completely surrounded

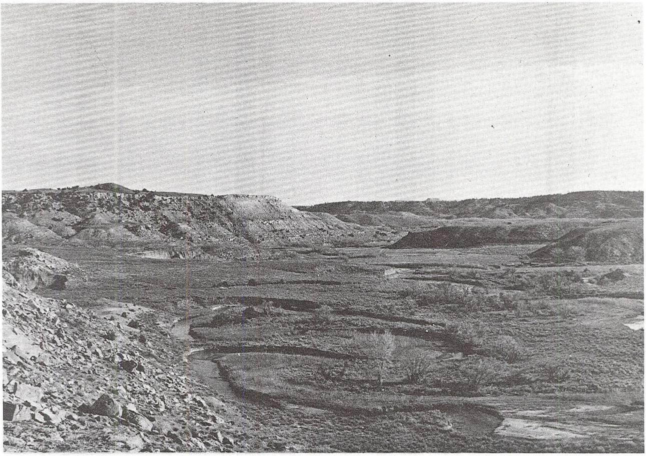


Figure 4.2.11-B
Reservoir site looking east through the damsite.

by the higher bluffs and benches of the river valley. As the observer crosses the river for the second time at the confluence of Beaver Creek, he drops to the level of the river and his position is normal to the surrounding foreground-middleground landscape. At this point the road curves northwest away from the river and the observer's attention is drawn to the middle and background views of Castle Rock, the Red Wall and the Big Horn Mountains.

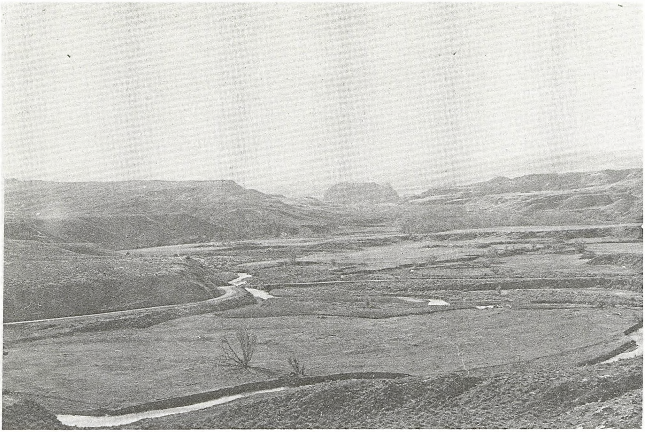


Figure 4.2.11-C
Castle Rock viewed through the reservoir site.

Air quality in the area of the proposed reservoir is excellent. There is only slight dust pollution of temporary duration due to use of dirt roads in the area by local ranchers and recreationists.

Man-caused noise levels in the area are very low with the only sources for such noise being occasional traffic on the existing highway, a limited amount of ranch and farm machinery operating in the area, and an occasional airplane flying overhead. Although slight, the man-made sounds cause some disruption of the otherwise natural audio experience.

4.2.11.1.1 Road relocation

In this section, two aspects of aesthetic quality are discussed in relation to alternative route locations for the state secondary highway which would be displaced by the reservoir. The first of these is the existing scenic quality of the alignments themselves, the second is scenic quality of the surrounding area as viewed from the alternative routes (see Figure 8.3-A).

The proposed road would traverse the south-facing slope of the divide between Middle Fork and Red Fork of Powder River just north of and above the reservoir site. The slope is characterized by extremely rough, highly eroded topography with numerous deep draws. Vegetation consists of grass and sagebrush with scattered juniper and scrub ponderosa pine trees. This disected topography with its numerous rock outcrops and scattered vegetation provides a variety of form, line, texture, and scale. There is color variation although this is generally muted or subdued. There is evidence that the area is grazed by domestic livestock and various forms of wildlife may be observed along the route.

Scenic vistas are excellent from the proposed road location. For most of its approximately four miles, once it turns west from the Brock road, the route is considerably above the reservoir site and most of the surrounding country to the south and west. Although the South Big Horn Mountains on the western horizon are higher, the distance (approximately 15 air miles) makes them appear to be at the same elevation as the observer on the road location. From various points along the route, almost the entire reservoir site and surrounding area are visible and prominent in the foreground-middleground. An important component of this scene are the various groups of ranch buildings and patches of cultivated land and irrigated pastures spread out along the valley

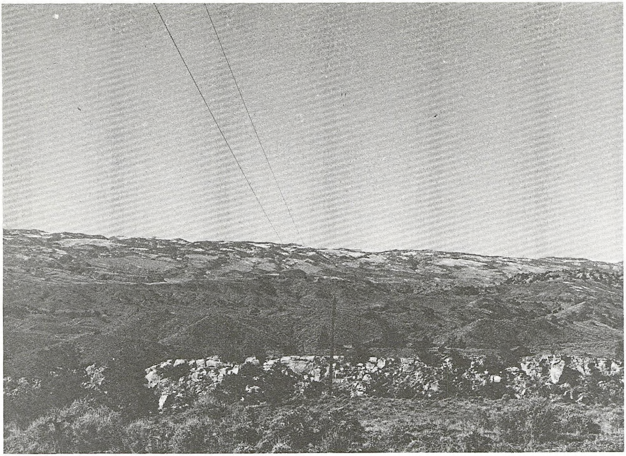


Figure 4.2.11-D
View to the west along the proposed road alignment.

floor. Castle Rock and the thick growth of large cottonwood trees along the river are prominent scenic features from the higher elevation particularly in the spring and summer when there is an extreme color contrast between the red of Castle Rock and the rich green of the vegetation. Because the route lies on the south slope of the Middle Fork-Red Fork divide, there are few opportunities for views to the north over the divide. In the locations where the road would be high enough on this slope the traveler would get glimpses of the color contrasts of the northern extension of the Red Wall along Red Fork of Powder River. Scenic vistas from the top of the divide (above the road) to the north are exceptional. The Red Wall and Gardner Mountain when viewed in contrast with the valley created by the Red Fork provide spectacular variety of all of the basic scenic elements: line, form, texture, scale, and color.

The north bank alternative lies on the bench just above the normal high water line except where the alignment crosses Davis Draw. The scenic characteristics of this route are essentially the same as those of the proposed route with the exception that the bottomland area along the Middle Fork is the prominent foreground-middleground feature. The background views are more limited but are of similar scenic quality and character.

Figure 4.2.11-E
Red Wall north of the reservoir site.

The southern road alternative presents many opportunities for scenic vistas of exceptional quality. To the north, background views of the Red Wall along Red Fork of Powder River and Gardner Mountain, and foreground-middleground of the Middle Fork valley in the reservoir area are the prominent scenic features. To the west, Castle Rock, Steamboat Rock, Middle Fork Canyon, and the South Big Horn Mountains comprise the prominent landmarks. Spectacular foreground-middleground views of the Red Wall from a normal observer position are characteristic on the road segment between Barnum and the Bar C Ranch.

Figure 4.2.11-F
Agricultural water use area

There are presently few unnatural intrusions along any of the identified alternatives. The only evidence of man's presence are a few jeep trails, fences, small power lines and telephone lines. The only exception is the Bar C Ranch headquarters on the southern route where considerable development has taken place.

4.2.11.2 Agricultural water use area

These irrigated and irrigable lands are located on the flood plain of Powder River and the scene presented is characteristic of most irrigated cropland -- a level plain geometrically segmented into variously sized and shaped fields. Color contrast is strong in the spring and summer when crops are being grown in these fields. There are many areas along the river where dense growths of cottonwoods and willows add variety and color to the scene. The landscape can best be characterized as presenting a domestic agricultural scene due to flat topography, cultivated fields, groups of farm and ranch buildings and domestic livestock grazing in the fields.

Because these irrigated croplands provide some wildlife habitat needs, various wildlife species are a component of the scenery. Deer and antelope comprise the big game species and although limited, small numbers of upland game species are present. Red fox are fairly abundant and when seen, enhance the scenic quality of the area.

4.2.12 Recreation resources

4.2.12.1 Area recreation resources

The area considered here consists of significant recreation resources in the South Big Horn Mountain area, primarily in Johnson County, but including portions of Natrona and Washakie Counties.

The proposed reservoir would be situated in an area possessing outdoor recreation potential. Lying in the foothills just east of the Big Horn Mountains, the reservoir would be located along a major access route into the southern Big Horn Mountains. The variety of topography, vegetation, wildlife, cultural resources and other factors inherent in this foothills and mountainous area is generally highly attractive to recreationists, offering a wide variety of outdoor recreation opportunities. Recreation opportunities are also available in Johnson County east of the mountainous region in the plains area, although such opportunities are generally more extensive and are primarily limited to sightseeing, hunting, and cultural resource interpretation.

Due to the lack of large reservoirs there are few opportunities for recreation activities requiring large areas of still water such as pleasure boating, shore and boat fishing, sailing, water skiing, swimming, and ice fishing. The only reservoirs large enough to support these activities are Dull Knife (130 acres) and Lake deSmet (presently 2,653 acres, being increased to 3,599 acres).

In its 1973 Wyoming Statewide Comprehensive Outdoor Recreation Plan, the Wyoming Recreation Commission provides recreation participation data by selected activities in all counties in the State. This data for Johnson County is summarized in Figure 4.2.12-A as estimated for 1970 and projected for 1990. Figure 4.2.12-B identifies major recreation areas in Johnson County.

4.2.12.2 Reservoir area

Existing recreation resource quality within and immediately surrounding the reservoir site varies from low to high for various recreation activities. Almost all of the land within the reservoir site is privately owned, thus restricting public recreation opportunities. Primary recreation opportunities within this area are hunting, fishing, and sightseeing in relation to general scenery, wildlife observation, features of geological interest, and cultural resources. Due to resource character, existing level of development, and land use, this area exhibits no primitive or wilderness potential.

4.2.12.2.1 Zoological

Hunting. Hunting opportunities are best for deer, particularly mule deer. The Wyoming Game and Fish Commission reports the reservoir area provides approximately 80 hunter days for mule deer and 10 hunter days for white tail deer annually. Hunter success is reported by the Commission to be 30 deer per year.

The reservoir area provides poor habitat conditions for upland game thereby providing poor hunting opportunities for these species. Although there have been no hunting seasons for turkeys in this area in past years, some turkeys are present and the Wyoming Game and Fish Commission has indicated they may open a season for this game bird at some future date.

Fishing. Because of heavy sediment loads and high water temperatures in Beaver Creek and heavy sediment loads in Middle Fork of Powder River, the fisheries opportunities are poor on the reservoir site.

Despite these limiting habitat conditions, there are some brown trout in both streams with a few rainbow trout in Middle Fork. An additional limiting factor other than the biological is the private ownership of all lands along these streams. The Wyoming Game and Fish Commission estimates the following existing and potential fisherman use of the streams within the normal high water line of the reservoir:

STREAM	EXISTING USE	FISHERIES CAPACITY
Middle Fork upstream to Beaver Creek	1 fisherman/mile/year	100 fishermen/mile/year
Middle Fork from Beaver Creek to Bar C Ranch	10 fishermen/mile/year	100 fishermen/mile/year
Beaver Creek	12 fishermen/mile/year	36 fishermen/mile/year

Converting these figures to visitor days per year using a length of season of 365 days per year, existing visitor use is estimated at 3.6 visitor days per year and potential use at 36 visitor days per year. In summary, these streams could support a ten-fold increase over present use. No figures are available concerning fisherman success in this area.

Trapping. Although some trapping may occur in this area, the Wyoming Game and Fish Commission keeps no record of this use.

4.2.12.2.2 General sightseeing

The foothills region, where the reservoir would be located, has educational potential related to the sightseeing value of brilliantly colored cliffs and bluffs such as the Red Wall. The cutting action of numerous streams has exposed excellent cross-sectional views anticlines and synclines much as they were formed during geologic uplift of the Big Horn Mountains.

Figure 4.2.12-A

ESTIMATED TOTAL RECREATION PARTICIPATION
IN JOHNSON COUNTY - 1970 and 1990

ACTIVITY	1970*	1990**	% Inc. 90 over 70
Attending Athletic Events	12,007	15,725	31
Boating and Canoeing	4,666	10,974	135
Camping	64,328	110,332	71
Fishing	70,720	99,234	40
Golfing	9,841	20,510	108
Hiking	38,956	57,377	47
Hunting	15,409	16,157	5
Ice Skating	3,412	4,726	38
Picnicking	59,801	98,699	65
Rodeos	11,195	13,056	16
Sightseeing and Pleasure Drives	35,787	46,893	31
Skiing	8,548	11,973	40
Sledding and Tobagganing	1,428	1,978	38
Snowmobiling	4,395	7,934	39
Softball and Baseball	8,409	11,689	39
Swimming	15,902	25,839	63
Water Skiing	1,967	4,095	108
Tennis	1,985	2,775	40
Totals	368,756	559,966	52

* Based on Wyoming population of 332,416
** Based on Wyoming projected population of 384,384

Source: Wyoming Recreation Commission, Wyoming Statewide Comprehensive Outdoor Recreation Plan (1973).

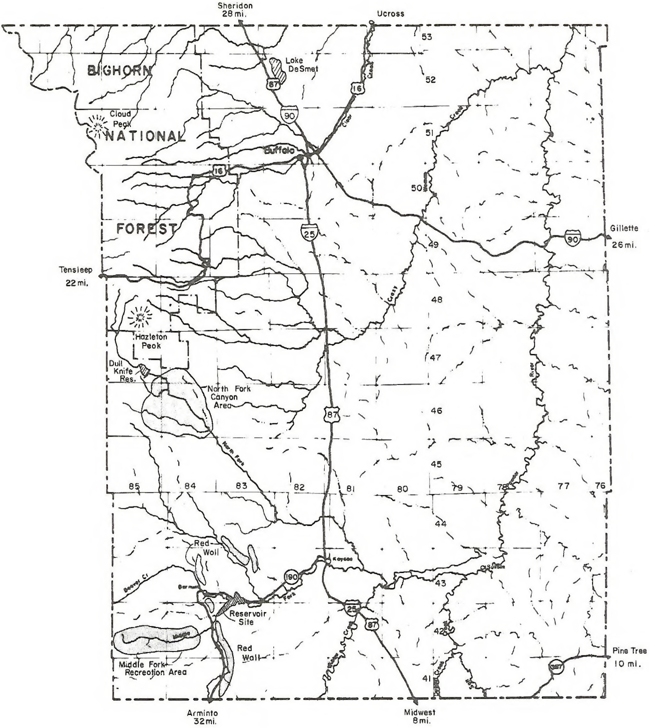


Figure 4.2.12-B

REGIONAL RECREATION RESOURCES

JOHNSON COUNTY

Figure 4.2.12-C
Red Wall viewed from the Barnum area.

Traffic on the state secondary highway in 1973 averaged 260 vehicles per day. If 80% of these vehicles composed the average daylight traffic, then approximately 5,100 visitor days per year can be attributed to general sightseeing in the reservoir area.

Opportunities for wildlife observation are fair in the reservoir site. The most abundant and visible big game species is mule deer although occasional white tail deer will also be seen. Brushy habitat along the river bottom supports many small mammals, songbirds, and small numbers of upland game species. The steep rims along the river valley and the Red Wall provide raptor habitat, thereby enhancing opportunities for observation of hawks, golden eagles, and an occasional bald eagle.

4.2.12.2.3 Cultural resources

Within the reservoir site, nine of the 56 identified prehistoric sites have known interpretive potential for recreation and education in addition to their scientific values. These consist of petroglyphs, pictographs, a series of rock cairns which may mark a prehistoric trail, a rock shelter, and three large camp sites. Pending further intensive archeological inventory, potential exists that other of the identified sites may also have interpretive potential. See Cultural Resources, 4.2.10.2, for additional detail.

Historic resources are numerous and present many opportunities for interpretive development. Of particular significance in the reservoir area are the people, events and sites associated with outlaw activity centered around the Hole-in-the-Wall in the period 1890-1910. A more detailed picture of historic resources is presented in section 4.2.10.3.

Paleontological resources in the reservoir area may provide opportunities for interpretation. A detailed inventory to identify such resources has never been conducted, however, preliminary studies indicate that potential exists as discussed in section 4.2.10.1.

4.2.12.2.4 Road relocation

With the exceptions of hunting and sightseeing, recreation resources along the proposed road alternatives are rather limited.

Hunting opportunities for mule deer are good although this is the only game species which is found in any abundance along the routes. There are no statistics available for game populations, hunter use, or hunter success in these specific areas. Although a large portion of the proposed and north bank routes are on national resource land, public access is presently limited due to poor legal and physical access into this block of public land. The southern route is almost entirely on private land.

There are excellent opportunities for signtseeing from all alternative road locations. Being at a higher elevation than all foreground features and most middle ground features, the observer is afforded sweeping panoramic vistas to the south and west from all alternatives. Good views to the north are available from the southern alternative.

Due to high elevations, there are excellent opportunities for "panoramic cultural vistas." Known recreational potential for interpretation of prehistoric resources along the road alternatives is low, although, future inventory may reveal interpretive opportunities based upon prehistoric resources along these alignments.

Although there are no known historic sites in the immediate area of the road alternatives, high elevations along these routes provide excellent opportunities for sites for historical interpretation.

4.2.12.3 Agricultural water use area

Recreation resources and opportunities are generally limited on the privately owned agricultural lands. Due to private ownership, the lands are closed to public recreation use with the exception of hunting on a fee basis. Only one landowner is known not to charge a trespass fee to hunt on his land.

Hunting opportunities are best for deer, primarily mule deer. Information from landowners indicates that just over 600 people hunted deer on their lands in 1974, with 451 confirmed kills. Antelope provide 20-25 hunter days of use annually with an estimated harvest of 10-15 animals per year (Wilson, 1974). Upland game is not abundant and landowners indicate there is no hunting activity for these species.

Due to poor fisheries habitat and resultant lack of game fish, opportunities of fishing recreation in this stretch of Powder River are essentially non-existent.

General sightseeing opportunities are good (see Aesthetics, 4.2.11.3, for a discussion of scenic values). Based on average daily daylight traffic in 1973 of 232 vehicles, approximately 7,450 visitor days of sightseeing use occurs annually along the highway.

Recreation opportunities based on cultural resources are generally poor. Because there has never been any inventory conducted on these lands, the existence of prehistoric resources of recreational value has not been documented. Evidence exists from scattered archeological discoveries in the region that there were prehistoric peoples in the area and future inventory efforts may identify resources of this type with recreational value and potential. There is virtually no opportunity for interpretation of historic resources in the agricultural water use area. The only known historic site is Portuguese Houses, located on private land. See the appropriate Cultural Resources in section 4.2.10 for additional detail.

4.2.13 Agriculture

4.2.13.1 Johnson County area

The predominant type of agriculture within Johnson County is livestock production. Cattle and sheep are the principal livestock types.

Most ranches utilize grazing land principally and cultivation is largely limited to production of crops which are used as supplemental feed.

Of the total land area of Johnson County 60.8% is privately owned pasture and range land and 32.4% is federal land. Most of the federal land is used for pasture as well, making a total of 93.2% in this category. Only 1.9%, or 50,993 acres, are classed as cropland (Johnson County, a Resource Inventory, Buffalo-Johnson County Planning Office). There are 273 farms or ranches in Johnson County. The average size farm is 7,803 acres (U.S. Dept. of Commerce, 1969 Census of Agriculture).

A large proportion of the western half of Johnson County consists of the Big Horn Mountain range. Many ranches own private land with BLM grazing leases in the South Big Horns area and Forest Service grazing permits in the Big Horn National Forest, in addition to owning private land in the foothills and away from the mountains. These ranches annually move sheep and cattle from winter range to summer range in the mountainous areas. Most ranches are breeding herd operations and very little livestock feeding is practiced. Marketing takes place mainly in the fall.

Other statistical information is contained in Figure 4.2.13-A.

There were 55,283 cattle and calves and 150,795 sheep and lambs in Johnson County in 1964. The numbers increased to 56,995 and 159,516 respectively in 1969 (U.S. Dept. of Commerce, 1969, Census of Agriculture). However, other sources indicate both livestock classes are declining from a peak in 1965 and 1966 (Olson, Morgan, Marquardt, 1971, Vol. II). There is a general tendency in the area toward a decline in

Figure 4.2.13-A

SELECTED STATISTICS OF FARMS AND RANCHES IN JOHNSON COUNTY, 1969

Total land area	2,671,872
Land in farms (including range land)	2,130,277
Percent farmland to total land	79.7
Number of farms	273
Average size	7,803.2
Cropland harvested	32,831
Irrigated land in farms	41,629
Woodland	5,587
Average value of land and buildings:	
Per farm	$270,526
Per acre	$34.66

Source: University of Wyoming, College of Commerce and Industry, Division of Business and Economic Research, Wyoming Data Book 1972, (Laramie: University of Wyo.).

sheep. Many ranchers are shifting from sheep to cattle to take advantage of more favorable economic conditions. Several other classes of livestock are present, but are of only minor importance.

Most of the livestock are produced utilizing native forage. However, winter feeding is usually necessary due to low temperatures and snow conditions. Most of the irrigated acreage is utilized for producing winter feed. Irrigated lands in the county are concentrated along the major drainages. The largest irrigated area is in the vicinity of Buffalo (Piney, Rock, French, and Clear Creek drainages). The Crazy Woman drainage has some irrigated lands, particularly near the convergence point with Powder River (DEPAD, 1969). The other major irrigated area is in the Powder River drainage between Kaycee and Sussex, described in more detail in following sections. Crops grown on the cultivated areas consist almost entirely of wheat, a few other small grains, and alfalfa and grass hay (Census of Agriculture, 1969).

4.2.13.2 Site specific areas

Three specific areas of impact have been encountered: 1) the reservoir site (including the route of the relocated road) in which land is taken out of agricultural production, 2) the vicinity of the route of the transported water, and 3) the agricultural water use area where agriculture would be benefitted through the added irrigation water supply.

4.2.13.2.1 Reservoir area

4.2.13.2.1.1 Inundation and embankment area

In the reservoir corporation's land acquisition program there are six owner-operated ranch units and two ranch units under lease. See the Introduction section for a general discussion of the acquisition program.

The operations involved are basically livestock production oriented. Irrigation and cultivation are mainly for the purpose of raising hay and a small amount of grain for winter feed. There are substantial acreages which have a water right, but are not developed extensively and are irrigated mainly during flooding conditions. Cattle and sheep are the major livestock types, but other typical farm animals are present in minor numbers. A few of the operations have summer range on the Big Horn Mountains to the west and move livestock back and forth annually. Many of the operators have postponed needed improvements in anticipation of the reservoir's construction and efficiency has been lowered in the last few years due to underimprovement. A brief description of each ranch operation follows. The number of acres is given of each land type to be inundated by the reservoir to the 5,019.5 foot elevation (maximum high water line). The taking would involve around another 270 acres in the buffer zone to the 5,030 foot elevation, but the land would still be useable at no charge to the rancher. (See Table 5.12-A for a summary of the acreages involved.) No wild free-roaming horses or burros are present on the site.

Ranch operation 1. This unit is under lease to the owner of ranch operation 7. The ranch consists of a total of 600 acres, located mostly below the damsite. Of the total, 50 acres are irrigated and 550 acres are grazing land. The reservoir land acquisition program would involve 15 acres of irrigated stream bottom land and 17 acres of other stream bottom and adjacent land classified as non-irrigated grazing land, or a total of 32 acres, used mostly as winter pasture for sheep. The land to be taken would amount to around 3 animal units of carrying capacity.

(An animal unit consists of year-round support for one cow and calf or five sheep.) Improvements on the land to be taken consist of fences, an old log cabin of minimal value, and a shallow well in the vicinity of the cabin.

Ranch operation 2. This unit consists of 5,279 acres of deeded land plus 3,397 acres of national resource land leased from the Bureau of Land Management under Section 15 of the Taylor Grazing Act, hereafter termed a Section 15 grazing lease. Of the total deeded land, 70 acres are classed as irrigated pasture, and 5,150 acres are grazing land. The total operation amounts to several hundred animal units. The land acquisition program would involve 38 acres of grazing land, used mainly for winter pasture for sheep, or around one animal unit of forage. No improvements are involved except fences.

Ranch operation 3. This operation has its main headquarters around 4 miles distant and separated from the tract in question. The total operation amounts to around 140 animal units. The isolated tract contains 240 acres. Ownership of the tract provides the necessary contiguous land for issuance of a Section 15 grazing lease of an additional 763 acres of national resource land. The reservoir land acquisition program would involve 60 acres of irrigated land, 21 acres of non-irrigated stream bottom land, and 100 acres of grazing land (a total of 181 acres). This land represents 40 to 50 animal units of grazing capacity in the operation. It is used generally as spring and fall grazing land and no hay has been raised on the land recently. Improvements consist of fences and buildings, including a small house, garage, barn, and chicken house. The buildings are unoccupied and are in a somewhat weathered condition.

Ranch operation 4. This operation consists of 276 acres total of deeded land and 766 acres of national resource land under Section 15 grazing lease, which together would support around 85 animal units. There are 40 acres of irrigated cropland in hay, 20 acres of irrigated pasture, and 211 acres of grazing land. The reservoir land acquisition program would involve 25 acres of irrigated cropland, 10 acres of irrigated pasture, 20 acres of creek bottom pasture, and 21 acres of grazing land (total of 76 acres). The hay and pasture land is used for grazing, mainly in winter. The taking constitutes around 8 animal units of grazing capacity in the ranch. There are no improvements involved in the taking other than boundary fences.

Ranch operation 5. The original operation consisted of 5,516 acres total of deeded land and 639.42 acres of national resource land under Section 15 grazing lease. Of the deeded land, 60 acres are irrigated cropland, 20 acres are non-irrigated stream bottom land, and 5,412 acres are grazing land. Of the grazing land, 2,880 acres are isolated several miles distant. The owner also leases the land in operation 6. The operation has the potential for around 250 animal units of carrying capacity, but is currently stocked at a rate of between 125-150 animal units in anticipation of the reservoir project. The reservoir corporation has purchased the lands needed for the project and leased them back to the former owner. The lands taken consist of 60 acres of irrigated cropland, 56 acres of non-irrigated stream bottom land, 20 acres of irrigated pasture, and 130 acres of grazing land (total of 266 acres). This hay land and pasture is grazed by cattle and sheep, mainly in winter. The taking also involves the headquarters area. This taking is vital to the ranch operation as it now exists, since it constitutes nearly 225 of the 250 animal units estimated to be the total available in the ranch.

The improvements involved in the taking consist of the ranch headquarters (one old house, one newer house, a chicken house, a barn and corrals, a cistern, and fences), and a few miles of boundary and interior fences removed from the headquarters area.

Ranch operation 6. This operation has been acquired by the reservoir corporation in an exchange of lands. It is under lease by the owner of operation 5. It consists of 435 acres. Of this total, 50 acres are irrigated cropland, 30 acres are irrigated pasture, and 355 acres are grazing land. The reservoir land acquisition program involves 50 acres of irrigated cropland, 30 acres of irrigated pasture, 80 acres of stream bottom pasture, and 165 acres of grazing land (total of 325 acres). At the present time, the lessee grazes this land in winter and spring in connection with his adjacent operation. Improvements involved consist of a house, barn, shed, corrals, fences, and a non-movable cistern. The buildings are unoccupied, largely unused, and in a somewhat weathered condition.

The taking would involve all irrigated land and would leave only 110 acres of grazing land, thereby reducing the operation from a marginal economic unit to three irregular, isolated parcels providing approximately three animal units of forage.

Ranch operation 7. This operation consists of 1,426 acres of deeded land and 493 acres of national resource land under Section 15 grazing lease. The owner also leases the land described in operation 1. Of the deeded land, an estimated 60 acres are irrigated cropland, 47 acres are non-irrigated stream bottom land, and 386 acres are grazing land. The reservoir land acquisition program would involve 60 acres of irrigated cropland and 65 acres of non-irrigated stream bottom classed as grazing land (total of 125 acres). The pasture is grazed by cattle and sheep, mainly in winter. The operation is currently supporting 700 animal units. The taking constitutes an estimated 500 animal units considering its effect on the overall operation and the amount of carrying capacity which would remain in the ranch.

Improvements involved in the taking consist of one older house, one newer house, one granary, one tack room, two sheds, one roping arena, corrals, and a few miles of boundary and interior fences in good condition.

Ranch operation 8. This operation consists of two separate ranches, one to be impacted by the reservoir construction and one to be benefitted by the additional water to be made available by the reservoir. The ranch near the reservoir site consists of 3,880 acres of deeded land and 5,686 acres of national resource land under Section 15 grazing lease. Of the deeded land, 215 acres are irrigated cropland, 100 acres are irrigated pasture, and 2,765 acres are grazing land. The lower ranch includes 597 acres of irrigated cropland which will receive a proportionate share of the irrigation water. The reservoir land acquisition program would involve 10 acres of irrigated cropland, 10 acres of stream bottom land receiving some overflow irrigation and 40 acres of grazing land (total of 60 acres). This land is grazed, mainly in winter and spring by cattle. No improvements are involved other than a short segment of the boundary fence. The taking constitutes approximately three animal units in the overall ranch operation.

4.2.13.2.1.2 Relocated road

The route of the relocated county road has not been finalized yet. It is estimated the actual new road construction would be around six miles long. Only an estimated three quarters to one mile of the road would be located on private land in two approximately equal segments and the remainder would be on national resource land. Assuming the road right-of-way will be 100 feet wide, the total land to be involved would amount to around 70 acres. The private land involved would amount to around 12 acres and the remainder would consist of national resource land.

The route is through strictly grazing land; no other land types are involved. The right-of-way would traverse an estimated 18 acres of the hillside vegetation type (see Vegetation section) with an estimated grazing capacity of 4 acres per AUM and 52 acres of gradation between the badlands and hillside types with an estimated grazing capacity of 10 acres per AUM. Therefore, an estimated 8 to 10 animal unit months of forage is involved in the road construction.

4.2.13.2.2 Agricultural water transportation route

This includes the existing stream channel from the damsite to the Sahara ditch diversion structure, involving an estimated 20 miles. Several ranches are located along the stream in this area and the town of Kaycee is located at the crossing of Interstate 25. These ranches are similar in nature to those of the reservoir basin vicinity. Livestock production predominates with slightly more cultivated land than the upstream ranches, but considerably less cultivated land than the ranches farther downstream inside the irrigation district.

4.2.13.2.3 Agricultural water use area

Ranching and livestock farming are the main agricultural enterprises associated with the irrigated lands. The major crops grown are improved varieties of grasses, alfalfa, corn, small grains, and sorghum. The lands provide both a summer and winter base in forage production for livestock operations. Peak stream flows usually occur during the month of June, with the annual discharge fluctuating widely from year to year. Such conditions create a water shortage annually in July and August and an undependable supply yearly for irrigated agriculture. Forage crops are best suited to such conditions and if extra water were available in July or August additional cuttings could be anticipated. The excess of water during May and June results in the wild flooding of as many acres as possible, and some fields are planted at the risk that additional water may not be available. Attempts to utilize spring flows as they occur require extensive and large water distribution systems. Such systems become a high fixed cost and are considered poor water management when the entire length of growing season cannot be utilized under a limited available water supply.

Drainage, particularly surface ponding is a problem, and some drainage facilities have been installed within the area.

Commercial fertilizer is sparsely used as its benefits are closely associated with having a full water supply.

4.2.14 Transportation networks

The transportation networks that may be involved with the proposed project are highways, including streets, roads, and freeways, and pipe lines and transmission lines. Only a portion of the regional networks affect the project area. Two areas are considered here: Johnson County and the Barnum, Kaycee, Sussex area.

Highways. Highway routes in Johnson County are shown on Figure 4.2.14-A. The county is well served with highways into and out of the area, both north/south and east/west. A 20-mile portion of Interstate 25 has not been completed extending south from the southerly border of the county.

Access to the proposed reservoir site is from Interstate 25 at Kaycee by state route 190, a two lane farm to market type road which is blacktopped as far as the site of the proposed reservoir. A portion of this road would have to be relocated if the reservoir is constructed. It provides access for residents, primarily agriculturalists, and recreationists to the area west of Kaycee.

The area to receive agricultural water from the proposed reservoir is to the east of Kaycee, toward Sussex, and is reached by state route 192, a two lane, paved farm to market type highway.

Figure 4.2.14-B indicates traffic volume in terms of the number of vehicles passing through in a 24-hour period.

Traffic on route 190 averaged 260 vehicles per day in 1973 and route 192 averaged 310 cars per day. During the same period Interstate 90 averaged 1,700 vehicles per day just east of Buffalo.

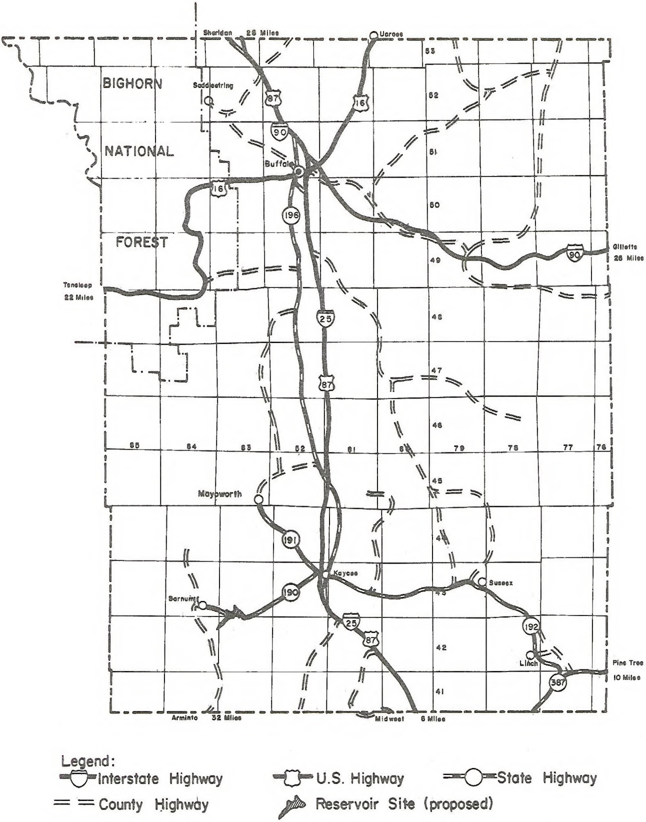


Figure 4.2.14-A

HIGHWAY MAP

Source: Wyoming Highway Department

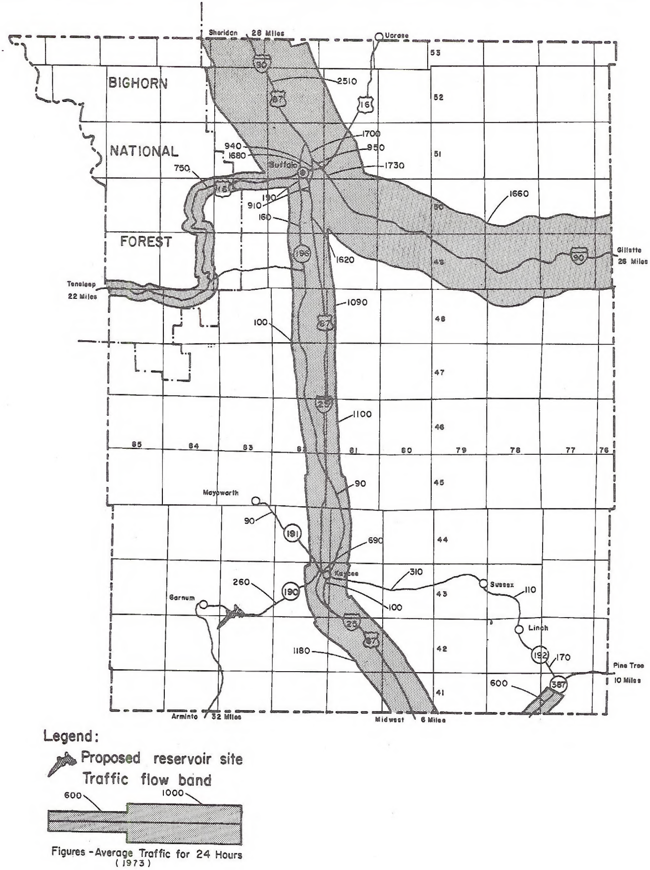


Figure 4.2.14-B

TRAFFIC FLOW MAP
Average Daily Traffic

Source: Wyoming Highway Department

Pipe lines and transmission lines

Major oil and natural gas pipe lines and electric transmission lines within Johnson County are shown on Figure 4.2.14-C. The pipe lines shown are engaged primarily in the transportation of petroleum products from oil and gas fields. The products include crude oil, natural gas, gasoline, propane, and butane. An existing 161 KV electric transmission line traverses the county in a north/south direction between Sheridan and Casper. Another transmission line is proposed that would go east from Buffalo through Gillette with a 161/230 KV capacity.

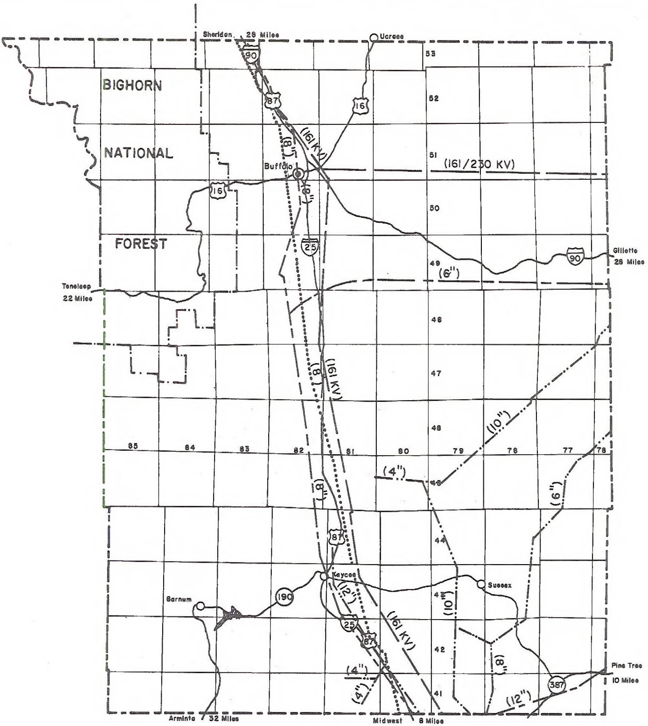
Pipe lines and transmission lines traverse the project area in a north/south direction and are generally east of Kaycee. They do not affect the area of the proposed reservoir and should not affect the agricultural area receiving water.

4.2.15 Land use controls and constraints

Federal, state, and local governmental entities exercise certain types of land and resource use controls over portions of Johnson County and the project area. The Bureau of Land Management administers some 500,000 surface acres in Johnson County and the Forest administers more than 300,000 acres (a portion of the Big Horn National Forest) in the county.

Controls are effected through issuance or nonissuance of a variety of leases, permits, licenses, etc. Each authorization to use federal lands contains provisions to control that use.

A number of state agencies have authority over state owned lands. Additionally, under state statutes the State is authorized to perform



Legend:
- — — Oil
- — - — Gas
- ——— ——— Electric Transmission (proposed)
- ············ Products
- Reservoir Site (proposed)

Figure 4.2.14-C

PIPELINES AND TRANSMISSION LINES

Source: Energy Resource Map of Wyoming, 1972, Wyoming Geologic
Oil and Gas Fields and Pipelines of Wyoming, U.S.G.S., 1974 Survey.

and administer certain surface land use, planning, and development activities. Federal properties are not under state control, except as provided by law. Except where controls have specifically been delegated to counties or municipalities, the State has total jurisdiction over state and privately owned lands. The Environmental Quality Act of 1973 authorizes the State to control air quality, water quality, and solid waste management.

State statutes enable counties to effect a wide variety of controls. This applies to the unincorporated portions of the county. A county may regulate and restrict location and use of buildings and structures and use, condition of use or occupancy of lands for residency, recreation, agriculture, industry, commerce, public use, and other purposes. The authority does not apply to zoning controls over lands used or occupied for the extraction or production of minerals.

Where a county or city lacks a specific authority, provisions of the Wyoming Joint Powers Act are available to enable joint exercise of power, privilege or authority. This legislation enables specifically, two or more agencies such as cities and counties, or counties, to jointly plan, create, finance, and operate (control) water, sewage, or solid waste, fire protection, transportation, and public school facilities.

Buffalo and Kaycee are the only incorporated communities in Johnson County. The statutory authority for cities to control land use is quite restrictive. They may effect a master plan, zoning, and other regulatory controls, but may not effect controls over minerals extraction or production within their corporate limits. The Wyoming Environmental Quality Act of 1973 preempts incorporated communities' authority to regulate and control air, water, solid waste, and land quality standards except where control is specifically delegated.

In summary, the respective jurisdictions have sufficient authority to impose land and resource use controls.

Local regulatory structures. The Johnson County Commissioners enacted countywide mobile home and subdivision regulations in November 1973. Proposed county zoning was defeated in early 1972.

The Johnson County Planning and Zoning Commission was formed in March 1972 in a cooperative effort with the City of Buffalo Planning and Zoning Commission. The commissions hired the first planner for the area in September 1972 and established the Buffalo-Johnson County Planning Office. While primary concern has been related to Buffalo and the adjacent area, the county has adopted countywide regulations for subdivision and mobile homes. A comprehensive plan is being developed concentrating on the Buffalo area, as this area is experiencing rapid growth related to energy development. Planning for the Kaycee area is anticipated in the next few years.

Opposition to land use planning and regulation has been strong in the Kaycee area as in much of the State. However, while local government is actively working on land use problems it is limited in its effectiveness by opposition to infringement of private property rights and limited enabling legislation at the state level.

4.2.16 Socio-economic patterns

4.2.16.1 Population

Since 1950, the county population has grown by 880 people to 5,587 people in 1970, and the population of Buffalo, the county seat, has increased by 720 to 3,394. In the 1960-1970 decade, the population in Johnson County and Buffalo grew 2.0 percent and 16.8 percent, respectively. Kaycee, which was not incorporated in 1950, experienced a 4.2 percent decline in population from 284 persons in 1960 to 272 in 1970.

In 1970, approximately 60.7 percent of the county population resided in Buffalo, the only city with 2,500 or more population in the county. The county population density in 1970 was only 1.3 people per square mile, below the 3.4 state average.

Social characteristics of the county population

Figure 4.2.16-A indicates population distribution by age, sex, ethnicity, and the educational level of persons 25 years old and over. The majority of the county population is between 18 and 64 years of age (52.6%) and racially white (97.5%). The population distribution by sex is approximately even (50.2% male, 49.8% female). People 25 years old and over in the county had a 12.2 median number of school years completed, slightly above the 12.1 national average. The county's percentage of persons (25 years old and over) with four years of high school or more (59.1%) surpasses the 52.3 percent national average. However, the county's percentage of persons with four or more years of college (9.2%) is below both the state average (11.8%) and the national average (10.7%). Because of the lack of business opportunities and reduced needs of a

Figure 4.2.16-A

POPULATION DISTRIBUTION BY AGE, SEX, ETHNICITY
AND YEARS OF SCHOOL COMPLETED

1970

	JOHNSON COUNTY	STATE
Total population	5,587	332,416
Percent under 18 years	34.4	36.1
Percent 18-64 years	52.6	54.8
Percent 65 and over	13.0	9.1
Male (percent)	50.2	50.2
Female (percent)	49.8	49.8
White - number	5,448	305,073
- percent	97.5	91.8
Black - number	3	2,568
- percent	0.1	0.8
Spanish - number	102	17,951
- percent	1.8	5.4
Indian - number	22	4,980
- percent	0.4	1.5
Other - number	12	1,834
- percent	0.2	0.5
Total number of persons 24 years old and over	3,217	175,649
Four years of high school or more - number	1,901	110,397
- percent	59.1	62.9
Four years of college or more - number	296	20,693
- percent	9.2	11.8
Median school years completed	12.2	12.4

Source: U.S. Department of Commerce, Bureau of the Census, Census of Population, 1970.

small population for professional services, it is likely that people with four or more years of college education would find work in larger urban centers, both in and out of State.

4.2.16.2 Employment

Total employment within Johnson County increased by 12 percent during the ten-year period 1960 to 1970. This increase resulted primarily from increased employment in the other residentiaries sector, which includes three service sectors: a) consumer service which exists primarily to serve local households, exclusive of governmental and educational service; b) government and education services and public administration as well as military employment; and c) business services which exist in large part to provide services to the business community. Figure 4.2.16-B summarizes county employment for 1960 and 1970. The 1970 unemployment rate for Johnson County was 1.7 percent. Similar information is not available for Kaycee and Buffalo.

4.2.16.3 Income

The median and mean 1970 income levels for Johnson County were $8,263 and $11,389, respectively. Forty and six tenths percent of the families had incomes of $10,000 or more a year and almost 20% exceeded $15,000 per year. Thirteen and three tenths percent of the families had incomes less than poverty level ($3,328 per year or less for the average family). The figure varies with family size, farm, non-farm residence, and sex of family head. Figure 4.2.16-C shows income distribution compared with state averages.

Figure 4.2.16-B

EMPLOYMENT SUMMARY FOR JOHNSON COUNTY

	1960		1970	
	Number	Percent	Number	Percent
Population	5,475		5,587	
Employment				
Agriculture	549	27.9	410	18.6
Petrochemicals				
Petroleum & Natural Gas	146	7.5	101	4.6
Synthetic Gas				
Coal Mining	-	-	34	1.5
Uranium Mining & Milling	3	0.1		
Power Generation				
Other Mining	2	(insig.)	19	0.9
Other Manufacturing	63	3.2	44	2.0
Railroads				
Construction	235	12.0	294	13.4
Other Residentiaries	968	49.3	1,300	59.0
Total Employment	1,966	100.0	2,202	100.0

Source: University of Wyoming, Water Resources Research Institute (1974)

Figure 4.2.16-C

INCOME DATA BY FAMILY INCOME GROUP

1970

Family Income	Johnson County Percent by Group	Johnson County Number of Families	State Percent by Group	State Number of Families
0 to $ 4,999	24.8	374	20.3	17,154
$ 5,000 to 7,999	23.6	356	21.6	18,262
8,000 to 9,999	10.9	165	15.9	13,466
10,000 to 11,999	10.9	165	13.5	11,448
12,000 to 14,999	10.7	162	13.1	11,115
15,000 or more	19.0	287	15.6	13,258

	Johnson County	State
Total families	1,509	84,703
Median income	$ 8,263	$ 8,943
Mean income	$11,389	$10,127
Per capita income	$ 3,421	$ 2,910

Source: U.S. Department of Commerce, Bureau of Census, Census of Population: 1970

4.2.16.4 Housing

There were 2,255 houses in the county, 83.5% of which were occupied in 1970. Buffalo had 1,295 of the county's housing units, of which 92.9% were occupied. Data was not collected for Kaycee; its housing was counted with the 960 houses outside of Buffalo. More than two thirds of the housing was occupied by its owners, which was typical for the State. Buffalo and the county had smaller household sizes than the State (2.8 and 2.9 persons per household vs. 3.1 for the State) and the renters household size tended to be smaller than the owners-occupier's, also typical of the State. Figure 4.2.16-D shows the distribution of houses by type and age for Buffalo, the county, and the State.

4.2.16.5 Schools

All schools in the county are administered by the Johnson County Unified School District. There are 6 elementary schools (2 1-8, 2 1-6, and 2 1-4) and 2 high schools (9-12). Total district enrollment in fall 1974 was 1,264 students. With 76 teachers the district has less than 17 students per teacher.

Figure 4.2.16-E indicates the grade levels, current enrollment, and maximum enrollment capacity for each school. In Buffalo, enrollment is under capacity in high school by 26%, and over capacity in elementary school by 2%. Kaycee's enrollments are under capacity in both elementary and high school by 29% and 50% respectively. In rural schools, enrollments range from 7 to 31 pupils per school, significantly under their capacities. All high school, seventh and eighth and some fifth and sixth grade students are taught in either Buffalo or Kaycee.

Figure 4.2.16-D

SELECTED HOUSING CHARACTERISTICS, 1970

	BUFFALO	JOHNSON COUNTY		STATE
		TOTAL	RURAL	
Population per Household				
All Households	2.8	2.9	3.1	3.1
Owner Occupied	2.9	3.0	3.1	3.2
Renter Occupied	2.6	2.8	2.9	2.8
Total Year Round Houses	1,319	2,158	839	114,572
Single Family Units	1,009	1,684	675	85,163
% of Total	76.5	78.0	80.5	74.3
Multiple Family Unit	254	277	23	19,153
% of Total	19.3	12.8	2.7	16.7
Mobile Homes	56	197	141	10,256
% of Total	4.2	9.2	16.8	9.0
Age of Structures				
Built before 1940	728	1,118	390	49,055
% of Total	55.2	51.8	46.5	42.9
Built after 1968	38	60	22	3,144
% of Total	2.9	2.8	2.6	2.7

Source: U.S. Bureau of the Census, Census of Housing: 1970

Figure 4.2.16-E

JOHNSON COUNTY UNIFIED SCHOOL DISTRICT, 1974

TYPE AND NAME OF SCHOOL	NUMBER OF TEACHERS	GRADE LEVELS	CURRENT ENROLL-MENT	MAXIMUM ENROLL-MENT CAPACITY	PERCENT OF MAXIMUM ENROLLMENT CAPACITY
City of Buffalo					
Elementary	32	1-8	663	650	102.0
High School	24	9-12	370	500	74.0
Town of Kaycee					
Elementary	8	1-8	128	180	71.0
High School	6	9-12	50	100	50.0
Rural Schools					
Billy Creek	1	1-4	9	40	22.5
Kearney	1	1-4	6	20	30.0
Linch	3	1-6	31	125	24.8
Sussex	1	1-6	7	50	14.0
TOTALS	76		1,264	1,665	75.9

Source: Mr. Gerald Carroll, District Superintendent, Johnson County Unified School District, October 1974

4.2.16.6 Health and social services

Health and social services in Johnson County are limited and those available are located in Buffalo. Individuals seeking such services must either go to Buffalo or to some other urban area such as Casper or Sheridan. To improve access to health facilities, Buffalo has an ambulance service and Kaycee has a volunteer ambulance and emergency crew. When specialized service is required it is not uncommon for the patient to go to Billings, Montana or Denver, Colorado. Such practices are often found in rural areas.

Health facilities available in Buffalo include: a 26 bed hospital; a 40 bed nursing facility; a clinic with three doctors and a physician's assistant; a dental clinic with two dentists; a mental health center with a phychiatrist, nurse, and two visiting psychiatrists; and the 70 bed Soldiers and Sailors' Home. Social services are provided in the county by the State Division of Public Assistance and Social Services, through its Buffalo office.

4.2.16.7 Law enforcement

Johnson County's Sheriff's Department, the Buffalo and Kaycee Police Departments and local units of the State Highway Patrol provide local law enforcement services. Most of their work results from alcohol problems such as public drunkenness, drunk driving and underage drinking.

4.2.16.8 Water and sewer

Water and sewer needs in Johnson County are usually met through use of water wells, ditch water, and septic tanks. Buffalo and Kaycee own and operate their respective municipal water and sewerage systems. The

Buffalo water system has recently been improved and the sewerage system is currently being studied to determine how needed improvements can best be accomplished. Kaycee's water and sewerage systems are adequate in terms of capacity. Its water quality was questioned in a study, The Comprehensive Plan for Water and Sewerage in Johnson County, Wyoming, 1969, by the Wyoming Department of Economic Planning and Development and R. D. Connell and Associates, and without corrective action, water supply may be a problem in the future. Kaycee's sewerage system is designed for easy expansion as need arises.

4.3 Introduction - Assumed industrial use of water

This section describes the existing environment within which the assumed energy related industrial development may occur. This area is that part of the Powder River Basin in Wyoming lying generally eastward from the Powder River to the outcrop line of the coal resource and from somewhat north of Gillette to a point south of Douglas (see map on page 1-6). Obviously, the companies may also have options for coal development outside this arbitrary boundary.

Those components having a broader scope of geographic impact such as social conditions, economic factors, atmospheric influence, water resources, and recreation are discussed on a larger regional basis.

The Description of the Existing Environment contained in Volume I, Final EIS (FES 74-55) pages I-115 through I-458 of the Eastern Powder Coal Basin of Wyoming, dated October 18, 1974, contains a description of this area of consideration. This material for all components of the existing environment as contained in FES 74-55 is hereby incorporated in this draft EIS by reference.

Since the final EIS for the Eastern Powder River Coal Basin was released, several land use laws have been enacted by the State of Wyoming. These two laws affect the land use controls and constraints component of the existing environment.

The 1975 State Industrial Facilities Siting Law requires application for a permit for construction of such major facilities as powerplants and synthetic fuel plants, plus any other facility estimated to cost over 50 million dollars; control includes the authority to deny a permit for any of certain specified reasons.

The 1975 State land use planning legislation provides State oversight to local planning activities, authorizes grants to local governments for planning, and mandates such governments to develop local land use plans.

4.4 Possible future environment without project implementation

The purpose of this section is to provide a base for comparison by describing what the future environment may be without implementation of the proposed project, in this case, a 50,000 acre-foot reservoir which would provide water for agricultural and industrial development. This description will include other proposed developments which may be implemented in the area and how they may cause a change in future conditions.

Without project implementation, the environment at the reservoir site would be unaltered and would be expected to remain as described in the section on existing environment (4.2). No changes would be anticipated in agricultural water use patterns and no new acreage would be cultivated. As such, the area would also remain essentially as described in section 4.2.

Although other proposed and potential developments would alter the future environment of the area, these would be primarily energy related with coal as the basic resource. The developments include expansion of existing coal mines, development of new mines, coal gasification plants, coal fired steam electric generating plants, coal slurry pipelines, and all associated supporting transportation systems. These types of developments were the subject of the regional analysis portion (Volumes I and II) of the Final Environmental Impact Statement, Eastern Powder River Coal Basin of Wyoming. As the area of consideration for that analysis coincides with the area for which the possible future environment is being described, this section is based on the information and projections contained in that document.

The Powder River Basin is the western extension of the great plains in Wyoming. The basin covers nearly half of northeastern Wyoming and parts of southeastern Montana. The structural or geologic basin is bounded by the Big Horn Mountains on the west, the Black Hills on the east, the Laramie Mountain Range on the south, and the Cedar Creek Anticline in Montana on the north. The Wyoming portion of the basin contains approximately eight million acres.

The basic study area, the "Eastern Powder River Coal Basin," contains all of Campbell County and that part of Converse County north of the Platte River as outlined on Figure 4.5-A. It includes 4,978,560 acres. Gillette and Douglas, the major communities, are the county seats of Campbell and Converse, respectively. Glenrock, Moorcroft, and Arvada are other small communities located on edges of the study area. Rural post offices, country stores, gasoline stations, rural schools, and oil camps are scattered throughout the area at places such as Weston, Spotted Horse, Recluse, Reno Junction, Bill, Hilight, etc.

Large tracts of land are leased for coal development extending from 25 miles north of Gillette to 70 miles southeast of that city. An additional area approximately 22 miles long and located about 32 miles northwest of Douglas is also covered by several leases.

Present indications are that there will be two centers of coal development in the time frame of the present to 1990, although it is probable that most of the large leases will eventually be developed. The first of these centers is the Gillette vicinity. Two mines are

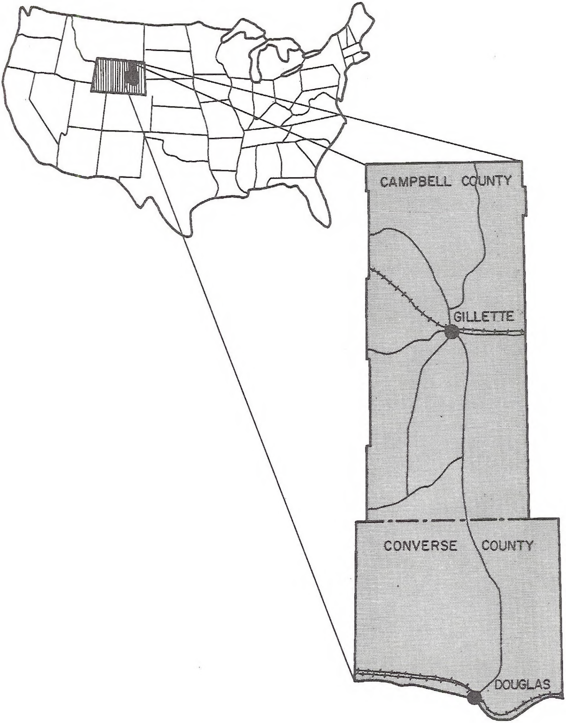


Figure 4.4-A

Basic Study Area Location Map.

(EASTERN POWDER RIVER COAL BASIN)

now active near Gillette, the Wyodak mine about five miles east and the Amax mine about 14 miles southeast. In addition, Carter Oil Company plans to develop a mine about eight miles north of Gillette. Finally, it is expected that before 1985 a second Amax mine will be developed north of Gillette and Sun Oil Company will develop a mine about 17 miles to the southeast. These mines, centered around Gillette, will create a population and activity center with that city as nucleus.

A second center of mining activity will be about 12 miles southeast of Reno Junction, the Junction of State Highways 59 and 387. Here leases of Atlantic Richfield Company and Kerr-McGee Coal Corporation are scheduled for early development. Also in this area, the lease of Peabody Coal Company is to be developed in conjunction with a coal gasification plant to be built by Panhandle Eastern Pipeline Co. Location of the primary plant site has been announced as being 15 miles northeast of Douglas and about 40 miles south of the lease area. Lying just to the west of the Peabody and Atlantic Richfield lease is a large lease block held by Pacific Power and Light Company. Development of the Peabody and Pacific Power leases is expected prior to 1985. Commuting distances are about 50 miles from Gillette and 80 miles from Douglas. Because of these distances, some employees may choose to settle closer to their work in order to cut down commuting time.

The Douglas vicinity may be a third development area. As mentioned above, the primary plant site for the Panhandle Eastern coal gasification plant is near Douglas. In addition, some employees of the Altantic-Kerr-McGee-Peabody-Pacific Power mine complex may choose to live in Douglas in spite of the longer commuting distance.

Certain potential impacts of coal development within the Eastern Powder River Coal Basin are not confined to the study area. Considerations of socio-economic conditions, land use controls and constraints, transportation, history, archeology and paleontology, air quality, water resources, and climate were analyzed basinwide (Figure 4.5-B) and included the eight-county area of Sheridan, Johnson, Natrona, Campbell, Converse, Crook, Weston, and Niobrara Counties. Analysis of recreation impacts extended beyond the Powder River Basin proper into Montana, South Dakota, and eastern Wyoming so that major, popular recreation opportunities available to residents of the basin could be identified. Such analyses as topography, soils, minerals, aesthetics, vegetation, wildlife, and agriculture were primarily confined to the basic study area with such minor exceptions to accommodate data sources aggregated on some other geographic basis.

In the United States about 600 million tons of coal annually are mined and consumed or exported. Of this amount, less than 1 percent is produced from the Eastern Powder River Basin. However, because of the presence of shallow, thick coalbeds, industry plans to mine significant quantities of coal in the next few years from the basin.

There are four active coal mines (Figure 4.5-C) in the Eastern Powder River Basin, the Antelope mine of Brannon, the Belle Ayr South mine of Amax Coal Company, the Dave Johnston mine of Pacific Power and Light Company, and the Wyodak mine of Wyodak Resources Development Corp. Most production from the Dave Johnston and Wyodak mines is used to fuel coal fired steam electric generating plants near the mines.

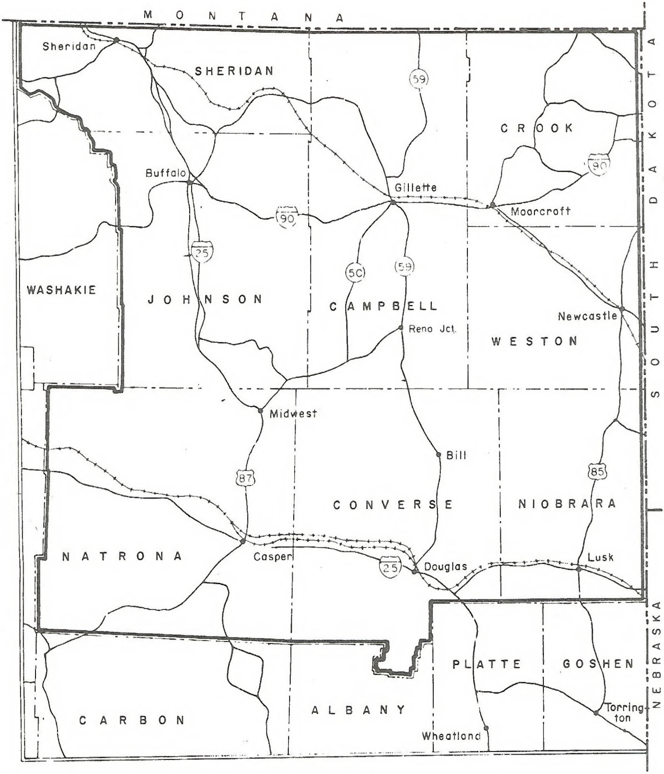


Figure 4.4-B

EIGHT COUNTY BASIN AREA

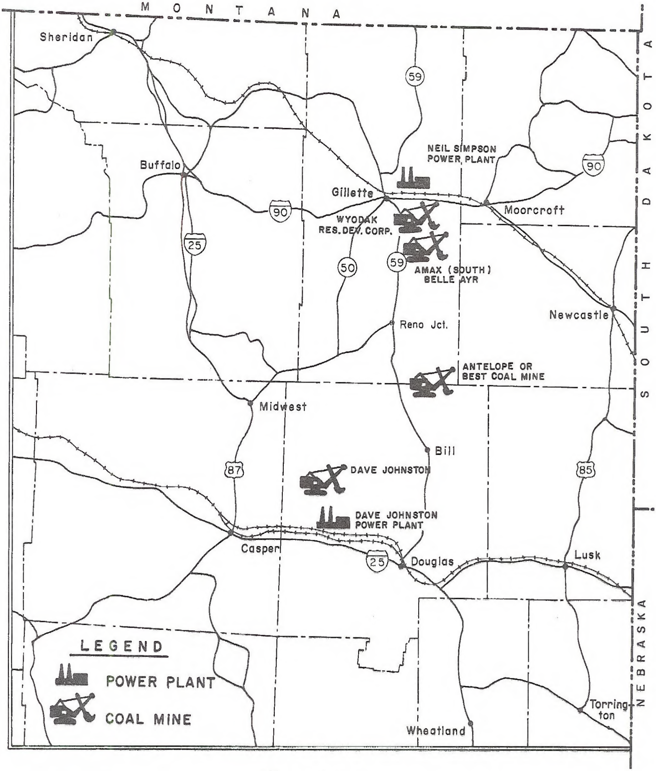


Figure 4.4-C

Existing Power Plants and Coal Mines Within the Study Area (1974)

Other coal produced from mines is used locally for space heating or exported for domestic consumption. Of these four companies, Wyodak Resources Development Corp. plans to increase coal production to fuel power plants. In addition to Wyodak, three companies plan to open new coal mines to satisfy out-of-state demand. The Black Thunder mine of Atlantic Richfield Co., the Jacobs Ranch mine of Kerr-McGee Corporation, and the North Rawhide mine of Carter Oil Company are all scheduled to begin production no later than early 1977. Several companies are making final plans or have started extensive studies directed toward the opening of new mines or increasing production from active mines. Thus, for purposes of estimating future potential coal development of the Eastern Powder River Basin, there are three active mines (two of which plan expansions) and seven proposed mines. There are also two power plants, one proposed power plant, and one proposed coal gasification plant directly related to existing or proposed coal mining activities.

The analysis developed in the Final Environmental Impact Statement, Eastern Powder River Coal Basin and the description of the future environment are based on 1990 projections. The cumulative environmental change is quantified, to the extent possible with existing data, only to this time period. The probability is recognized that, based on current leaseholds and investments, the pattern of resource development and growth will continue after 1990, though at more modest rates. Cumulative environmental impacts will also increase.

Development to the year 1990 within the study area is projected to consist of: ten mines with plans to produce 296 million tons of coal by 1980, increasing to 12 mines, 858 million tons by 1985 and 14 mines and 1,543 million tons by 1990; construction and operation of a 330-megawatt air-cooled power plant and a 250-million cubic foot per day gasification plant by 1980, a 450-megawatt air-cooled and a 500-megawatt water-cooled power plant as well as a second 250 cubic foot per day gasification plant by 1985 and another 500-megawatt water-cooled power plant by 1990; construction of 16 miles of road, 44 miles of powerline, 30 miles of coal slurry pipeline, 140 miles of rail line by 1980; 20 miles of road, 164 miles of powerline, 145 miles of rail line by 1985; and 24 miles of road, 225 miles of powerline and 150 miles of rail line by 1990; all of which will cause various impacts and changes on the environment and its individual components.

These impacts and resultant changes will play a major role with regard to the makeup of the future environment. Future trends for the environment of the area are summarized by component as follows.

Climate

Development of a number of coal mines, power plants, and gasification plants and disturbance of significantly large areas of land surface may cause significant changes that could detrimentally affect weather and climate. The two major consequences of large-scale energy development which may lead to significant inadvertent modification of the regional weather and climate are increases in atmospheric particulate loading and changes in natural land surface characteristics which affect the precipitation mechanism.

Air quality

Industrialization and development of the study area will result in a decline in ambient air quality. A general decline will occur from 1974 to 1980, with a more serious decline during the 1980 to 1985 period. The rate of decline is expected to level off after 1985, since by this time major projected development will have leveled off with only minor increases proposed for the 1985 to 1990 time period. The decline in air quality will remain fairly constant for the rest of the time period (1985-1990).

Increased plant stack plumes and haze from disturbed soil and coal dust will result in poorer visibility within the basin and possibly in areas to the east and southeast of the basin.

Present ambient air quality in the study area is good, but it will decline with the development of complex pollution sources as industrialization takes place.

Topography

Mining of coal and construction material such as sand and gravel will significantly impact the topographic shape of the areas mined. The surface would also be altered, but to a lesser degree, by construction of new roads, rail lines, and other transportation systems. In addition, alteration of the land surface will result from construction of industrial plant sites.

Soils

Development of coal resources and attendant facilities will impact soils within the area. Disturbance will result in soil losses and productivity will be reduced.

Mineral resources

Future developments will utilize nonrenewable resources of the area, decreasing reserves of minerals such as coal and sand and gravel.

Water resources

Development of coal resources within the area will create increased demand on water resources.

Increased industrial use of water may limit amounts available for agricultural and irrigation uses. This limitation or reduction could adversely impact other resource uses such as recreation, farming, wildlife, and grazing.

Overall water quality may decrease. The total effect on regional quality cannot be assessed with data currently available. Monitoring systems will be necessary to determine actual impacts on water quality.

Vegetation

Vegetation will be removed by mining operations, construction of plants and housing to accommodate the increased population, pipelines to transport coal and manufactured gas out of the study area and water to the plant facilities, rail lines to haul the coal, and transmission lines to transport electrical energy necessary to operate mines and plants and to move the developed energy to other areas. It will also be partially disturbed by increased recreational use originating from the larger population within and adjacent to the study area.

Cultural values

Energy development and the attendant increase in population will increase the risk of damage and destruction of the area's cultural values.

Aesthetics

The area can be expected to gradually change from a rural setting, basically uninhabited, to a character that is more representative of areas with more industrial activity and higher population densities.

Wildlife and fish

Coal development and industrialization of the area will result in impacts on the fish and wildlife habitat and conversely on wildlife population quantity and quality. The change of the area from a relatively quiet, rural setting to one of increased human activity will indirectly affect wildlife and its habitat, resulting in a change in species composition and numbers.

Recreation

The overall effect of the projected development on the recreation resource of the area will be to diminish quality for the residents. It may also affect long-term economic strength for certain business sectors by reducing nonresident recreation days.

Agriculture

The direct loss of agricultural land and production by 1990 would not constitute an important regional impact as lost production by that time is anticipated to represent one percent or less of the total regional agricultural production. However, on a local or individual basis, there could be significant impact.

Transportation networks

Existing transportation networks will receive increased use and as a result require increased maintenance and upgrading. New transportation systems will be needed to accommodate increased demands.

Development of the area would probably result in an improved and expanded overall transportation system.

Socio-economic conditions

Employment, construction and permanent, resulting from these developments will cause population increases of: 27,000 by 1980, 42,000 by 1985, and 47,000 by 1990 in the study area. These increases in population will require associated facilities such as schools, sanitary land fills, sewage plants, increased social services, all having additional environmental impacts. Population in the surrounding six-county area is projected to increase only moderately: 10,000 by 1980, 11,000 by 1985, and 13,000 by 1990.

It is acknowledged that not all environmental impacts associated with this development are confined to the State of Wyoming. If coal is exported from the study area to such places as Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Louisiana, Nebraska, Oklahoma, and Texas, impacts from energy conversion will occur in those areas. The exact nature of these impacts is not reasonably foreseeable due to the inability to fully anticipate how and under what conditions the coal and energy will be utilized. It should be noted that the impacts resulting from consumption of coal in electric power plants outside of the study area may be similar to the impacts of consumption of coal for electric power generation within the study area, varying essentially with respect to the degree of impact in relation to environmental conditions existing in those areas. Environmental impact of the use of coal and energy developed in the study area will be analyzed at the time other major federal actions are required.

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5. Probable impacts - Agricultural use of water

5.1 Climate

Evaporation from the reservoir may slightly increase humidity in the immediate vicinity.

5.2 Air quality

Construction could impact air quality during the 2 years of construction by dust from earth moving activities, smoke from burning debris, and engine emissions from construction equipment.

Diesel powered heavy construction equipment would be the major source of air pollution. Assuming 24 units operating sixteen hours a day, about 3,800 gallons of diesel fuel would be consumed per day. According to the Environmental Protection Agency, maximum daily emissions would be about 49 pounds of particulates, 100 pounds of sulfur oxides, 85 pounds of carbon dioxide, 190 pounds of hydrocarbons, and 1,400 pounds of nitrogen oxides. This is similar to an average highway construction project.

Winds common to the area should disperse and dissipate the pollutants. Inversions, primarily in winter, may inhibit atmospheric "flushing" temporarily. Dust may result from barren soil exposed as the reservoir water level recedes. This could produce hazardous driving in windy conditions by reducing visibility.

Additional cultivation east of Kaycee should not impact air quality.

5.3 Topography

5.3.1 Reservoir area

Construction will change topography as irregularities are removed or filled to construct the reservoir and the road. Temporary roads, storage areas, and buildings may also be constructed modifying the topography to a lesser extent. Impacts would be primarily visual, such as exposed dirt in road cuts and fills.

Appearance of the terrain would change as the reservoir fills and operates, covering and exposing topography as the water level fluctuates.

5.4 Mineral resources

Construction is expected to require about 1,860,000 cubic yards of fill material for the reservoir and road. This material would be consumed by the project. To the extent it comes from the area to be flooded the impact of its use would be minor. It would represent a depletion of non-renewable resources, no matter where it came from.

An undetermined quantity of low quality sand and gravel would be covered with water as the reservoir filled. This material would be lost.

The project would not affect bentonite or oil and gas.

5.5 Soils

5.5.1 Reservoir area

Soils adjacent to the steep shoreline areas may develop visible white salt accumulation through capillary movement of salts from soils below water level. This is common along drainages in the county during spring runoff, and it would destroy or alter the existing vegetation in those areas.

Proposed construction involving approximately 163 acres around the reservoir site, access roads and spillways, 144 acres in relocation of the road, and clearing heavy vegetative areas below water line would destroy or alter soil horizons. This compaction of soil material could result in changing permeability and infiltration rates, and increasing runoff, soil erosion, and sedimentation. Removal of vegetative cover would expose this acreage to direct wind action causing finer soil particles to be carried into the atmosphere, while sand particles would move along the ground surface resulting in soil loss and dislocation. This could continue from two to four years in the inundation area before disturbed areas were covered by rising water, and an estimated one to two years in other areas until rehabilitation measures are initiated.

5.5.2 Agricultural water use area

A major impact to the soil would be the addition of 20 to 30 inches of water (approximately twice the amount currently used) moving through the soil profile due to increased irrigation during the 120 day growing season. This should increase plant vigor and improve the soil productivity by increasing surface organic matter, water intake rate, soil structure, and movement of undesirable soluble salts downward into the subsoil. Increased land treatment measures could be expected, such as land shaping, land leveling, improved irrigation delivery and application systems, to help improve field site characteristics and irrigation management. Fertilizer applications might be increased to increase productivity. These measures would alter soil structure and profiles, and result in increased soil productivity. Class IVw lands (soils with very severe limitations for cultivation because of drainage) should sustain a marked raising of their water table level with adverse effects on vigor and growth of existing vegetation and could lead to replacement with other vegetative types. This results from increased surface and subsoil moisture from adjacent upslope land areas.

Various types of drainage systems would likely be installed in this area to improve water and air relationships. This may make these lands more suitable for vegetative growth.

5.6 Water resources

Beneficial uses of the impounded water, change in streamflow and sediment load, and their effects downstream are important impacts which could occur. Primary ground water impacts will probably occur along the channel between the reservoir and Red Fork and in the agricultural water use area below the Sahara Ditch. Many impacts can be assessed only qualitatively due to lack of data and studies necessary to quantify them.

5.6.1 Surface water resources

5.6.1.1 Surface water timing and quantity

5.6.1.1.1 Regional

Water supplies are limited. Figure 5.6-A shows potential for water development in Powder River Basin and cumulative water requirements expected between 1974 and 1990. Water consumptively used is not available for other uses. Use of water from Middle Fork Reservoir for irrigation will probably consume a large fraction of the water. About one-third is expected to return to Powder River, and the remainder would be lost (Banner, 1970). Energy-oriented industries in Powder River Basin are largely consumptive users of water (Wyoming State Engineer's Office, 1972). As with irrigation, water consumed by industry is not available for other uses. The consumptive use of water would thus be an undesirable impact.

Storage of water in Middle Fork Reservoir and the irrigation of 363 previously unirrigated acres will result in increased water losses by evaporation. Average potential evaporation in the area is approximately 30 inches a year (Banner, 1970). Based upon the proposed reservoir

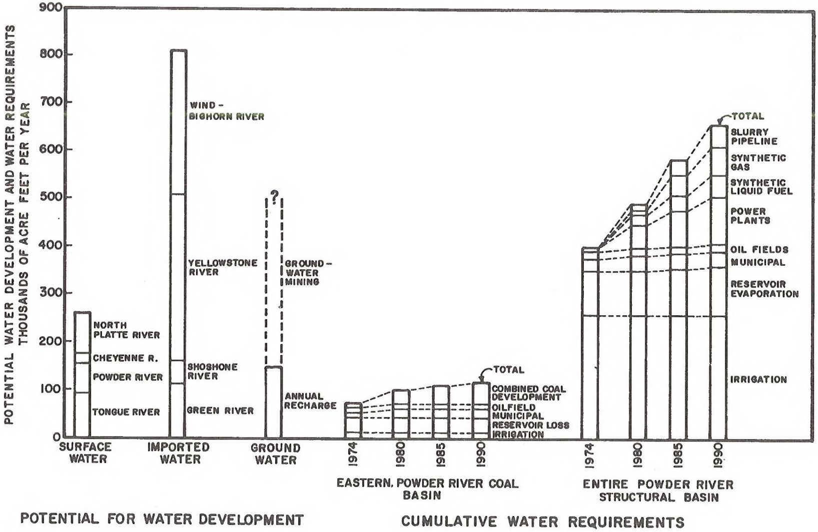

Figure 5.6 - A

Potential Water Development and Water Requirements in the Powder River Basin, 1974 to 1990.

Source: Department of the Interior, 1974.

operation plan, the average annual surface area of the reservoir is 650 acres. The corresponding annual evaporation loss is 1,625 acre-feet. The average annual consumptive use of water by irrigated crops is estimated to be approximately 2 acre-feet per acre (U. S. Bureau of Reclamation, 1967). The average annual evaporation loss as a result of reservoir storage and the irrigation of 363 acres will be approximately 2,350 acre-feet. This represents a loss of water that would have been available for other uses in Powder River Basin.

The magnitude of the loss can be assessed when expressed as a percent of the measured flows of the Middle Fork. An evaporative loss of 2,350 acre-feet per year represents 3 percent of the observed maximum annual flow of the Middle Fork (76,190 acre-feet), 5 percent of the average annual flow (45,000 acre-feet), and 7 percent of the minimum flow (33,930 acre-feet).

5.6.1.1.2 Reservoir area

Reservoir impacts relate to impounding a free-flowing stream. The impact of the reservoir upon the flow of the Middle Fork is indicated in Figure 5.6-B. Here the average monthly flow of the Middle Fork and the average proposed reservoir releases are shown. Although streamflow and reservoir releases will vary, the use of average flows indicate what generally occurred during the years that were included in the operation plan. During most of the year, reservoir releases will be much less than streamflow prior to dam construction. During May, the greatest reduction will occur when average reservoir releases will be only 6 percent of the average streamflow. During July, August, and September, reservoir releases will generally exceed the historical streamflow.

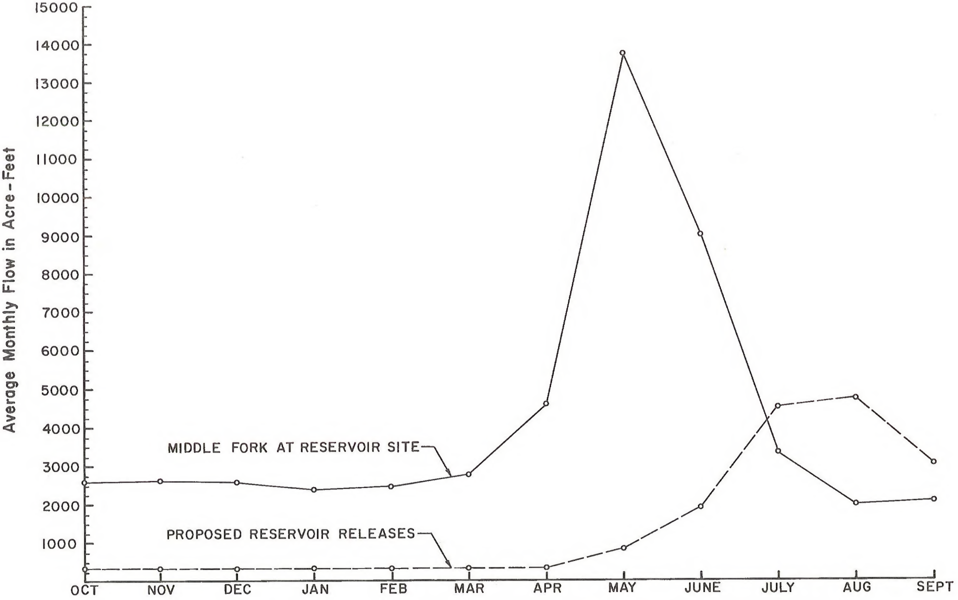

Figure 5.6-B. The average monthly flows of the Middle Fork at the reservoir site (solid lines) and the average monthly reservoir releases (dashed lines) for the period 1951-1969.

In order to determine the impacts of the reservoir on the growing season flow regime downstream of the dam, a water budget was written for downstream reaches. For the period (1951-1969) that the operation study included (Banner, 1970), the year of minimum flow of the Middle Fork (water year 1959-1960) and the year of maximum flow (water year 1966-1967) were selected. A water budget was written beginning with the measured streamflow of the Middle Fork at the reservoir site. A second water budget was written beginning with the proposed reservoir releases. This was carried out for the growing season of each of the two years. Average monthly flow rates (in cubic feet per second) and average monthly irrigation requirements were used. Several simplifying assumptions were necessary. Therefore only relative magnitudes of change may be assessed from the water budgets. A summary of the water budgets has been placed in Figures 5.6-C and 5.6-D.

The Middle Fork and mainstem Powder River were divided into seven reaches. The major inflows and outflows of water in each reach were considered, resulting in a monthly budget showing the flow at the upstream end and downstream end of each reach, called, respectively, the top and bottom of the stream reach. The reaches, labeled R1 through R7, are shown in Figure 5.6-E.

From the summary, the approximate effects of the reservoir operation upon Middle Fork and Powder River flow may be seen. During the low flow year, 1959-1960, the controlled and natural flows are similar, except that the natural flows during May are considerably reduced under controlled conditions. This reflects the necessity of satisfying down-

Figure 5.6-C

Summary of the Growing Season Water Budget
For the Middle Fork and Mainstem Powder River
1966-1967 Water Year

	Top of R1		Bottom of R1		Top of R2		Bottom of R2	
	Natural	Controlled	Natural	Controlled	Natural	Controlled	Natural	Controlled
May	314	2	317	5	350	38	356	55
June	384	0	388	4	395	11	404	20
July	113	76	118	81	96	59	107	70
Aug.	38	70	43	75	19	51	30	62
Sept.	52	29	55	32	58	25	64	31

	Top of R3		Bottom of R3		Top of R4		Bottom of R4	
	Natural	Controlled	Natural	Controlled	Natural	Controlled	Natural	Controlled
May	369	29	333	32	379	77	381	81
June	485	39	428	44	947	563	953	569
July	129	14	57	20	107	70	115	78
Aug.	43	0	6	6	7	7	15	15
Sept.	73	1	37	4	65	32	69	36

	Top of R5		Bottom of R5		Top of R6		Bottom of R6	
	Natural	Controlled	Natural	Controlled	Natural	Controlled	Natural	Controlled
May	378	78	382	82	379	79	383	83
June	948	564	954	570	949	565	955	571
July	109	72	117	79	111	73	119	81
Aug.	9	9	17	17	11	11	19	19
Sept.	66	33	70	37	67	34	71	38

Figure 5.6-D

Summary of the Growing Season Water Budget
For the Middle Fork and Mainstem Powder River
1959-1960 Water Year

	Top of R1		Bottom of R1		Top of R2		Bottom of R2	
	Natural	Controlled	Natural	Controlled	Natural	Controlled	Natural	Controlled
May	92	0	95	3	125	33	131	39
June	29	29	33	33	24	24	33	33
July	10	9	15	14	0	0	11	11
Aug.	8	8	13	13	0	0	11	11
Sept.	19	19	22	22	14	14	20	20

	Top of R3		Bottom of R3		Top of R4		Bottom of R4	
	Natural	Controlled	Natural	Controlled	Natural	Controlled	Natural	Controlled
May	104	12	107	15	118	26	122	30
June	0	0	5	5	10	10	16	16
July	0	0	6	6	4	4	12	12
Aug.	0	0	6	6	5	5	13	13
Sept.	0	0	3	3	4	4	8	8

	Top of R5		Bottom of R5		Top of R6		Bottom of R6	
	Natural	Controlled	Natural	Controlled	Natural	Controlled	Natural	Controlled
May	119	27	123	31	120	28	124	32
June	11	11	17	17	12	12	18	18
July	6	6	14	14	8	8	16	16
Aug.	7	7	15	15	9	9	17	17
Sept.	5	5	9	9	6	6	10	10

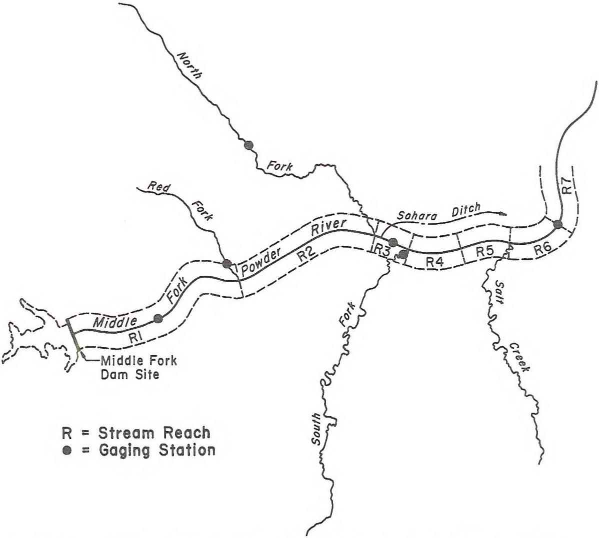

Figure 5.6-E The Upper Powder River Basin showing stream reaches (RI thru R7) used in the irrigation season water budget.

stream senior water rights. The occurrences of no flow indicate that the streamflows may be totally utilized. During years of low flow, such as 1959-1960, reservoir control will have little apparent effect.

In Figure 5.6-C, the water budget for a high flow year (1966-1967) is shown. The effect of reservoir control will be a reduction in mean monthly flows during the months May through July. During August and September, the effects are more variable, depending upon the irrigation demand within the reach. No flows occurred twice under controlled conditions, during June at the top of reach 1 and during August at the top of reach 3. This indicates that, due to irrigation demands in these reaches, flows may become negligible along some distance within the reach.

Damming of the Middle Fork is expected to reduce the flood hazard below the reservoir down to the confluence of the South Fork. In the past, flooding of Kaycee and the agricultural lands along Middle Fork and the mainstem Powder River has occurred (Wyoming State Engineer's Office, 1972). In flood routing for major dam design, the flood resulting from the maximum probable precipitation falling on a saturated watershed and flowing into an already full reservoir is assumed. For the Middle Fork Reservoir, Banner (1970) determined that this maximum probable flood was approximately 110,000 cubic feet per second. The resulting peak outflow from the emergency spillway was 93,000 cubic feet per second, a reduction of flood peak of 15 percent.

This probable maximum flood is much larger than the 100-year flood. The 100-year flood at the Middle Fork near Barnum gage, which is near the tailwater area of the reservoir, is approximately 16,000 cubic feet per second (Figure 4.2.7-L). The average storage of the reservoir at the end of May, the month of highest storage, for the period of the reservoir operation study, was 32,400 acre-feet. This corresponds to a water elevation of 4,994 feet (Figure 1-C). The crest of the principal spillway is at elevation 5,002 feet, a difference of 8 feet. If the outlet gates were closed, the reservoir would have to fill approximately 6,000 acre-feet more before discharge through the principal spillway would occur. The effect would be a considerable reduction in the peak flow. The flood crest below the dam would be much less because of the modifying influence of the reservoir.

Of the three tributaries upstream from Kaycee (Middle Fork, Red Fork, and North Fork), the Middle Fork is the larger. Thus, the modifying influence that the reservoir would exert upon Middle Fork flows would reduce flood flow peaks downstream as far as the confluence with the South Fork, which would be a beneficial impact.

Due to the large floods that can be expected from the South Fork, the Middle Fork Reservoir would probably have little flood abatement effect below the confluence of the South Fork with the mainstem Powder River (Figure 4.2.7-L).

The Middle Fork carries relatively little sediment. At the reservoir site, the average suspended sediment load is 1.1 tons per acre-foot of runoff (Figure 4.2.7-K). The sediment load near Kaycee is 3.4, reflecting the sediment contribution from the Red Fork and North Fork. The decreased flow of the relatively low sediment carrying Middle Fork will result in increased concentration of suspended sediment downstream from the confluence of the Red Fork. Also, because of the reduced flows, sediment deposition will probably occur at the confluence of the Red Fork and the North Fork. Because high peak flows will not occur on the Middle Fork, the flushing effect that such flows had on channel deposits will be considerably reduced, further aiding sediment deposition.

A beneficial impact of the Middle Fork flow modification will be higher summer flows than occurred prior to damming. These flows will not be great enough to remove all sediments deposited as the result of decreased peak flows, so there will still be a net accumulation of sediment. However, higher summer flows will aid in the dilution of irrigation return flow that may contain increased concentration of salts.

The probability of the proposed dam failing is extremely remote. The most possible cause of dam failure in this size range is from the spillway being cut down by a volume of water which approaches the maximum amount the emergency spillway can handle. The probability of a storm which would produce enough water with the reservoir at capacity to exceed the capabilities of the emergency spillway is also extremely remote - approximately once in a thousand years. Other conditions which must also be present is a completely saturated watershed area above the reservoir.

This volume of water necessary to cause failure would already have inundated the flood plain before any significant increase would occur from the dam's failure. Therefore the dam would not cause an increased threat to downstream improvements.

5.6.1.2 Surface water quality

5.6.1.2.1 Construction

Construction fuel storage areas and vehicle parks could affect water quality if oil is spilled, such as in changing oil in construction equipment, in areas to be inundated or near a stream.

Surface disturbance, such as clearing of the reservoir site, may be a source of sediment. Road relocation and dam construction may also result in extensive disturbed areas. Such areas lend themselves to accelerated erosion as do steep slopes. High intensity rain storms, such as thunderstorms, would further aggravate the problem in areas of highly erodable soils. This could result in increased sediment reaching Middle Fork. These impacts should cease or be reduced when the reservoir is completed and filled.

5.6.1.2.2 Reservoir operation

Reservoir operation will increase the mean annual total dissolved solids, primarily through evaporation. The U. S. Bureau of Reclamation (1967) determined the flow weighted mean total dissolved solids to be 560 mg/l with a range of 230 to 930 mg/l. In the same study, it was predicated that the total dissolved solids would increase to 580 mg/l in the reservoir. This would be an adverse impact; however, frequent large drawdowns would probably prevent concentrations much above this level.

A beneficial impact upon the chemical quality of reservoir releases will be a reduction in fluctuation in total dissolved solids. It was estimated that releases during the period May through September would average 550 mg/l, while releases during October through April would average 600 mg/l.

Although the annual average total dissolved solids will be higher, the reservoir releases during the summer will be somewhat lower than the TDS of natural summer low flow conditions which will aid (coupled with higher summer releases) in the dilution of downstream water high in TDS.

The outlet works, through which water will normally be released is at elevation 4,930. The surface elevation of water corresponding to an average storage (end of May) of 32,400 acre-feet will be approximately 4,990. Thus, the water being discharged would be from a depth of 60 feet below the surface. At the end of September (again using average storage), the water would be discharged from a depth of 50 feet. This water would be cooler than water flowing in the Middle Fork under natural conditions. This cooler water would have a beneficial impact, at least on the reach down to the Red Fork.

Below the Red Fork and North Fork confluence, the beneficial effects of a cooler water with higher chemical quality during the summer months would be less due to mixing and also irrigation diversion.

The Wyoming State Engineer's Office (1974) estimated the trap efficiency of several proposed reservoirs on the Powder River and its tributaries to be 98 percent. Thus, most of the suspended sediment will be retained within the reservoir. Due to the sediment introduced into the mainstem Powder River by other tributaries, the sediment trapped by the reservoir would have only a minor direct effect upon the total sediment load of the Powder River.

Since reservoir releases will usually be considerably less than natural flow conditions and will have only a negligible sediment load, the main channel will degrade for a short distance downstream of the dam as the clear water entrains sediment up to its maximum sediment carrying capacity. This will probably initiate headcutting on small tributaries entering the Middle Fork upstream from the Red Fork confluence. The channel degradation will probably not extend downstream from the Red Fork confluence.

Due to the decreased sediment and lower temperature, the channel reach downstream from the dam will probably provide an improved aquatic habitat. However, this effect will extend but a short distance downstream, becoming smaller as sediment is entrained and the Middle Fork flow mixes with that of other tributaries.

In several larger reservoirs that are routinely sampled, stratification has been observed. The hypolimnion has been observed to occur at a depth of approximately 30 feet. The stratification has occurred in reservoirs despite large inflows, large discharges and relatively rapid movement of water at depth toward the dam outlets. (Mr. Jim Rucker, U.S. Geological Survey, Cheyenne, Wyoming, July 1975, personal communication.)

Because the depth of water will exceed 30 feet in part of the reservoir, stratification may occur. This will result in low dissolved oxygen contents of the water withdrawn through the outlet works, since oxygen will be depleted by algae and organic matter on the reservoir bottom.

A proposed reservoir downstream from the Middle Fork Reservoir was classified as a hill-type reservoir (Wyoming State Engineer's Office, 1974). A similar classification would apply to the Middle Fork. In such a reservoir most sediment deposition will be on the lower middle of the reservoir between the bottom and the maximum normal water surface elevation (Wyoming State Engineer's Office, 1974). Thus, large delta deposits would not be expected in the tailwater area. This would be a beneficial impact in that most sediment would be deposited in the reservoir bottom and would not settle out in the Middle Fork Channel above the reservoir. Some heavier particles would settle out near the channel entrance to the reservoir due to reduced velocity. This aggradation would be an adverse impact upon the upstream channel for a short distance.

The impacts of the reservoir upon fisheries and wildlife are discussed in section 5.8.

The emergency spillway is to be bottomed with topsoil and vegetation planted. Erosion would occur when flow in the emergency spillway took place. Because of a semiarid climate, a dense vegetation stand on the channel would not be expected. In addition, relatively steep gradients in the spillway and natural drainage into which the spillway opens would promote relatively high velocities. This would be an adverse impact although it would be small due to the relatively low frequency that flows would occur in the emergency spillway.

Irrigation of semiarid lands with water that is relatively high in salts can result in increasing soil salinity accompanied by decreased productivity. Without proper management such soils can eventually be ruined. However, much land in the Western United States is irrigated under similar conditions. The productivity and useful life of such soils are maintained indefinitely through proper management. The increased salinity of the water is an adverse impact in that the leaching requirement for proper soils management is increased. The U. S. Bureau of Reclamation (1967) estimated that the leaching requirement would be increased by 20 percent to control the increased salinity of the irrigation water.

5.6.2 Ground water resources

The reservoir should not impact ground water conditions in the area. Most of the reservoir bottom consists of alluvium resting on alternate horizontal layers of sandstone, siltstone, and claystone (Banner, 1970). Once the alluvium is saturated, little downward seepage should occur. Reservoir sedimentation will probably further reduce any downward seepage. As the reservoir fills during spring runoff, some lateral infiltration may occur into sandstone, and more rapidly, into terrace alluvium occurring higher on the reservoir banks. Deeper aquifers would be separated from the reservoir by impermeable layers. Bank storage would return to the reservoir as its water level declines. Some local recharge of terrace gravel aquifers may occur around normal reservoir water levels, increasing local ground water.

Some additional total dissolved solids may be added to the reservoir from bank storage, leaching, and water returning to the reservoir. This should have little effect on water quality.

The reservoir's major impact on ground water would probably occur in irrigated areas. The irrigated areas are primarily flood plain soils or terrace soils with a perched water table. Increased irrigation and use of fertilizer would probably impact gravel aquifers underlying the flood plain soils. The water table would be expected to rise. This may result in increased productivity of wells penetrating these gravel aquifers, as well as aid in maintaining a return flow to Middle Fork.

During spring runoff, some recharge of alluvium along the streambank between the reservoir and Red Fork may occur as the stream carries more water (Kohout, 1957). This could be reduced or eliminated by regulation of the streamflow by the reservoir.

The water table would be lowered and production of wells penetrating the alluvium away from the irrigated areas decreased.

Increased use of fertilizer, in addition to total dissolved solids already in the irrigation water, may bring about an eventual degradation in quality of the water in the gravel aquifers.

5.7 Vegetation

5.7.1 Reservoir area

5.7.1.1 Inundation and embankment areas

The largest impact on vegetation would be below the high water line of the reservoir where inundation would occur. Clearing for the reservoir would eliminate all 104 acres of the willow-cottonwood vegetation type, approximately 5 acres of the inland saltgrass-western wheatgrass type associated with removing man made structures, and some relatively small areas of big sagebrush-blue grama grass. Cleared areas might be left in a disturbed condition for 2 years during construction and from 2 to 4 years after the reservoir construction is complete, depending on how long it takes for the reservoir to fill. The balance of the vegetation types listed in the table below would probably be lost from inundation as the reservoir is filled. If the water controlled by the Carter Oil Company and Atlantic Richfield Company, were not removed from the reservoir for a few years, loss of vegetation to inundation would be practically assured, since water levels could be considerably higher. The willow-cottonwood vegetation type is not of commercial value.

SUBTYPE	ACREAGE
Inundated area:	
Stream	20
Willow-cottonwood	104
Inland saltgrass-western wheatgrass	390
Greasewood-inland saltgrass	64
Silver sagebrush-rubber rabbitbrush	80
Big sagebrush-blue grama grass	432
Talus slopes	44
Curlleaf mountain mahogany	26
TOTAL	1,160

Some vegetation might return to areas not frequently inundated, such as the area between normal high water line and the reservoir's normal operating level. Past streamflow records indicate that the reservoir would operate somewhere below normal high water about 90% of the time (89 out of 100 years). While the amount of such vegetation depends upon how often the area is covered with water and for how long, the vegetation types expected are species resistant to inundation such as annual forbs, weeds and sedges.

The problem experienced in other areas of invasion of riparian-type vegetation is not expected here. The fluctuation of the water line would create high enough water tables at times for riparian species to grow, but since annual precipitation is quite low, the water tables would not remain high long enough for permanent establishment. There is no known problem of this nature on fluctuating reservoirs in the vicinity, probably for these reasons.

The table below lists subtypes and approximate acreages of vegetation that would probably be disturbed by construction of reservoir embankment and spillway areas. These areas are expected to be almost completely disturbed during construction activities for two years before rehabilitation is initiated. Successful stands may not be established for two additional years after rehabilitation.

SUBTYPE	ACREAGE
Embankment and spillway areas:	
Stream	3
Inland saltgrass-western wheatgrass	30
Willow-cottonwood	18
Talus slopes	8
Big sagebrush-blue grama grass	104
TOTAL ..	163

A concrete plant might be used during the construction period. Such a facility might partially disturb about 10 acres of vegetation, but because its location is not known the vegetation type that could be disturbed is not known.

A few very small areas near the mouths of drainages may develop higher water tables which could benefit plant growth.

As indicated under 5.5, Soils, some areas adjacent to steep shorelines may develop salt accumulations, through capillary movement of dissolved solids, which could be detrimental to plant growth.

5.7.1.2 Proposed relocated road

About 40 acres (60%) of the 70 acres of road right-of-way would probably be disturbed during road construction. Of this some 10 acres would be hillside type vegetation and the rest hillside-badlands type vegetation. Much of this would remain disturbed during the year of road construction before rehabilitation started. It could take an additional 2 years before successful vegetative stands are established. If a plant for road surface material were established it could disturb an estimated 10 acres of vegetation. As with the concrete plant, vegetation disturbance would depend on location of the plant, which isn't known at this time.

5.7.2 Agricultural water transportation route

Water would most likely be transported within the Middle Fork from the reservoir to the Sahara Ditch diversion and then along the Sahara Ditch until released on the land. Streamflow variations caused by reservoir operations could be expected to impact streambank vegetation by reducing both average monthly and annual streamflow. If the reservoir capacity committed to non-agricultural purposes, approximately 28,000 acre-feet a year, was transported directly from the reservoir to its point of use, annual streamflow would be further reduced. This could occur if the water was piped out of the immediate area (see section 5.6, Water Resources).

The growing season period from May to September is of particular importance to vegetation. Figure 5.7-A shows the change in volume during the growing season, in the 4-mile segment of stream from the reservoir to the confluence of Red Fork of Powder River. Since no other streams enter Middle Fork in this segment, total flow would be dominated by releases from the reservoir. The operation plan would have the effect of evening flows during the growing season, that is, decrease flows during May and June and increase them during July, August, and September. By decreasing flows during the remainder of the year to store a large quantity of water for release during the next growing season, water tables could be lowered and bank storage reduced. This would change vegetation composition, but the amount of change is not known. There may be greater domination of vegetation composition by deeper-rooted, riparian types which could survive dry periods more effectively. Where the water table is presently too high for optimum plant growth, there may be a change in composition which would allow greater overall vegetation productivity. Increased flows later in summer may have a beneficial effect on plant vigor.

These effects could also occur all the way to the Sahara Ditch Diversion, but because Red Fork and North Fork would maintain a substantial stream flow in the channel below this confluence, the effects would be reduced.

Figure 5.7-A

Comparison of the Operation Plan Average Flows
to Average Natural Streamflow
Between the Damsite and Red Fork Confluence
During Growing Season*

Month	Streamflow Records (acre-feet) 1/	Most Probable Operation Plan 2/ (acre-feet)	Change (acre-feet)
May	13,816	1,106	- 12,710
June	9,347	5,483	- 3,864
July	3,334	4,828	+ 1,494
August	1,988	4,706	+ 2,718
September	2,103	2,850	+ 747

* Average over 18-year study period, water years 1950-51 to 1967-68.

1/ Correlation of two stream gaging station records in the vicinity (from J. T. Banner and Associates, 1970).

2/ Columns 2 + 7 + 8 + 17 of the operation plan.

5.7.3 Agricultural water use area

Additional water distributed evenly over the growing season could be expected to increase plant vigor and growth resulting in increased agricultural production. Intensive agricultural management practices could make the most of such increases. Some areas adjacent to cultivated land may experience similar increases from increased water in the form of runoff and raising water tables resulting from additional water applied to the cultivated lands.

Raising water tables could result in drainage problems, particularly where such problems have occurred in the past. They could also result in changes in vegetative composition if water tolerant species replace existing species where high water levels develop in root zones. High water tables could also inhibit vegetative growth and reduce production (see Figures 4.2.6-B and -C).

5.8 Wildlife and fish

5.8.1 Reservoir area

5.8.1.1 Terrestrial wildlife

About 1,160 acres are expected to be inundated and lost as wildlife habitat. It is assumed that some individual animals may be temporarily absorbed into suitable adjacent habitat. However, if adjacent habitat could support more and if adjacent populations would tolerate more individuals, they would already be there. Therefore, the long-term effect on populations would be loss of those animals now supported on the area to be inundated.

This loss would include the turkey population (about 30-plus), about 130 deer (100 mule deer and 30 white tails) representing the entire resident herd, and unknown numbers of other game and non-game species. In addition, habitat would be lost to seasonal animals, e.g. doves, golden eagles and other winter visitants, and to amphibians and reptiles unable to flee.

In the short run, displaced animals could cause local overuse of habitat until population levels balance with forage.

It cannot be assumed that local landowners would reduce their livestock numbers in recognition of loss in forage. Therefore, it is likely that adjacent lands would be even more heavily grazed. This would result in added competition with wildlife and aggravation of watershed conditions.

Recreationists drawn by the proposed reservoir could increase hunting pressure, poaching, disturbance and harrassment of resident animals and wintering raptors. This could also result in an increased enforcement load for Wyoming Game and Fish Commission.

The proposed road realignment would remove additional acreage from wildlife habitat. Habitat lost would be similar regardless of the route chosen.

Relocating the road north of the reservoir and inundation of the existing road would probably result in loss of access and hunting on a sizeable block of national resource lands south of the reservoir. This could impact proper harvest of game species in that area.

The broader expanse of open water would provide escape or resting area for waterfowl. The operation plan with its fluctuation precludes establishment of emergent vegetation desired by many aquatic birds for nesting, feeding, brooding, etc. Some ducks should be able to nest above the water line and walk their broods to water. The area would make poor brooding habitat, however, because it would be almost totally lacking in escape cover.

5.8.1.2 Fish

Middle Fork Reservoir would inundate 6.5 miles of Middle Fork Powder River and the lower 2 miles of Beaver Creek, with subsequent loss of this stream habitat and the trout fishing it now supports. The reservoir could fluctuate about 83 feet between normal high water line and the dead storage pool, varying the surface area of the reservoir from 1,160 acres (50,000 acre-feet) to 140 acres (2,400 acre-feet).

Past livestock use of the area should provide a good source of nutrients. This would be highly desirable for growth of plankton, a major source of food for all species of fish present. There would also be some increased growth of bacteria, algae, and aquatic weeds; however, the fluctuating water line would limit this increase to areas of shallow water near the upper boundary but below the usual low water line. Most vegetation established in periods of stable water levels would die out as the water line fluctuated up or down. The resulting decaying vegetation and any decaying vegetal matter left after the clearing operation would contribute to a general decrease in oxygen in the water.

The limiting factor on fish populations in the reservoir would be the amount of habitat provided by the inactive pool after maximum annual drawdown is completed. Game fish may be further limited by increased turbidity from sediment washed from shore by wave action and lack of food types associated with a stable, non-fluctuating aquatic environment. From past experience with other reservoirs built in the Big Horn Mountains, a natural increase in all species of fish populations is expected as the reservoir begins to fill. Emigration would occur from nearby rivers and creeks as native species drifted down into the new impoundment. These immigrant fish could then become a self-sustaining population and would permanently reside within the reservoir, migrating upstream only during spawning periods and returning to the reservoir after spawning is completed. When young fish are large enough, they would also move downstream into the reservoir to grow and supplement the existing population. They then would become a supplemental food source for large fish in the reservoir. Therefore, periodic planting of the reservoir with game fish would not be necessary, with at most a one-time plant of sub-catchable trout needed to supplement the native population (John Mueller, 1974).

Beaver Creek falls, a natural barrier to upstream movement, would be inundated by backwaters of the reservoir at high water line. This would allow migration of rough fish, mainly the longnose sucker and flathead chub, into the remainder of Beaver Creek where they do not now occur. These fish would introduce competition with game fish for space and food, interfere with reproduction, and generally lower the quality of the sport fishery. They would, however, also serve as a food source for trout.

The four-mile segment of river between the reservoir and Red Fork confluence would have high fishery potential if water quality improved due to settling of sediments in the reservoir and decreased summer water temperatures from higher flows. However, the probable plan of operation (section 1) does not provide the necessary minimum winter flow for maintenance of a resident population. It is estimated by Wyoming Game and Fish Department personnel that 10 c.f.s. constant flow is the absolute minimum necessary to maintain a fishery, but a flow more nearly approaching 40 c.f.s. would be desirable. The reservoir corporation has stated that the minimum flow would be in accordance with the policies of the State Engineer's Office. The State Engineer's Office has stated that they have no set policy and do not normally require a minimum flow. Therefore, the potential of this tailwater fishery would probably not be realized.

5.8.2 Agricultural water use area

5.8.2.1 Terrestrial wildlife

Only 363 of the 5,116 acres under the irrigation plan would be new irrigation. Because most water would be used on presently cultivated lands for late-season irrigation, little transformation of habitat or effect on wildlife is anticipated. Depending on the types of crops grown and their proximity to cover, some benefit may accrue to pheasants, doves, Hungarian partridges, and non-game birds in increased habitat and populations.

Carrying capacity may be increased for antelope and they may increase in numbers. Deer and turkeys would be adversely affected if cover thickets are destroyed in the process of conversion to cultivation.

Deer and antelope on cultivated lands may become regarded as pests. Populations may be subjected to increased hunting pressure for depredation control.

The probable operational plan (section 1) for the reservoir would mean a change in peak flow from spring to late summer, much higher flows during July, August, and September than in previous years, and much lower minimum flow during the storage period. Possible removal of water for industrial use would diminish total flow in the river system.

The effects of these changes on vegetation, i.e. wildlife habitat, are difficult to predict. Increased water availability throughout late summer would prolong the green period and growing season, and would benefit wildlife. Additional streambank vegetation may become established, benefiting fish and terrestrial species.

5.8.2.2 Fish

The proposed reservoir would have very little effect on fish populations along Powder River near the irrigated lands around Sussex. Summer flows would be higher and water temperatures lower, but the limiting factor of low winter flow would remain unchanged. Because of this the stream would continue to be of little value as a fishery.

5.9 Cultural resource impacts

Cultural resources are fragile and limited resources which are easily impacted. Such impact includes: destruction or alteration of the site, isolation from or alteration of its surrounding environment, or introduction of physical, visual, audible, or atmospheric elements that are out of character with the resource and its setting. These impacts can damage or destroy scientific, aesthetic, symbolic, recreational, or human interest value of the cultural resources. In addition, previously unidentified cultural resources can be damaged or lost during the course of project activity. While the number and value of as yet unidentified resources is not known, areas as rich in cultural resources as the Middle Fork have often had extremely valuable sites discovered some time after initial discoveries were made.

Adverse impacts on cultural resources are anticipated from increased population in the region (see Eastern Powder River Coal Basin Environmental Impact Statement). Attracted by the reservoir and other resources (including cultural resources) of the Middle Fork area, these people could cause major impacts on cultural resources. For example, as public use increases so does vandalism on cultural resources, and Outlaw Cave, an Indian burial, and pictographs in Buffalo Creek Canyon have already suffered from it.

The Dull Knife Battlefield is in the same topographic region (Middle Fork-Red Fork drainage systems). Increased recreational use of the region would lead to an increase in vandalism to cultural resources

(Dull Knife Battlefield included). Increased vandalism would damage and alter part of the Dull Knife Battlefield with a potential of significant loss in historic and scientific value.

5.9.1 Reservoir area

Preliminary cultural resource studies indicate that constructing and flooding Middle Fork Reservoir would have a significant adverse impact on paleontological cultural resources which have scientific and educational value.

The reservoir would cover outcroppings of Morrison and Sundance formations occurring in the inundation area which are known to contain fossil remains. Information on life forms of the Jurassic epoch, preserved in these outcroppings would be lost to scientific and recreational use.

Fifty-six known prehistoric sites would be adversely impacted by Middle Fork Reservoir. These fifty-six sites and other unknown sites may contain key information on several periods of North American prehistory. Of these, forty-nine open camp sites reported in preliminary studies would be adversely impacted. Most are below normal high water line and would be totally destroyed. A few open camp sites are near the high water line and would be damaged by shore erosion and vandalism. One reported stratified rock shelter is near the high water line and would be subject to erosion and vandalism. One tipi ring would be destroyed, another subjected to vandalism.

The Middle Fork pictograph and petroglyph panels are located along the proposed normal high water line. These panels would be subjected to erosion which would damage and destroy the scientific, aesthetic, symbolic, recreational, and human interest value of these panels. Conditions caused by the proposed project which would have an adverse effect are destruction and alteration of all the property, isolation from and alteration of their surrounding environment, and introduction of visual elements that are out of character with the historic setting of this site.

The panels are located near the upper (southwest) end of the proposed pool area, along the proposed high water line and would be subjected to the largest fluctuation in water level. The action of the fluctuating pool level would cause destruction and alteration of all of this property.

One section of the panels would be below the high water line. The fluctuation of water over these panels would destroy the pictograph. The water action would also erode the rock face and remove evidence of the petroglyphs. About one-third of the panels would be totally lost by this action.

The permeability of the sandstone cliff would allow water to be drawn into the rock behind and below the panels situated above the high water line. Alternating freezing and thawing of this water would cause the rock face to flake off, thus removing the panels. The presence of water in the sandstone and increased humidity near the pool location would also damage the natural paints used in the pictographs.

Shore erosion from the fluctuating pool would remove the deposits of sand at the base of the panels. This action would destroy any stratified cultural material located within these deposits.

All of the panels would be subjected to increased vandalism during construction of the reservoir and by later recreational use. The pictograph-petroglyph panels are within the ten vertical-foot buffer zone around the high water line which would be open for recreation. Whenever human use increases, so does the incidents of vandalism to cultural resources.

The reservoir would also introduce visual elements which would be out of character with the historic and natural setting of the panels. The reservoir itself would be one visual element which would be out of character. Clearing the vegetation from the pool area would change the visual elements of the natural environment. Mud flats in the valley bottom during low water levels would also be out of character with the historic setting.

The proposed Middle Fork Reservoir would damage the scientific and human interest value of the Castle Rock Archeological Site by destruction and alteration of part of the property, isolation from and alteration of its surrounding environment, and introduction of visual elements which would be out of character with the historic setting.

The Castle Rock Archeological Site is situated at the uppermost (southwestern) end of the proposed pool area. The proposed high water line would follow along the base of the talus slope and old terrace upon which the site is located, at the northeastern end of the site. Shore erosion during fluctuations of pool levels and associated wave action, would erode the northeast end of the site and damage or remove portions of the stratified cultural deposits.

The site is partly within the 10.5 vertical-foot buffer zone above the proposed high water line which would be open for public access and recreational use. The public use of the area at and around this site would cause vandalism which would damage the scientific value. During salvage operations, if the proposed project is allowed, the Castle Rock Archeological Site would be excavated both for salvage of this site and to provide stratigraphic control for other excavated or salvaged sites affected by the proposed project. By the nature of salvage excavations and current methods, not all the available scientific data could be recovered, and thus salvage could damage some of the scientific value. The valuable undisturbed information contained in this site may not correspond to current research problems; some of the information which does not correspond could be overlooked during salvage, which would be important to future research problems on prehistoric sites of this type. Proper archeological techniques require at least half a site be left in place as a storehouse of basic scientific data in an undisturbed form; shore erosion and vandalism may not allow half of this site to be left undisturbed.

The presence of the proposed reservoir, which would flood the valley northeast from the site, would isolate the site from the surrounding environment. The reservoir would also form an alteration of the surrounding environment. This alteration would destroy or damage other prehistoric sites which may relate to the cultural groups which occupied the Castle Rock Site.

The reservoir would block one of four historic access routes into the famous Hole-in-the-Wall area. This area was a popular outlaw hide-out because of limited access from the east and these access routes are of prime significance to historic value of Hole-in-the-Wall. The blocked access route also contained the old wagon road over which supplies were carried into Hole-in-the-Wall. Several miles of this road location including its fork at Beaver Creek would be covered by the proposed reservoir. Remains of early homesteads in the valley would be destroyed by removal of historic buildings and surface disturbance during construction and flooding of the reservoir.

Also significant would be cumulative impacts to sites of a characteristic category (such as homesteads, tipi rings, or pictographs). Progressive destruction of a characteristic resource may seriously impair future scientific research or preservation of representative examples.

5.9.2 Road relocation

The surface would be disturbed along the right-of-way and within borrow areas during road construction. Since cultural resources are remains on or within the surface of the land, any sites located along rights-of-way or in borrow areas would be destroyed.

5.9.3 Agricultural water use area

Much information on a cultural resource site is contained within the first few inches of the surface. When a site is plowed or land leveled cultural materials are mixed and stratigraphic context is lost. Since land which would be irrigated has not been systematically inventoried, plowing new land could damage an unknown cultural resource.

The Portuguese Houses are located on private land within the irrigation district which would benefit from the proposed reservoir. The soil at the site in Class IIs with a slope of less than 3 percent, slow runoff, slight hazard of erosion, is suitable for the production of hay, pasture, and small grains. The increased irrigation water, available over a longer portion of the growing season, should improve production of existing crops - alfalfa and grasses. It should allow new varieties and practices, such as corn and grasses for ensilage, and irrigated pasture, to become part of some operations. The increased irrigation and changes to new crops could require land leveling and deep plowing; both could adversely affect Portuguese Houses.

If the amount of irrigation water allows the current pasture use of Portuguese Houses to be changed to crop production, there would be an adverse effect in the destruction of buried remains. This would result in the loss of scientific information and value of this early fur trading post. Whereas, if the present land use remains unchanged, there would be no adverse effect from the project.

The detailed plans for the use of the irrigation water have not been made; therefore, there remains a potential for adverse effect. However the current landowner has stated he has no plans for development and he recognizes the historic value of the site.

Some evidence of the Father DeSmet Expedition may be located in the proposed irrigated area. Additional plowing or land leveling could damage or destroy such evidence.

Several historic sites including: Bozeman Trail, Cantonment Reno, Emergency Landing Strip, Fort Reno, Lutheran Mission, and Powder River Crossing, could be adversely impacted by any expansion of the irrigated area beyond that contemplated by the present project.

Paleontological values would not be impacted on the irrigated lands.

Vandalism on cultural resources located east of Kaycee, Wyoming, is currently a problem. The Eastern Powder River Coal Basin Environmental Impact Statement identified Cantonment Reno, Fort Reno, Powder River Crossing, and Portuguese Houses as endangered by vandalism. The proposed project should not add significantly to vandalism of these sites.

The proposed project and agricultural water use as outlined and without expansion, would not have an adverse effect upon Cantonment Reno or Fort Reno. Earlier studies of the project contemplated development and irrigation of lands along Powder River which included Cantonment Reno and Fort Reno. However, as outlined, the actual water use is planned for land within the irrigation district west of the sharp bend in Powder River. This plan places the agricultural water use area over three miles upstream from Cantonment Reno and seven miles from Fort Reno, thus not adversely affecting them.

5.10 Aesthetics

5.10.1 Reservoir area

Construction of a reservoir in this area would increase visual contrast significantly due to change in the basic scenic elements: form, line, color, and texture. Contrast created by the reservoir, dam, and emergency spillway would dominate the characteristic landscape of the area, thus constituting an adverse aesthetic impact. As viewed against the existing natural landscape, the new landforms and structures would create a high degree of contrast, making the project highly visable. Aesthetic impacts of the proposed action would be most significant on the reservoir site. These would range from negative to positive varying with the type, magnitude, and significance of impacts. All project phases would result in on-site aesthetic impacts as discussed below.

Construction operations would generally have short-term aesthetic impacts which, while significant on a temporary basis, would not contribute greatly to the long-term cumulative impacts of the completed reservoir and its operation since the results of this activity would be covered by water. Surface disturbance would be great. Movement of large volumes of material would require the use of numerous large earth-moving vehicles making approximately 32,000 round trips on access roads constructed for this purpose over a period of approximately 100 days; dust and exhaust pollution of the air could be substantial. Operation of the concrete batch plant near the dam site would not be expected to have any significant adverse aesthetic impact on air quality on the site. Negative impacts on air clarity and quality would be localized on the construction site and have temporary impacts downwind. Noise of heavy equipment operation and any blasting would temporarily destroy the peaceful mood at the site.

Construction activity around the reservoir would contribute to erosion of streambanks and adjacent areas and resultant heavy siltation of the stream. Stream diversion through outlet works would be the first step in complete and permanent alteration of the natural and free-flowing Middle Fork, an irreplaceable element of the existing high quality scenic environment.

Figure 5.10-A
South dam abutment and emergency spillway area.

Wherever the required concrete aggregate comes from there would be impacts similar to those discussed above. An estimated 1,160 acres would be cleared of trees, brush, and all other floatable material. Heavy equipment used in this operation would contribute dust and exhaust pollution to that from other construction activity. Access roads, coupled with clearing operations, would create serious erosion potential. Spring snowmelt and summer and fall rains during the construction period would result in erosion of denuded slopes and cause additional silt loads in Middle Fork, the effects of which would be felt downstream at least as far as the confluence of Red Fork. Along the stream channel, approximately 104 acres of dense willow and cottonwood growth would be removed, thus eliminating highly scenic natural contrast of form, color, and texture. An additional impact of the clearing operation would arise through disposal of the cleared material. If vegetative matter is burned, smoke pollution would be extremely heavy during burning periods and would have significant off-site impacts as the smoke and

Figure 5.10-B
Vegetation which would be cleared in the reservoir headwaters area.

odors drift downwind. If this material is hauled off-site, additional vehicular activity would add to air and noise pollution already disturbing the natural scene.

Rehabilitation at the project can generally be expected to have beneficial aesthetic impacts, removing, over time, some of the construction scars and reducing visual contrast. Vehicular use and other activities in this phase would have similar but lesser negative impacts on air and noise pollution encountered in other phases discussed above.

Inundation would completely alter the appearance of the reservoir site. As the reservoir fills, the scene presented would become progressively more pleasing to the eye, at least in a relative sense. Gradually, the cleared reservoir site would be covered with water causing a transformation to a scene with a large body of still water contrasted against surrounding rocks, hills, mountains and sky. This effect would be partially negated by the presence of large amounts of floating debris, which would remain until washed up on the shoreline, picked up or became waterlogged and sank. The water could be expected to remain murky for a considerable period of time until shoreline erosion stabilizes and the loose soil material settles out on the bottom. Small oil slicks may be common during this initial period also, the result of spills from machinery used during construction.

Once the reservoir became operational, annual recurring long-term impacts due to fluctuation would begin. Aesthetic impacts of the reservoir would be variable, from positive in the spring when the reservoir is fullest to negative from late summer through winter when drawdown has occurred and extensive areas of bare ground and mudflats are exposed.

On the extremes, the reservoir may fill beyond normal high water line by late spring presenting an aesthetically pleasing scene, or by fall of a dry year be drawn down to approximately one-quarter of the total pool area in which case scenic qualities would be severely affected. Visual contrast would be high in either case.

In an average year, the reservoir would fluctuate about eighteen feet vertically. The following table summarizes average maximum and minimum water level elevations, reservoir capacities (acre-feet) and the water and land areas (acres and percent of total area) which would result at those elevations. Normal high water line (NHWL) is given as a reference point.

WATER LEVEL	ELEVATION	RESERVOIR CAPACITY (acre-feet)	WATER AREA		LAND AREA	
			ACRES	% OF TOTAL AREA	ACRES	% OF TOTAL AREA
NHWL	5,013	50,000	1,160	100	0	0
Maximum	4,997	34,500	890	77	270	23
Minimum	4,978	20,000	620	53	540	47

On the average, about one-quarter to one-half of the area below the normal high water line would be exposed as barren ground and would constitute a negative aesthetic impact. (A more detailed analysis of the aesthetic impacts of the reservoir operation is found in the appendix.)

Spring vegetation, growing along the water's edge and in the water through summer, would be left dry and decaying as the shoreline recedes. Odors resulting from decay may be a negative impact.

5.10.2 Road relocation

Aesthetic impacts of the relocated road would depend upon its specific placement and alignment. Figure 8.3-A illustrates three general alternatives. Greatest aesthetic impacts would occur along the proposed route, which traverses extremely rough topography and would require extensive cuts and fills, which would be highly visible from the road and the reservoir site, particularly from the south shore. From the north reservoir shoreline the bluffs immediately above the reservoir would obstruct some views up the slope thus hiding portions of the road from view. Such visual impacts are typical of road construction. Because of surface disturbance, serious drainage and erosion problems would be anticipated. These problems could cause adverse aesthetic impacts along the road and downslope to the reservoir.

Aesthetic impacts of the north bank alternative would be less significant than those of the proposed alignment because it is generally level and surface disturbance could be held to a minimum, thus keeping the visual contrast to a minimum.

The south alternative would be generally out of sight of the reservoir and construction would require a relatively small amount of surface disturbance, lessening aesthetic impacts.

Road construction activities would result in impacts similar to those encountered during reservoir construction. Temporary aesthetic impacts, primarily of noise and air pollution, would occur from operation of heavy construction equipment and a hot mix plant in the area.

5.10.3 Summer homesite development

Although the reservoir would not be highly desirable for recreation, summer recreational homesite development could occur in the reservoir area, due to the lack of opportunities for such development in the region. Such development, an indirect impact of the reservoir, could impact local scenic quality, increasing the overall level of visual contrast due to the project.

5.10.4 Agricultural water transportation route

Some aesthetic impacts are likely on Middle Fork downstream from the reservoir. Storage of spring flows could reduce average total annual flow by one-half, and average maximum and minimum flows by about 90%. This could contribute to a change in streambank vegetation and increase streambank erosion and headcutting of tributaties between the reservoir and Red Fork (about 4 miles). Lower flows in Middle Fork could cause more sedimentation at Red Fork and could change the stream's course. All of this would adversely impact existing high quality aesthetic resources and eliminate the free-flowing nature of the stream.

5.10.5 Agricultural water use area

Aesthetic impacts from additional irrigation water on agricultural lands would be negligible. Irrigation water would be used primarily for extension of the growing season on presently irrigated lands which would add color from growing crops to the scene for that extended period. New irrigated land (363 acres) would increase total irrigated area by only seven percent, and would not have a significant aesthetic impact.

5.11 Recreation

5.11.1 Regional

Presence of the reservoir would have indirect impacts on the region due to provision of new recreation opportunities and attractions. As people learn of these opportunities, regional recreational activity should increase. Such increases would be expected to be heaviest in the South Big Horn Mountains and particularly in the Middle Fork Canyon recreation area, less than five miles from the reservoir site. Recreational use in the mountain area is already heavy and growing annually. Projections of large population increases in northeastern Wyoming due to mineral activity in the Powder River Basin would greatly expand the population base from which recreationists would be drawn (see Eastern Powder River Coal Basin Environmental Impact Statement). This alone would increase pressures on all available recreation resources and opportunities, and the reservoir may add incentive for people to visit the region.

No attempt can be made to quantify reservoir related recreational use which could be generated by the proposed reservoir. Recreation opportunities appear to be limited due to high annual water level fluctuation, and there are no recreation development plans upon which to base visitor use projections. These facts, however, do not mean that use would not be generated by the reservoir, since such water-related recreation opportunities are in short supply in the region.

Cultural resources, particularly prehistoric, could be impacted. Many sites have been identified in the reservoir area (see Cultural Resources, 4.2.10). Any increased recreation activity could significantly impact the prehistoric resource base. Historic sites in the area may also be impacted by increased visitation (see Cultural Resources.

5.11.2 Reservoir area

A reservoir in this location could completely alter local recreation resources. Some opportunities presently available would be lost, others would be altered or changed and significantly affected by the purpose and operation of the reservoir, particularly fluctuation of its surface.

5.11.2.1 Zoological

Most existing hunting opportunities at the reservoir site would be lost due to loss of suitable habitat and possible displacement of game species (see Section 5.8.1.1). In terms of positive impacts, the reservoir may provide escape and resting areas for migratory waterfowl, and limited hunting opportunities.

Stream fishing opportunities would be lost with elimination of 6.5 miles of Middle Fork of Powder River and the lower two miles of Beaver Creek. In addition, fisheries in Middle Fork below the reservoir may be eliminated due to reduced streamflows. Winter flows would be expected to be as low as 5 c.f.s., too low to maintain a fishery. However, given a minimum reservoir pool of 400 surface acres, a self-sustaining reservoir fishery could develop, providing fishing opportunities which are presently in short supply in the region.

Most existing wildlife observation opportunities would be lost with inundation of the site, except for some opportunities to watch wildlife water at the reservoir. These opportunities would not be outstanding due to absence of brushy habitat along the edge of the water. Waterfowl using the reservoir would provide new opportunities for observation.

There will be a loss of trapping opportunities along the existing stream, although similar opportunities might eventually be provided by existence of a reservoir.

Further information concerning the impacts on wildlife-related recreation resources is found in section 5.8.

5.11.2.2 General sightseeing

The landscape and scenic character of the site would be totally and permanently altered (see section 5.10.1, Aesthetics). Pleasing stream bottom views would be replaced with a large body of still water. As the reservoir fluctuated scenic quality of the area would change, becoming generally less attractive as summer progresses and more of the reservoir bottom is exposed to view. If the existing road is rerouted north of the reservoir, sightseeing opportunities would be good; only the quality will change throughout the year. The exact location of the road alignment on the slope above the reservoir would determine the perspective the observer gets of the reservoir. From the proposed alignment part way up the slope (Figure 8.3-A), the reservoir would fall into middle ground views and occasionally the foreground. From the north bank alignment closer to the shoreline, the reservoir would almost fill the entire foreground view. Since foreground views are most prominent and noticed by the observer, road location would in large part determine observers' perception of the scene.

5.11.2.3 Cultural resources

A reservoir in this location would have serious adverse impacts on opportunities for interpretation of cultural resources. Fifty-six known prehistoric sites below normal high water line would be lost. Preliminary investigation indicates at least nine sites with good potential for interpretive use. Similar opportunities adjacent to the reservoir may be entirely lost or partially destroyed by construction activity, shoreline erosion and recreational use of the reservoir. Although the petroglyph and pictograph panels would not be under water, access would be partially cut off, decreasing opportunities for their interpretation. These panels may be accessible by boat when water levels are high and could result in vandalism.

Some historic resource interpretation opportunities would be lost by flooding of the reservoir site. The most significant loss would be historic access routes into Hole-in-the-Wall and the Big Horn Mountains. These routes could be interpreted from other locations, but such interpretation would not have the meaning and significance of on site interpretation.

5.11.2.4 Water-oriented recreation

The reservoir could provide opportunities for flat-water recreation activities including pleasure boating, boat and shore fishing, water skiing, sail boating, ice fishing, and possibly swimming. Such opportunities would be new to this specific area and are presently limited in the region. The quality of such opportunities would in large part be dependent upon fluctuation of the reservoir and availability of boat launching and related facilities. Due to fluctuation, many of these activities would be restricted to the spring and early summer months.

The recreational opportunities on the reservoir would provide hazards not presently existing in the immediate area. These normally take two forms: drownings and boat related accidents. Drownings have the possibility of occurring any time anyone is out on or in the water or on ice in the winter. Boating accidents may occur at any time boats are used on the reservoir.

5.11.2.5 Water level fluctuation

The primary determinant to quality recreation opportunities would be fluctuation of reservoir water levels. In addition to aesthetic impacts (5.10.1.5), fluctuation would have adverse impacts on recreation access, a significant factor in determining quality of recreation opportunities.

The most desirable situation would be stable water at normal high water line. Under the proposed operation, based on past historic flows, that would only be reached 11% of the time over an extended period of years (11 out of every 100 years). Water would reach this level in late spring and remain there only a few days before reservoir drawdown began. As the summer recreation season progressed, the water level would continue to drop at an average rate of six vertical feet per month, from mid-May through August.

Under normal operating conditions the reservoir would be drawn down to an end-of-September average elevation thirty-four feet below normal high water line. This would result in 520 acres or 45% of the area below normal high water line being exposed and would constitute an obstacle to access to the water's edge, particularly vehicular access.

The worst possible situation would occur in a dry year if the water receded to the dead storage level. The result would be an eighty-three foot vertical drop below normal high water line. This would probably not occur until January through April, but a comparatively low level would be reached by the previous August. Water levels could be so low and pool area so small through the following recreation season that most water-oriented recreation opportunities would be virutally eliminated.

Figure 5.11-A graphically depicts water level fluctuation under the proposed operation plan. This profile was constructed from a topographic map of the reservoir site. Three views of the same profile are shown to illustrate water level fluctuation and distances the shoreline would recede from normal high water line in wet years (maximum elevations), average years (average elevations), and dry years (minimum elevations). This illustrates the relationship between topography and recreation access, particularly access for boat launching.

The majority of the shoreline is characterized by two topographic extremes: very steep and very shallow slopes. In areas of steep slopes, vehicular access would be impossible and in many cases access on foot would be difficult. In areas of shallow slopes access would be available, but boat launching would be difficult. Two locations on normal high water line have been identified which may be suited for boat launching. Figure 5.11-A illustrates one of these. In an average year, the water level at the beginning of the recreation season would be about

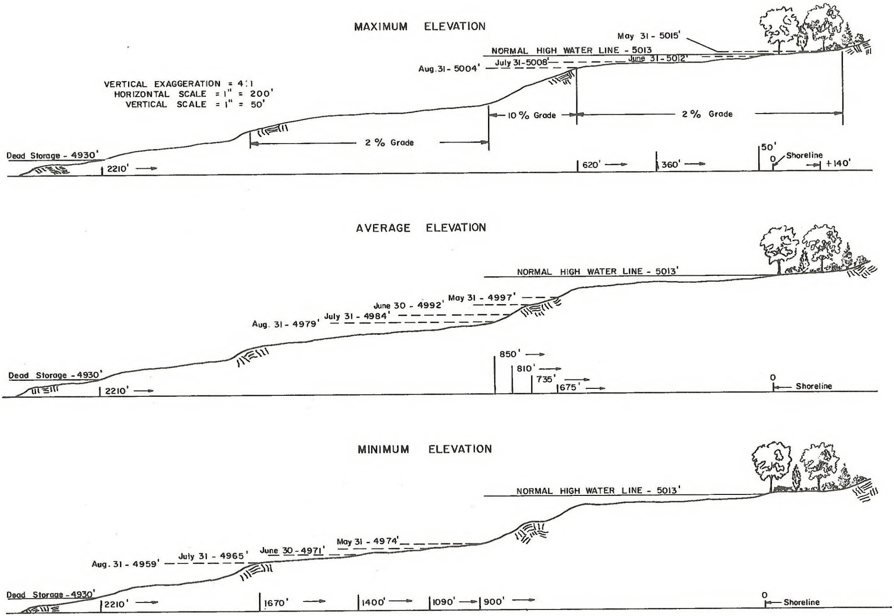

Figure 5.11-A

SHORELINE PROFILE AND RELATIONSHIP WITH FLUCTUATION sixteen feet below normal high water line, exposing in the example used approximately 675 feet of barren beach between normal high water and shoreline on that date. By the end of August the shoreline would have receded a total of 850', to a water level thirty-four feet below normal high water resulting in more than 1/8 mile of barren beach to cross to get to the water.

The high degree of fluctuation under the proposed operation would make access difficult due to the long distances water recedes on slopes suitable for boat launching. Although paved boat ramps could be constructed, they would be expensive and maintenance could be expected to be difficult and costly. Wind is an additional consideration in location of boat ramps since boat ramps facing into prevailing winds are difficult to use and maintain. Of the two locations discussed above, one faces into the prevailing southwesterly winds.

Access for recreationists on foot would be generally good, as steeper slopes can be negotiated on foot, and the presence of muddy areas on gentle slopes during drawdown would not impede pedestrians as it would vehicles.

5.11.3 Road relocation

Location of the relocated road would have an impact on recreational potential of the reservoir, particularly ease and availability of access to shoreline.

The two alternatives to the north of the reservoir (Figure 8.3-A) would present the best potential for access. The north bank alternative would have the greatest beneficial impact since its alignment is close to normal high water line. The proposed alternative would be farther up slope and access to shoreline would be more difficult. Either of these alignments would generate the greatest recreational impacts on the reservoir and provide access to the large block of national resource land to the north. They would generate no greater impacts on the region to the west than the existing road.

The road alternative south of the reservoir would have lesser recreational impacts on the reservoir, but a greater potential for indirect impacts on the surrounding region, particularly the Middle Fork Canyon area, by providing more direct access to the canyon and areas south and west. It would also provide access to a large block of national resource land south of the reservoir.

5.11.4 Agricultural water use area

Additional irrigation water would have no significant impact on recreation opportunities. As discussed in impacts on Wildlife (section 5.8.2), there could be an increase in antelope and a decrease in deer but hunting opportunities would not change significantly.

5.12 Agriculture

5.12.1 Reservoir area

5.12.1.1 Inundation and embankment area

In the description of the existing environment section, each individual ranch operation was described. The existing contribution of the lands to be taken to the entire ranch operation was described in order to distinguish between direct and indirect impacts of the proposed action.

The effect of the proposed action would be to essentially remove the lands in the taking from the productivity of the ranch. The impacts of this taking are quantified in Figure 5.12-A. The carrying capacity reduction estimation is based on the overall effect of the taking on the entire ranch. Approximately 270 acres of additional land would be purchased but would not be inundated and would be available for use by the former owners on a continual basis without charge (see introduction section).

As described in the existing environment section, the portions taken are to a large extent lands utilized during the spring, fall, and winter months for grazing of livestock. In operations 3, 5, 6, and 7, significant amounts of critical winter pasture are involved. Some of the land produces hay harvested during the summer and used for winter feed. A large percentage is irrigated, and in some cases, the land taken would be the most productive in the ranch operation. In operations 5 and 7, the ranch headquarters and family residences would be displaced. In operations 2, 5, and 7, there would be a significant dividing effect caused by the reservoir causing inconvenience and a loss of operating efficiency on the lands remaining. The impact of the land taken from production in operations 3, 5, and 7 amounts to more than the individual grazing capacity of each parcel. Taking the key areas of productive land from these operations would reduce the capability of the remaining land significantly. Operations 5 and 7 would probably not be able to operate as economic units capable of supporting their owners. As is usually the case, the remaining lands of these ranches would probably be absorbed into adjacent or nearby operations. However, the owners and families would still experience the impacts of disruption from having to move.

5.12.1.2 Proposed relocated road

If the road right-of-way were fenced it would be unavailable for livestock grazing by adjacent landowners and lessees of BLM land. However, livestock herds being trailed along the road could utilize forage in the revegetated and undistrubed areas inside right-of-way fences. Such use would be temporary in spring and fall. Since only 8 to 10 animal unit months of forage are involved, this aspect is considered of minor importance. If the right-of-way were fenced it would inhibit livestock movement by dividing the land. However, no routes used heavily by livestock were identified which would be cut off by the road.

5.12.2 Agricultural water transportation route

The operation plan's effect on the vicinity of the stream from the reservoir to the Sahara ditch diversion would be to change vegetation composition and growth patterns. The nature of these changes and their effects are not known. In some areas, there may be a reduction in forage, while in others there could be an increase. Reduction in vegetation growth would have a detrimental effect on ranch operations (see section 5.7, Vegetation).

Little change is expected in the irrigation capabilities of ranches along the transportation route but outside the irrigation district. Some may receive small amounts of irrigation water from the reservoir, but the operation plan allows only a small amount for this purpose. The

Figure 5.12-A

Land and Improvements Impacted

RANCH OPERATION NUMBER	LAND TYPES IN THE TAKING: IRRIGATED	CREEK BOTTOM	DRY GRAZING	TOTAL	IMPROVEMENTS	ESTIMATED CARRYING* CAPACITY REDUCTION: ANIMAL UNITS	PERCENT OF TOTAL
1.	15	17		32	Log cabin Well	3****	Small
2.			38	38	Fences	1	Small
3.	60	21	100	181	Small house, Garage**, Barn, Chicken house	40-50	25-35
4.	35	20	21	76	Fences	8	10
5.	80	56	130	266	Old house, New house***, Chicken house, Barn, Corrals, Cistern, Fences	225	85
6.	80	80	165	325	House, Barn, Shed**, Corrals, Fences, Cistern	Less than 10 remaining****	Nearly all
7.	60	65		125	Old house, New house***, Granary, Tack room, 2 Sheds, Roping arena, Corrals, Fences	500	70
8.	20		40	60	Fences	3	Small

* Approximate, considering the total ranch operation, based on data from interviews with owners.
** Unoccupied.
*** Displaced family residence.
**** This ranch is not operating as an economic unit.

ranch located immediately below the reservoir (see ranch operation no. 2 under 4.2.13.2.1.1, Agriculture) may have domestic water supply problems if the water table lowers and the well at the headquarters becomes less productive.

5.12.3 Agricultural water use area

Additional reservoir water is expected to allow introduction of intensive irrigation practices on land receiving the water. It would allow irrigation later in summer when water has not previously been available. This should make improved water distribution systems such as sprinkler systems more numerous. This in turn should increase water efficiency and reduce labor costs. Production of existing crops, such as alfalfa and grasses, could be expected to increase by a third or more. Introduction of improved varieties of crops, such as corn and grasses for ensilage could be anticipated as part of expanded farm operations. Increased use of commercial fertilizers is also expected. An adequate water supply should increase alternatives available to ranching operations.

Drainage problems may increase from application of additional water. Harmful chemicals might accumulate in the soil and ground water from the shift to more intensive agriculture. For example, additional row crops could require use of more insecticides and herbicides. Because these chemicals break down slowly they could accumulate to dangerous concentrations.

5.13 Transportation networks

Impacts on transportation networks could result from: construction of the reservoir, including the road relocation, and recreation use of the reservoir.

Construction of the reservoir and relocation of the road would primarily affect state route 190 -- the road from Kaycee to the site. Impacts could result from movement of equipment, materials, and workers to and from the site. Impacts would be variable in magnitude and continue over the anticipated two-year construction period. They would be perceived as inconvenience from increased traffic and delays resulting from construction equipment blocking traffic.

Water-oriented recreation use of the reservoir could impact route 190 between Kaycee and the reservoir. This would result from heavier traffic during recreation use.

5.14 Land tenure

The reservoir proposal has already impacted land tenure. The reservoir company has purchased 1,103 acres and paid damages on 841 acres representing portions of 8 ranching operations to gain control of the surface area involved in the construction of the reservoir and road relocation. It should also result in an additional 363 acres being brought under irrigation. Present ranchers impacted by the reservoir may buy comparable property elsewhere, operate with less acreage in their ranch, or possibly go out of business.

5.15 Socio-economic conditions

Assuming the project will be constructed in the next few years, say before 1980, no major adverse impacts on socio-economic conditions are anticipated in the project area or Johnson County. That is, socio-economic impacts should be minor enough that existing social and economic systems can absorb them without difficulty. For example, there appears to be sufficient capacity in local schools to handle without strain increased enrollments resulting from the project.

It is anticipated that the project would stimulate the local economy, particularly those sectors serving construction needs, such as motels, restaurants, construction materials sales.

If rapid regional development takes place as projected in numerous reports the project could become part of cumulative regional impacts. Such impacts, anticipated in the 1980 to 1990 period, are portrayed as severe, for example, limited availability of housing, overcrowded schools, hospitals, etc. Extensive treatment of potential regional impacts can be found in Eastern Powder River Coal Basin of Wyoming Final Environmental Impact Statement, (October 18, 1974) Department of the Interior, and Coal and Uranium Development of the Powder River Basin - An Impact Analysis, (June 1974) Wyoming Department of Economic Planning and Development. The bibliographies of these reports cite numerous similar reports.

The balance of this section briefly indicates potential impacts on selected aspects of socio-economic conditions.

5.15.1 Population

The proposed reservoir is expected to require a construction force of 75 persons over a two-year period and road relocation would require 40 workers over 12 months. This work force would probably experience two kinds of fluctuations: growth and decline as construction begins, progresses, and ends, and seasonal variations, as when weather causes construction to slow or stop during winter months.

Impact of construction of the reservoir and road on local population is expected to be temporary and short term. Impact on population resulting from recreational use of the reservoir may result from service sector expansion to meet needs of non-resident recreationists.

A slight population decline may result from ranchers leaving as their ranches are impacted. Additional population is not anticipated from the increase of irrigated lands through use of the reservoir's water.

5.15.2 Employment

One hundred and fifteen construction jobs would be available locally offering employment for qualified local workers. Local construction employment should increase. As demand for local services increases service employment, such as waitresses, sales persons, etc. should increase. Some shifting in employment should take place with workers moving to higher paying employment, such as from agriculture to construction or housewife to sales person.

Local employment would probably decline as the project is completed (over two years). Some service employment may be permanent to meet the needs of recreationists attracted by the reservoir.

5.15.3 Income

Local incomes would probably increase from additional employment, sales and higher wage levels typical of construction employment. Some inflation may result if demand for goods and services increases faster than supply of such items. This could be reflected in price increases. While wages may increase enough to soften the effect of rising prices on employed persons, those on fixed incomes, such as the retired or disabled, may experience a decline in buying power and standard of living. Local businesses, particularly those serving the project and its workers, should benefit from increased activity.

5.15.4 Housing

Because of the temporary nature of construction of the project, permanent housing is not anticipated to be a major problem. Workers would most likely disperse over a fairly large area, not be accompanied by their families, use motels, tourist-oriented mobile home parks, or a construction camp location for mobile homes and campers.

Permanent residents arriving through recreation-oriented employment may experience difficulty in locating adequate housing.

5.15.5 Social services

Social services may experience some impact from the project as construction workers, in some instances accompanied by their families, pass through the area. This could take the form of assistance needed to deal with turn over, such as families needing support money as the project is completed and wage earners are between jobs.

5.15.6 Law enforcement

Some increase in demand for assistance from law enforcement agencies could be anticipated in conjunction with the proposed project. Experience seems to indicate somewhat less desirable behavior from predominantly single, temporary construction work forces. This impact would be short-term and within capabilities of existing agencies.

While no outstanding increase in crime should be anticipated in conjunction with the proposed project, construction materials might be attractive to theft and some drinking violations with associated assaults could be anticipated.

5.15.7 Water and sewer

Population increases from the project might contribute to sewer system problems in Buffalo and to water quality problems in Kaycee.

Water from the project could benefit Kaycee's water system in terms of increased quantity which, in turn, might improve water quality.

5A. Probable impacts - Assumed industrial use of water

Chapter 4.3 identifies the existing regional environment within which the assumed industrial development (coal gasification) would occur. As specific plant sites have not been identified, the impacts described in this chapter are those which would be typical for most any future plant site(s) within the described environment.

The impacts described below are those which can be anticipated as a result of the construction, operation and maintenance, and phase out of two 375 million standard cubic feet per day (MMSCFD) coal gasification plants with supporting transportation systems and related population growth.

In view of other major energy development proposals in the area, the impacts of the assumed coal gasification plants must also be reviewed as part of the cumulative impact of all of the potential projects in the Eastern Powder River Basin. These potential cumulative impacts are the subject of Volume II, Final Environmental Impact Statement--Eastern Powder River Coal Basin of Wyoming (1974) which considers the projected development to the year 1990 including: coal mines, coal fired steam power generation plants, coal gasification plants, varied transportation systems, and the population increases resulting from these developments.

5A.1 Climate

The assumed coal gasification plants will likely result in some minor changes in the micro-climate of the immediate plant areas, such as slight increases in air temperature and humidity.

In conjunction with other proposed and projected development in the Eastern Powder River Basin, climate could be affected to a significant degree. Quoting from the Eastern Powder River Coal Basin Final Environmental Impact Statement:

"Development of a number of coal mines, power plants and gasification plants, and disturbance of significantly large areas of land surface may cause significant changes that could detrimentally affect weather and climate.

Recent studies indicate that large urban-industrial areas affect precipitation. However, studies have not been conducted in semiarid climates; therefore, potential effects are inferred from theoretical relationships and knowledge concerning precipitation mechanisms and studies of climate modification in other areas.

Two potential major consequences of large-scale energy development may lead to significant inadvertent modification of the regional weather and climate. These are increases in atmospheric particulate loading and changes in natural land surface characteristics which affect the precipitation mechanism.

Some evidence indicates that changes of atmospheric particulate loading and alteration of the earth-atmospheric energy balance may contribute to creation of drought conditions in semiarid climates. Reduction in precipitation could have severe affects on agricultural productivity, mined land reclamation, and water supplies within the region."

5A.2 Air quality

Development of two coal gasification plants, transportation systems, residential areas, and disturbances of relatively large areas of land would create multiple sources of air pollutants.

Development actions as outlined could generate dust and other suspended particulate matter from physcial activities and chemical pollutants such as hydrogen sulfide, sulfur oxides, nitrogen oxides, carbon monoxide, photochemical oxidants, hydrocarbons, trace elements and radionuclides from processing operations. These pollutants from complex sources would have an adverse impact on existing air conditions in and adjacent to the area.

Potentially, the most serious cumulative impact on air quality, with possible adverse impact on humans, animals, and vegetation, is from stack gases emitted by the two coal gasification plants. Emissions include sulfur oxides, nitrogen oxides, carbon monoxide, hydrocarbons, hydrogen sulfide, photochemical oxidants, and particulates.

The two plants are expected to produce yearly 16,000 tons of sulfur dioxide which under current emission standards would have to be reduced by at least 50 percent through treatment, 24,000 tons of nitrogen oxides, 7,500 tons of hydrocarbons, and 3,600 tons of particulates (assuming compliance with State and Federal air quality standards).

The industrial development and attendant population increase (18,750) will increase use of internal combustion engines of all types. Engine emissions will result in the addition of carbon monoxide, hydrocarbons, particulates, nitrogen oxides, and sulfur oxides in the basin air. These emissions are potentially harmful to the health of basin residents, vegetation, and animal life.

Increases in airborne dust and similar particulate matter will result from described development activities. Airborne particulate matter could reduce visibility and possibly cause traffic accidents during periods of inversions and periods of high winds. Particulate matter could also contribute to human allergies and similar irritations and coat vegetation with potentially harmful chemicals.

Based on the prevailing upper level wind direction (northwest), the impact from the increased airborne particulate matter could affect communities to the south and east.

Identification and quantification of impacts with precision is not possible until each system has been designed and a quantitative analysis performed. Prior to construction of each of the facilities, such an analysis will be conducted. However, based on assumed rate and type of development, certain qualitative impacts can be predicted for the study area.

The assumed industrial development will result in a decline in ambient air quality. Increased plant stack plumes and haze from disturbed soil and coal dust will result in poorer visibility within the basin and possibly in areas to the east and southeast of the basin.

Emissions could have injurious and toxic effects on humans working or living in the vicinity of the gasification plants in case of emergency or accidental high rate emissions or during periods of severe or repeated inversions. Throughout the Eastern Powder River Basin there is a probability of a two-day inversion occurring 15 times per year and a five-day inversion occurring four times a year. (Observations by Marwitz indicate persistent winter inversions--Hearings, Eastern Powder River Coal Basin Environmental Impact Statement, 6/26/74.) Impacts on health could result from long or repeated exposures to any severe air contamination during inversion episodes.

Present ambient air quality in the area is good, but it will decline with the development of complex pollution sources such as the assumed coal gasification plants.

5A.3 Topography

The land surface would be altered during site preparation for the two assumed plants, which require approximately 1,000 acres each. The extent of alteration and acreage disturbed would depend upon the specific plant sites ultimately selected, but would consist of grading and leveling to facilitate construction of the coal gasification facilities.

Construction of roads, powerlines, pipelines, and railroads would result in alterations of the land surface. To establish residential and commercial facilities for anticipated population growth, a further alteration of a portion of an additional 2,000 acres is anticipated.

5A.4 Soils

Soil disturbance will result from construction of the gasification plants, associated transportation systems, and community development. The soils on the majority of the 4,000± acres required for the two plant sites and community facilities would be disturbed.

As the sites are unknown, the length of rights-of-way for the transportation systems are also unknown. However, construction of these facilities will result in additional soil disturbance. An average disturbance of five acres per lineal mile for the various transportation facilities is estimated.

These disturbances on the plant and community sites and along the rights-of-way will result in fine grained soil and parent material being exposed to wind and water actions. Soil productivity, permeability, and infiltration rates will be reduced, increasing runoff, soil erosion, and sedimentation. Wind action, which is almost constant over the entire area, will cause fine soil, silt, and clay particles to be lifted into the atmosphere, reducing air quality and adding to soil loss. Prior to revegetation of exposed soils, soil erosion resulting from high intensity storms will remove fine materials and can result in formation of gullies. Alteration of stream channels and increased velocity will accelerate erosion of stream banks and cause headcutting of the streams. This will add to soil loss and sedimentation.

Increased population will cause additional loss of soil values primarily as a result of residential and commercial development and increased recreation such as off-road vehicle use.

5A.5 Mineral resources

The primary impact on mineral resources in the area would be the removal and subsequent combustion of 810,000,000 tons of coal during the projected 30-year life of the gasification plants. This coal production would result in the depletion of a nonrenewable energy resource.

Depending upon the ultimate location of the plant sites and transportation facilities, there could be a conflict if construction occurs on mineralized areas such as oil and gas, uranium, and sand and gravel, preventing the development of those minerals. The extent of this potential conflict is not known.

Another impact on mineral resources is that of utilization of significant amounts of aggregate material for construction purposes. Also, several other nonrenewable resources from the area of consideration would be used in construction and operation such as fill material, road surfacing material, and possibly limestone.

Energy fuels would be consumed during construction and plant operation.

5A.6 Water resources

Impacts on the water resource which would result from development of the proposed Middle Fork Reservoir are described in section 5.6. The consumptive water use for the assumed coal gasification plants would be approximately 25,000 acre-feet per year.

Other impacts on water resources in the Eastern Powder River Basin would result from the approximately 3,000 acre-feet/year required for the increased population supporting the coal gasification developments. This consumption is beyond the 25,000 acre-feet for gasification and would cause reduction in water quality and consumption of water presently being used for other purposes such as agricultural use, recreation, and fish and wildlife populations.

5A.7 Vegetation

The water available for industrial use will result in vegetation being destroyed in three principal areas. These are the two gasification plant sites (approximately 1,000 acres per site), the land area required for the transportation systems (roads, railroads, pipelines, etc.), and the land area required for residential and commercial development (2,000± acres) to meet the needs from an increased population.

As facilities will be constructed on the majority of the disturbed areas, most of the loss of vegetation will be for the life of the project.

In addition to the loss of vegetation from physical disturbance, the potential would exist for damage to occur as a result of air contamination consisting mainly of particulates, salt drift from cooling tower water evaporation, sulfur dioxide (SO_2), and nitrogen oxides (NO_x). The extent and type of impact on the vegetation from this exposure is not known. Although compliance with Federal and State air quality standards would tend to minimize the impact, some damage to vegetation could be expected.

Increased population will intensify recreation use which will destroy or decrease the vegetative cover depending on the amount of use an area receives.

Secondary impacts from loss of vegetation would result, such as increased soil erosion (wind and water), loss of cover for wildlife, loss of livestock forage, and an adverse effect on aesthetic values.

5A.8 Fish and wildlife

The assumed industrial development would result in impacts on the fish and wildlife in that wildlife and its habitat would be destroyed and overall populations would be reduced. Also, the increased human activity would indirectly affect wildlife and its habitat.

There is a direct cause-effect relationship involved with impacts on fish and wildlife as a result of industrial development. Direct mortality is rare on big game and other types which have the ability to flee. The direct action of industrial development destroys or impairs habitat. This impact on habitat then translates itself into an impact on fish and animal residents, resulting in loss of population.

Each wildlife species in the study area would be subject to the cumulative effects of several of the different categories of impacts caused by industrial development. These include:

--Direct destruction of animals.

--Permanent destruction of habitat.

--Initial destruction of habitat followed, in time, by some degree of recovery in habitat value.

--Impairment or reduction in value of habitat near human development or activities.

--Increased introduction of hazards into the wildlife environment.

--Offsite and secondary impacts caused by displaced animals, disrupted food chains, changed land and water uses, etc.

--Improvement of habitat.

Direct destruction of animals:

A number of development operations will directly destroy wild animals, ranging from individuals to entire populations. Those actions which cause the greatest losses are those which initially excavate, bury, overturn, clear, or grade large areas of previously undisturbed terrestrial habitat. The large machinery will bury, crush, and suffocate many small animals, primarily those which are not capable of moving fast enough to escape and those which retreat to burrows for protection. Any operations, including well drilling, blasting, or industrial and municipal use of water, which cause dewatering of aquatic habitats, will result in death to fishes, aquatic invertebrates, and amphibians in certain stages of life. This type of destruction occurs over time.

Habitat loss:

Permanent habitat loss will result from actions such as construction of plants, distribution systems, community expansion, transportation systems, etc. Greatest losses can be expected in the sagebrush and grassland vegetative types since they are predominant, but aquatic and terrestrial habitat would also be lost. Almost all animal species will be subjected to some permanent habitat losses. Most of the habitat disturbed will be in the sagebrush and grassland vegetative types, but significant disturbance will also occur in aquatic, riparian, and pine-juniper habitats. After the initial loss, revegetation of disturbed areas by either man-induced or natural processes will begin to restore wildlife habitat in one form or another. Following initial attempts to rehabilitate disturbed areas to perennial grasslands, the majority of the lands will most likely receive little or no special management consideration and will be subject to the same general conditions of climate, grazing, and land use as other rangelands in the region. Where artificial revegetation fails, natural plant succession will take over.

Habitat imparied or reduced in value:

The expected increase in population will foster increases in human activity over the immediate study area. This increased activity will cause some wildlife species to abandon their immediate habitat area.

Hazards introduced into the environment:

Increased vehicůlar traffic, new fences, off-road vehicle use, and power transmission lines are some of the hazards which would be introduced into the environment as a result of assumed industrial development. These hazards would result in the loss of an undetermined number of wildlife.

Threatened species

Ten species (black-footed ferret, spotted bat, prairie falcon, American peregrine falcon, northern swift fox, ferrunginous hawk, prairie pigeon hawk, mountain plover, northern long-billed curlew, western burrowing owl) having threatened--including endangered--or undetermined population status are known or believed to occur in the Eastern Powder River Basin. An additional four species (shovelnose sturgeon, goldeye and sturgeon chub, western smooth green snake) that have been identified by the Wyoming Game and Fish Department as being rare or endangered within the State of Wyoming may occur in the study area.

Inventories as to the exact occurrence and dependency of these species on the area to be developed and/or disturbed have not been accomplished. Therefore, precise impacts cannot be analyzed at this time. Habitat which is suitable for use by these species is found in the area. Unless certain species inhabit the area to be disturbed, where direct mortality could occur, the major impact would be a reduction of the range of habitat which is suitable for their continued existence. Without adequate knowledge of ranges and habitat requirements, any reduction in range may have serious long-term consequences.

5A.9 Cultural resources

Since the locations of plant sites, transportation systems, etc., are not known, it is not possible to provide a specific identification and analysis of impacts on cultural resource values (archeological, paleontological, historical, contemporary). There will be approximately 4,000 acres disturbed during construction of the plants and community facilities. Roads, railroads, pipelines, etc., will disturb additional acreage. If cultural sites exist in these acreages, they will be damaged and/or destroyed, making the values unavailable for future study and salvage.

Besides the direct impact that the construction would have on any of these values which may be located in the area, indirect impacts will occur. The indirect impacts would be associated with the population increase expected to be generated by construction and operation of the facilities. Increased population would permanently remove and disturb additional acreage which could possibly contain cultural values. Recreational use associated with this population would impact known as well as unknown sites throughout the study area. Arrowhead hunters, rock collectors, pot hunters, and off-road vehicle users would all disturb additional surface acreage, destroying evidence which could provide information on cultural sites.

Beneficial impacts would result from the inventory and recognition of the cultural values.

5A.10 Aesthetics

Construction, physical existence, and operation of the gasification facilities, transportation systems, and resultant residential and commercial development will generally have an adverse effect on the aesthetics of the area through alteration of the landscape, increased noise levels, and air contaminants such as dust, plant emissions, and vehicular emissions.

5A.11 Recreation resources

Impacts on the recreation resources would primarily result from increased population within the region due to the construction and operation of the two coal gasification plants. Another potential source of impact would be the loss of any land base committed to recreation use. Without knowing the specific development sites, the extent or significance of this impact cannot be determined.

Industry with its attendant population increase would require additional acreage. Development of material sites, replacement agriculture lands, and increased recreational use, such as off-road vehicle use, would alter additional recreational land. As experienced in other states, when population and recreational use levels increase, more private land normally available for this type of use is closed and posted, further reducing the recreation land base. Residents have been very reluctant to pay hunting fees to landowners and rapid, rather significant, changes will have to take place in the attitudes of landowners and hunters if sufficient harvests are to be obtained. The loss resulting from this type of action could be more significant than the physical loss of land base to permanent facilities.

Much of the projected demand for sand, gravel, and clinker material may be mined from stream courses, alluvial mountain slopes, or limestone outcrops within the study area. This would impact scenic recreation lands, either directly (streambeds) or indirectly (sightseeing).

The anticipated population growth would generate increased demand on recreation facilities. Recreation facilities near the population centers of Gillette and Douglas would experience the greatest demand and be subjected to greater impacts.

Reduction in air quality from industrialization would impact the recreational sightseer. During inversion periods and high winds, visibility will be reduced, obscuring to some extent the scenic views of the area and reducing the visitor's enjoyment. Additional powerlines would also impact the sightseer and reduce his enjoyment of the view.

The overall effect of industrial development on the recreation resource of the area would be to diminish present quality for the residents. It may also affect long-term economic strength for certain business sectors by reducing nonresident recreation days. Increased use of recreation resources outside the area could result in the lowering of recreation quality in an ever widening circle.

5A.12 Agriculture

Construction of two coal gasification plants and related support components, transportation systems, and housing for the increased population would precipitate changes in land use. Since agricultural use is a dominant use on lands within the area, these changes could ultimately reduce available agricultural lands. Land use changes which would occur to accommodate plant sites and community development are estimated at 4,000 acres. This does not include the acreage for the transportation systems as the lineal distance of the rights-of-way is not known at this time.

With regard to livestock grazing in the area of consideration, a loss of approximately six acres would represent an estimated loss of one animal unit month of grazing (AUM). An AUM is a measure of forage or feed requirement to maintain one animal (cow or five sheep) for a period of thirty days. Using the above acreages, which excludes the transportation systems, the annual loss of livestock forage could range from 600 to 700 AUMs. Quantification of this impact is based on the assumption that the plant sites would be located on lands presently used for livestock grazing.

Besides direct loss of livestock forage, secondary impacts associated with population increases will occur due to construction and related developments. Recreation use will occur that causes a nuisance problem and may cause temporary impairment of livestock forage use. Livestock are generally left unattended on the open range most of the time with little control other than fences. Improved access and the projected increase in population will result in increased vandalism of livestock watering facilities and fences by hunters and general outdoor recreationists. Rustling and disturbance of property has occurred in the past because of the inherent lack of protection. Disturbance of grazing animals, especially during calving and lambing by off-road vehicle use, is a serious problem to ranchers. These types of incidents would be expected to increase. Expanding residential areas would result in greater impact on agricultural lands and grazing livestock.

Construction of railroads, highways, and service roads would lead to land separation and alter present ownership patterns. Railroad, highway, and many county or heavily travelled access roads are usually fenced to prevent accidents and loss of livestock. This would result in the separation and isolation of ranch properties, which would disrupt established use patterns, cause access problems to livestock waters, buildings and for care of livestock. Small isolated tracts could result which are too small in size to be used profitably.

Livestock drift with the wind during extreme blizzard conditions of severe winter storms. Historically, heavy livestock losses have occurred by animals being trapped by fences, deep-cut draws, and other obstacles. Many projected developments will create additional obstacles. Additional livestock losses can be expected to occur from obstacles and traps created by additional fences, road and railroad rights-of-way, and similar developments.

Physical separation of adjoining private land from Bureau of Land Management Federal grazing leases and division of grazing allotments by fenced rights-of-way cause loss of leases or, in the case of Forest Service administered lands, necessitate realignment of grazing allotment boundaries and users.

Generally, each livestock watering facility services several square miles. Some loss of livestock water is anticipated through change of land use or land severance. The loss of water source could affect the useability of several square miles of rangeland. The high cost of replacing wells and reservoirs may prevent easy reestablishment of adequate livestock water.

Some grazing lands could be affected by increased erosion and sedimentation. Alteration of drainages by mining or disturbed lands could cause accelerated erosion and headcutting in productive drainage bottoms, resulting in additional losses of livestock forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

Loss of irrigated and nonirrigated lands cannot be determined as specific site locations are unknown.

5A.13 Transportation networks

Impacts on transportation networks would be caused by construction and operation of the two plant sites, the associated transport systems, and the increased employment and population, all of which create additional use of existing networks likely requiring changes and/or upgrading.

Roads and highways would be the most affected throughout all phases of the development. Increased use of the existing roads and highways requires increased maintenance expenditures, upgrading to higher road standards in some cases, and possibly relocation of sections of particular routes.

Construction of the new transportation networks would result in conflicts with existing systems, such as, disruption of an existing facility while new ones are being constructed which cross or in some other way affect those systems in operation.

In some cases the new transportation facilities which would be constructed will complement the existing facilities. An example of this may be where an existing road needs upgrading at the present time and the upgrading would be facilitated by construction of the assumed coal gasification complexes.

5A.14 Land use controls and constraints

The assumed industrial development may precipitate a need to revise or develop land use controls and constraints, as the existing ones, or lack of, may not adequately guide the development.

In order to formulate a base for development of new or revised controls, land use planning efforts will most likely be necessary.

5A.15 Socio-economic conditions

The assumed industrial development with associated increases in employment and population would have varying impacts on the socio-economic conditions of the area. In fact, the increase in population which will occur is the foundation and cause of many of the secondary impacts associated with industrial development.

Population

The following population figures are estimates of population growth that might result if the two gasification plants are constructed. These figures do not reflect population and employment for coal mining and supply.

Potential Population Growth in the Study Area
from Industrial Growth Possible with
25,000 AF/Yr. Additional Industrial Water

PROCESS	GASIFICATION 750 MMSCFD (2 plants)
Low estimate, new permanent employment	2,000
Induced non-industrial employment 1/	2,000
Total new employment	4,000
Additional population 2/	12,000
Low estimate, average temporary construction employment	3,000
Induced non-construction employment 3/	1,500
Total new construction related employment	4,500
Additional population 4/	6,750
All new employment	8,500
All additional population	18,750

1/ Assumes 1 new non-industrial employee per each new industrial employee.
2/ Assumes 3 persons per each new employee.
3/ Assumes 1/2 new non-construction employee per each construction employee.
4/ Assumes 1-1/2 persons per each new construction related employee.

The table indicates that the 25,000 acre-feet/year of water that would be available for industrial use could result in 18,750 additional population. While the addition of population is not necessarily adverse, the impact of population growth may generate negative secondary effects which are discussed in the following sections.

Employment

An employment growth of 8,500 is possible as a result of construction of the two coal gasification plants. Construction labor per plant could vary from 1,500 to a peak of 3,000. Construction could take three years per plant. Permanent employment to operate each gasification plant is estimated at 1,000.

The assumed industrial development will provide a large number of basic and secondary jobs which will compete for the available labor supply. Skilled labor shortages for construction peak may be severe and could be worsened by simultaneous plant construction.

The growth in industrial employment will attract labor from other sectors of the economy, which could create at least short-term labor shortages in those sectors such as agriculture and services.

Jobs in the services sector (such as enforcement) will be difficult to fill, as salaries tend to be fixed with no allowance for areas of inflated incomes. The consequences could be recruitment problems, inferior personnel, and understaffing.

Income

Income levels for the entering industrial worker will range from $10,000 to $15,000 per year. Whether or not these incomes are sufficiently attractive to lure employees to the Eastern Powder River Basin is unknown. While incomes of the industrial workers will be high, incomes of the work force in supportive employment, e.g., government services and consumer services, may be relatively lower. The average income of the induced labor force will be greater than or at least equal to that of the region ($10,900). The effects of rising incomes, and probably inflation of prices and property values, will be particularly adverse on that portion of the population living on fixed incomes, such as disabled, aged, and welfare recipients. Although this condition is almost universal, rapid industrial growth could likely worsen the situation.

Housing

Based on an assumed 3.5 persons per household and an estimated population increase of 18,750, there could be a demand for approximately 5,000 to 5,500 housing units to meet the needs of the population influx as a result of the development of the two coal gasification plants.

The influx of a work force with associated families would create an immediate housing demand in whichever community or communities the increased population located. The present supply of housing would be inadequate to meet the projected housing demands. Consequently, new housing would be required if the demand is to be met.

Impacts likely to occur as a result of this housing demand are a shortage of housing, inflated prices for housing, and the use of substandard housing units.

Public education

The rise in population levels and immigration of various work forces with associated families would cause an increase in public school enrollments. Increasing student enrollments in turn would impact enrollment capacities of existing school district facilities and teaching staffs.

If timely accommodations are not provided for the increasing enrollments, the following impacts could result:

1. Classroom sizes would quickly reach capacity and necessitate very high students to teacher ratios;

2. Due to overcrowded conditions and the lack of classrooms in existing school facilities, it may be necessary to use temporary structures such as mobile trailers and modular units;

3. The lack of classrooms and adequate space (gymnasium, play areas) could cause a school district to operate certain schools on a double session basis;

4. Inter-county bussing of students between school districts could result and become necessary; and

5. The quality of education could be affected adversely.

Health and social services

The county or counties affected by the population increase would experience an increase in demand on their health and social services. As a result, health and social services manpower requirements will increase and shortages in manpower would likely occur.

Facilities and services will also receive increased demands. As a result, overcrowding of facilities and an over-extension of service capability may occur, ultimately causing a reduction in quality of health care.

Law enforcement

Population growth would create a need for increases in police manpower and facilities. If this increased need could not be met in a timely manner, crime incidence would rise.

Fire protection

As with law enforcement, additional manpower and facilities would be required for fire protection. Inability of communities to respond to deficiencies in manpower and facilities could result in increased property damage and loss of life.

Water and sewer facilities

If water and sewer facilities are not expanded in a timely fashion to meet the demands of an expanding population, significant secondary impacts could occur. If water is not treated properly, serious health hazards could develop. Use of a poor quality water could result in a higher incidence of disease and possibly to epidemics of major diseases.

Overuse of the sewage facilities could result in more sewage being dumped into stream channels. This would lower water quality and impact fish and wildlife populations. The polluted water could also act as the source of diseases, especially if ground water aquifers become polluted.

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6. Mitigating measures - Agricultural use of water

This chapter presents laws and regulations, and technological treatments that could mitigate possible adverse effects of the reservoir, relocated road and agricultural use area. A digest of laws and regulations cited in this chapter will be found in the Appendix.

Impacts of the reservoir and agricultural use located on private lands would not be subject to mitigation by any federal agency. The reservoir and agricultural use impacts on private lands would be subject to the legislation discussed under Existing Environment, No. 4, where the legislation applies. For example, the Wyoming Environmental Quality Act would apply to any pit opened for extraction of gravel deposits, but would not apply to surface disturbance caused in the construction of the reservoir itself.

However the issuance of a BLM right-of-way grant is a discretionary action and can contain stipulations to mitigate impacts on the national resource lands involved. These mitigating measures may be direct or indirect; direct as they apply to the operating plan of the reservoir and indirect as they apply to the construction of, and facilities created by, the reservoir.

Direct mitigating measures could be required regulating the duration and frequency of inundation of national resource land. Such measures would counteract the proposed operating plan.

Measures are directed toward mitigating those impacts resulting from scheduled reservoir and road construction and normal operations of the reservoir. Mitigating measures are cited with an overall view of private and federal lands in mind.

Since potential weather modification (climate) is closely related to air quality standards and resource disturbance, detailed information concerning mitigating measures are contained within the Air Quality section. The utilization of emissions control equipment on vehicles, plant stacks, dust control measures and timely revegetation of disturbed lands could reduce particulate matter available to the atmosphere and reduce the effects on weather from alteration of the atmospheric balance.

6.1 Air quality

All activities having an adverse effect on air quality must comply with state and federal air quality standards.

The following state and federal laws and regulations concerning air quality standards apply, in whole or in part, for pollution control during or after construction:

1) Federal Clean Air Act, 1970, as Amended
2) National Ambient Air Quality Standards
3) New Source Performance Standards (NSPS)
4) National Emission Standards for Hazardous Air Pollutants
5) Wyoming Environmental Quality Act of 1973
6) Wyoming Ambient Air Quality Regulations

Watering of haul roads in the construction area and dust control measures incorporated in crushing, storage and loading facilities could be used to reduce dust emissions. Control devices could be used on "batch" and "hot" plants, vehicles and equipment to reduce gaseous and particulate emissions. Borrow areas and reservoir site could be sprinkled or seeded with grass or other herbaceous plants to provide interim ground cover until the reservoir fills. Clearing operations could be delayed as long as possible to minimize the time that bare soil is exposed.

Immediate revegetation (topsoiling, seeding, mulching and fertilizing) of all disturbed areas could be undertaken and this would reduce short-term air pollution from blowing dust. Storing of initial topsoil and initial boxcut overburden with rough and uneven surfaces would reduce the amount of windblown dust.

6.2 Topography

Extensive disturbance and modification of the existing topography could be associated with the construction of the reservoir and relocated road through borrow pits and cuts and fills. This disturbance and modification could be reduced if a majority of the reservoir embankment material could be obtained from below the high water line, and if the relocated road could be designed for lower speeds. It is estimated a road designed for 50 m.p.h. will disturb twice as much area as a road designed for 35 m.p.h. Less topographic damage could occur if either of the two alternate road routes were chosen.

All disturbed areas could be graded to conform as nearly as practical with the adjacent terrain. Borrow pits and cut or fill slopes should be graded to as gentle a slope as possible (recommended 3:1 slope or less). High walls could be reduced. The landscape character could be studied for any possible means of altering normal results to increase aesthetic values and reduce the general impact on the area's appearance.

Prime consideration in grading and shaping would be the retention of any waters falling on the area to improve the water table, and retention of sediment so as to protect downstream areas from excessive sedimentation.

6.3 Mineral resources

Reservoir and road specifications are quite specific in regard to the quantity of sand and gravel that will be consumed under proposed designs.

The proposed road relocation might be designed for lower speeds, which would reduce the radius of all curves. This would lessen the amount of sand and gravel needed. Less materials would be consumed on either of the two alternate road routes, since they are more favorable topographically.

6.4 Soils

Adequate land rehabilitation practices should be used to minimize loss of topsoil; wind and water erosion; and soil compaction.

Topsoil could be stockpiled for later replacement. Mechanized equipment, such as scrapers, could be used in such a way as to minimize soil mixing. Disturbed areas could be watered to reduce soil loss from wind erosion. Ripping and contour furrowing, or terracing and mulching would reduce wind and gully erosion. Any unnecessary off road vehicle use could be prohibited to lessen soil compaction. Replacing topsoil would abet revegetation.

Accidental spillage of any detrimental or toxic material could be cleaned up and buried. Service roads, campsites and equipment storage areas should be cleaned up and rehabilitated to near natural conditions and revegetated.

Waterbreaks or terraces could be constructed on disturbed slopes to reduce erosion. General guidelines for installation of waterbreaks are: less than 2% grade, 200' interval; 2-4% grade, 100' interval; 4-5% grade, 75' interval; greater than 5% grade, 50' interval. A certain degree of latitude is practical in waterbreak interval spacing. Unstable soils may require a closer interval spacing, whereas the interval spacing may be greater on very stable soils or rock outcroppings. A channel grade of .002 is recommended from the waterbreak to the natural ground elevation. Construction could be accomplished for free drainage to the natural ground elevation.

On the agricultural water use area, it is expected that conservation practices would be implemented to take advantage of the extended growing season afforded by the additional water and minimize salt accumulation.

6.5 Water resources

Mitigating measures that can be taken are discussed. Some of the impacts on water resources can be mitigated by changing the reservoir operating plan or the point of diversion of the industrial water. Others can be mitigated by using conservation and rehabilitation measures during and following construction. Some adverse impacts created by the use of water can only be mitigated by its careful use.

Some specific mitigating measures are discussed. Others are discussed only in general because of a lack of knowledge. More specific measures regarding downstream water quality could only be recommended after intensive study. More data and a water quality model would be required for this. Similarly, mitigating measures for ground water impacts would require an intensive study of ground water in the area, resulting in a predictive model for impacts.

6.5.1 Surface water resources

6.5.1.1 Water supplies and streamflow characteristics

Two possible mitigating measures would have the greatest beneficial effect in reducing the impacts of the streamflow depletion anticipated under the operational plan: (1) a replacement operation plan may be devised which would allow larger releases to the natural stream and (2) the industrial water may be diverted downstream.

During the period October through April, the average daily streamflow of the Middle Fork is approximately 43 cubic feet per second. The proposed release will be 5 cubic feet per second. It is recommended that a higher minimum flow be maintained during this period in order to reduce impacts upon the downstream environment. This could be accomplished by modifying the operation plan, permitting greater releases during this period. However, this would result in a reduction in the amount of water stored and available for irrigation and industrial use. Inspection of Figure 1-C will reveal that the normal storage capacity was only reached four times during the 20 years included in the operation study.

The recommended mitigating measure is (2) above. A relatively constant industrial diversion of approximately 2,400 acre-feet per month is stipulated in the contract (including the increase suggested by Fisk). It is recommended that this industrial water be released into the channel. This would result in an average increase in daily discharge of 38 cubic feet per second. With the additional minimum release of 5 cubic feet per second, the flow during the period October through April would be nearly the same as the natural flow. During the period May through September the flows would be increased with the irrigation releases. The industrial water could then be diverted below the confluence of the Red Fork or below the confluence of the South Fork. The effect of this mitigating measure would be protection of the downstream environment.

Even though reservoir releases will be greater during the summer months than the average natural flows, heavy irrigation withdrawals may still result in the complete diversion of streamflow. Transport of the industrial water in the natural channel would eliminate the occurrence of no flow that may presently occur due to heavy irrigation demand, especially during years of below average flow. Since this presently occurs, adoption of alternative (2) would constitute a definite environmental enhancing measure. This mitigating measure is further recommended on this basis.

6.5.1.2 Water quality

Erosion of areas disturbed during reservoir clearing, dam construction, and road relocation as well as oil spills are potential causes of surface water quality degradation amenable to mitigation.

Sediment from accelerated erosion of areas disturbed during construction and oil spills should be mitigated through the following actions.

The applicants have stated the intentions of reseeding and mulching disturbed areas after construction. This is an important measure for mitigating accelerated erosion from these sites. It will be more effective if, on steep slopes, the reseeding and mulching were accompanied by the application of binding emulsions. These would aid in holding the seed and mulch on the slope by retarding erosion until adequate stands of seeded vegetation are established.

Mulching of disturbed areas even before construction is completed would reduce raindrop impact and soil compaction. This will reduce the amount of sediment reaching streams during construction, even before reseeding operations are carried out. If the shrubs and tree branches removed from the reservoir site were chipped rather than burned, the chips could be used as mulch.

Downslope of disturbed areas, small detention dams, and water-spreading furrows should be constructed to reduce the amount of sediment reaching the reservoir. These structures would be especially useful below the relocated road and steep slopes where revegetation may be difficult.

Vehicle parks and fuel storage areas should be located above the maximum high water line to reduce the possibility of spilled or leaked oil and fuel reaching the streams, and upon completion of the dam, the reservoir. Such areas should be located on interstream areas as far as possible from stream channels.

To further mitigate the adverse environmental effects of oil and fuel spills, equipment maintenance and refueling should be carried out only in designated sites. These sites should be located in areas similar to other vehicle parks and fuel storage areas.

Mulch, such as wood chips, should be scattered over the surface of vehicle parks, maintenance areas, and fuel-handling facilities. This would mitigate small spills of fuel and oil and leaks from equipment. The mulch should be removed when nearly saturated and burned. Berms and detention dams should be constructed downslope from all these facilities as a precautionary measure for larger spills.

At the junction of the emergency spillway and the natural channel into which the spillway will discharge, possible erosion of the channel should be reduced by reducing the velocity. Installation of an energy-dissipating device at the junction would accomplish this. Maintenance of a good vegetation cover in the channel would further mitigate the erosive effects of water flowing through the channel.

Because of reductions in downstream flow rates caused by the dam and increased irrigation, degradations in downstream water quality are anticipated. This water quality degradation can be mitigated by using the natural channel to transport the industrial water to a downstream diversion point rather than diverting it at the dam. This measure, discussed under section 6.5.1.1 above, is further recommended because of this water quality consideration.

A mitigating measure that should be considered is the managed release of water for the recreation and downstream water quality maintenance. For example, allocation of 8,000 acre-feet to these purposes would result in an average end-of-May storage of 40,400 acre-feet (corresponding to 1,000 surface acres) and an average end-of-September storage of 28,700 acre-feet (corresponding to 780 surface acres). Although water in storage would be higher during wet years and lower during dry years, the values would fluctuate around higher average values.

A portion of this increased storage could be allocated to downstream water quality maintenance. If 4,000 acre-feet were allocated to downstream water quality maintenance, the minimum average release rate could be increased from 5 cubic feet per second to 10 cubic feet per second.

In order to increase the dissolved oxygen content of the water released through the outlet works it is recommended that consideration be given to the use of a multilevel outlet works. This would permit the withdrawal of water at different depths, and prevent the dissolved oxygen level of the water released through the outlet works from dropping below minimum recommended levels.

In Class 1 water the minimum levels specified in Wyoming Water Quality Rules and Regulations (1974) is 6 mg/l.

An alternative would be the use of reaeration devices attached to the outlet works.

6.5.2 Ground water resources

Few impacts on ground water resources are amenable to mitigation.

Possible lowering of the water table in the alluvium bordering the Middle Fork between the dam and the confluence with the Red Fork could be mitigated by increasing the depth of wells penetrating the alluvium.

The probable decrease in ground water quality resulting from increased use of chemical fertilizers should be mitigated by avoiding over application. Irrigation water added in excess of requirements to flush the soil of salts may also reduce the concentration of nitrates and phosphates reaching the water table when accompanied by adequate drainage.

6.6 Vegetation

6.6.1 Reservoir site

6.6.1.1 Inundation and embankment areas

Considering that essentially all vegetation in the inundation area would eventually be destroyed, it is felt that mitigating measures inside the reservoir basin would not aid the long-term vegetation situation. However, vegetative cover is significant to mitigation of secondary impacts, such as the temporary decrease in water quality from sedimentation during the clearing operation. Therefore, mitigating measures are cited for the clearing operation as follows:

Access road construction could be kept to a minimum and clearing could be directed toward removal of only the vegetal material with as little soil disturbance as possible.

Soil movement and general disruption of the area could be reduced by minimizing the time lag between the vegetation clearing operation and inundation. The size of the construction force could probably be increased to a certain extent to accomplish this.

Any remaining questions concerning the reservoir operation should be resolved before construction is started. If storage requirements are to be made which would dictate that the reservoir would never be filled to capacity, the possibility of reducing the cleared area should be investigated.

When the operation plan is finalized, a study could be made of the fluctuation pattern, the existing vegetation and soils and the terrain near the shoreline to develop clearing specifications. Consideration could be given to the possibility of retaining any vegetation which could survive below the high water line, and whether retention would benefit fish or other aquatic life. Since the reservoir would not reach the normal high water line more than eleven out of 100 years after the initial fill period, there may be areas where water tolerant vegetation species could be planted along the shore or even in areas of infrequent inundation, to enhance the landscape character and to reduce erosion of the shoreline from wave action. This study could be performed by, or with the supervision of, the Wyoming Game and Fish Commission. Other agencies should be consulted, such as the U.S. Fish and Wildlife Service, the National Park Service, Bureau of Reclamation, and the Soil Conservation Service.

The lowest water levels feasible in the overall operation would be most beneficial to vegetation in this specific area.

Proper precautions could be exercised during all activities to prevent and suppress wildfires.

With regard to construction activity involving surface disturbance above the high water line, stockpiling of topsoil could be practiced on all areas where the topsoil is of a quality suitable for later use to promote vegetative reestablishment. Topsoil from within the area of frequent inundation could be removed and stockpiled for use on disturbed areas of shallow soils. Topsoil could be distributed over the disturbed areas to a uniform depth or in a manner conducive to vegetative reestablishment.

All disturbed areas could be seeded with a seeding mixture of species best suited for each site, considering site characteristics such as soil, slope, aspect and soil moisture content. The seed should have 90% germination potential. A drill equipped with a regulator should be used to insure even depth of planting not to exceed 1/2 inch. The optimum seeding time is during the months of September to October following construction completion. Seeding should be repeated until a satisfactory stand is established. Other possible alternative rehabilitation measures are cited in Soils and Water Resources sections.

The disturbed areas could be mulched with a dry mulch such as straw or grass hay. Further protection from erosion can be achieved through the use of jute matting as described in the Appendix section which gives the Wyoming Highway Department's standards for secondary roads (Wyoming Highway Department, 1968 and 1974).

When operation plans are finalized, the recreation plan could be studied considering the possibility of utilizing construction access roads for future recreational benefit in order to minimize long-term vegetative disturbance. Conversely the construction plan could be reviewed considering any possibility of constructing the access roads where they can accomplish their purpose and still be utilized later for public access and/or recreation. Access roads could be kept to a minimum and a road grader or brush blade could be used whenever possible. Excessive cuts and fills could be avoided when constructing access roads. On level to gently rolling or sloping areas only the brush and surface obstructions could be bladed or smoothed and the understory cover left in place if possible. When a road is no longer needed for construction purposes or later recreational use, it could be obliterated and revegetated as described above.

6.6.1.2 Proposed relocated road

The relocated road could be constructed by or under the supervision of the Wyoming Highway Department. Construction could be accomplished to the standards necessary for designation and maintenance of the road as a state secondary. Construction to these standards would insure that vegetation rehabilitation measures would be adopted which would properly mitigate surface damage. These specifications are given in Appendix 13.2.

The proposed route is not the most favorable route with respect to damage to vegetation. As discussed in the Alternatives section, the route along the north shore line would be more favorable since the terrain is not as rough overall. The smoother terrain would necessitate less surface disturbance and therefore less vegetation destruction.

6.6.2 Agricultural water transportation route

The mitigating measure which could reduce the drying effect of streamflow reduction would be alteration of the project to allow greater streamflows the year around. One way to increase flows between the damsite and the Red Fork confluence without greatly affecting the purpose of the project would be to allow the industrial water to flow downstream from the dam to a diversion structure constructed near the Red Fork confluence. This would provide an additional constant flow of over 35 c.f.s., which would be beneficial to vegetation growth.

6.6.3 Agricultural water use area

The beneficial effects on vegetation can be enhanced by adoption of progressive farming methods made possible by the greater security of the water supply. A discussion of these practices is included in the Agricultural section.

6.7 Wildlife and fish

6.7.1 Terrestrial species

Once the terrestrial habitat is inundated, it will be lost for good. Even if legal or regulatory authority were avialable to BLM to require mitigation for wildlife losses due to inundation of private lands, opportunities are few and the nature of the habitat is such that similar habitat could be established locally only in areas where it already exists. No potential exists on national resource lands nearby. The following measures would partially offset adverse effects created by the proposed construction.

Utilization of forage by livestock is very heavy in the reservoir vicinity. Better management within one to two miles of the reservoir would increase carrying capacity for deer and improve riparian vegetation for streambank stabilization and cover.

The reservoir site is a wintering area for bald and golden eagles. No ospreys now occur, but Wyoming Game and Fish (R. Williams, pers. comm.) feels these birds would be attracted by a reservoir. To create or improve habitat for these and other raptors, cottonwood trees and snags protruding above the water surface should be allowed to remain. "Topping" or pruning could be done to provide roosting and possibly nesting sites.

Routing the proposed new road as close to the north shore of the reservoir as possible would disrupt wildlife and habitat the least. Presumably, there would be disturbances caused by recreationists on or near the reservoir. Confining the additional disturbance caused by vehicular traffic to the same area would be more desirable than an upland road some distance from the reservoir. In addition, it would be more desirable to keep a road at the edge of a block of terrestrial habitat rather than bisect it.

Many techniques could be employed, in cooperation with Wyoming Game and Fish and Soil Conservation Service, for creation or improvement of wildlife habitat on the irrigable lands. These include leaving thicket cover patches, hedgerows, ditchbank cover, unharvested grain, delaying mowing until after nesting season and avoiding monocultures.

6.7.2 Fish

Three mitigating measures would aid materially in establishing and maintaining a reservoir fishery. One, minimize fluctuation. Two, maintain a minimum pool of about 400 surface acres -- about 10,000 acre-feet. Three, design underwater borrow areas so that they create deep water and aid in maintaining the depth and size of the conservation pool.

For a tailwater fishery, a minimum flow of no less than 30 c.f.s. is required. This creates a conflict, because such a minimum downstream flow would interfere with desired water storage and might even contribute to greater fluctuation of reservoir levels. To offset this, another mitigating measure is worthy of consideration. The diversion of industrial water at a point downstream from the dam would be of immense benefit. This would result in an estimated 39 c.f.s. in addition to the proposed winter minimum flow of 5 c.f.s. This magnitude of flow would assure maintenance of a downstream fishery as well as streamside habitat for terrestrial species.

There are two main ways to mitigate the impacts of the increase in populations of rough fish. One, chemically treat the length of stream to be inundated to kill all the rough fish in the area. Two, construct a concrete waterfall-type barrier, upstream from the existing high water line on Beaver Creek. This would prevent certain species of rough fish that do not occur above the present Beaver Creek Falls from migrating upstream and inhabiting new areas.

Water quality to sustain fish habitat can be enhanced by the initial clearing of all vegetative matter that would be killed by inundation. Dead vegetative matter remaining under the high water line would decompose, reducing the amount of oxygen and increasing the amount of hydrogen sulfide in the water which would be detrimental to the fish population.

6.8 Cultural resources

6.8.1 Mitigating measures

Further professional investigations and salvage operations are essential to mitigate adverse impacts which would result from the proposed reservoir. All cultural resource values will be salvaged. The level of salvage required, e.g. recordation, collection, testing, excavation or relocation, will increase as the significance of the cultural resource increases. To assure compliance with legislative and administrative obligations which apply for cultural resources on any Federal approved right-of-way and resulting project, all investigations and salvage will be closely reviewed by the licensing agency. An explanation of these obligations can be found in appendix 13.6.

The seven additional steps which would be required are:

1. Specific mitigating measures for sites identified as eligible for nomination to the National Register of Historic Places (6.8.2).

2. Complete inventories of all existing cultural resources at the reservoir site, road relocation, and new irrigated lands, including a regional study of the Middle Fork region to locate all cultural resources which would be adversely impacted. The regional study would include interviews with long-time residents or descendents of original settlers in the region for historic information.

3. Conduct test excavations at selected sites to further assess scientific values and locate stratified deposits.

4. Additional excavation of selected sites identified in step 3 to provide stratigraphic control and dating for the sites studied within

the impact area. A portion of each site excavated should be left unexcavated to provide for future analysis. Selected sites which would be destroyed by the project would be completely excavated.

5. The results of all investigation would be published.

6. Cultural resources would be protected from vandalism by enforcement of existing Federal and State laws protecting antiquities. On private land the landowner's assistance would be needed in protecting the sites. Interpretive development at key locations would extend additional protection to cultural resources.

7. All sites identified as eligible for nomination to the National Register of Historic Places would be nominated.

6.8.2 Mitigating measures for cultural resources identified as eligible for nomination to the National Register of Historic Places

6.8.2.1 Middle Fork Pictograph-Petroglyph Panels

Suitable mitigating measures are not available or feasible which could recover or salvage all of the scientific data contained within these panels. However, there are some measures which would recover some of the scientific value but would not preserve the panels themselves. The panels are situated such that no feasible or suitable mitigating measures would totally prevent the loss of aesthetic, symbolic, recreational values or scientific data.

The following salvage operations or mitigating measures are available which could be applied by a professional archeologist acceptable to the Bureau of Land Management, Wyoming Historic Preservation Office, and the Advisory Council. The following steps could mitigate some but not all of the adverse impacts. The results of the mitigation would be published with copies made available to the Bureau of Land Management and Wyoming Historic Preservation Office. All material recovered would be placed in a public museum or with the University of Wyoming.

The first step of a detailed study would be the time-consuming and delicate job of removing a thin coating of red mud which presently covers large portions of the panels. Experiments would be necessary to establish the best method of exposing the full extent of the panels; however, the use of a delicate dry brush appears to be best suited. Care would be required since many of the pictographs, mostly the hand prints, appear to be made of a mud mixture splattered on the rock.

Careful steps would be taken to record all of the pictographs and petroglyphs present on the panels. Measurements would be made of size, location, relationships, and variations, in individual and groups of figures. Systematic photographs would be used to record a realistic picture and record of figures present. Experiments would be required to establish methods (time of day, lighting, type of film, etc.) best suited for recording this particular group of panels. Artist sketches would be used to record the panels, highlighting figures not visible in normal photographs.

Experiments would be made to establish the chemical composition of the natural paints used, source of paint materials, and methods of application. Research along this line would also include methods used in the petroglyphs.

The deposits at the base of each panel would be tested to establish if cultural materials are present. These deposits would be excavated if cultural materials are located. Attempts would be made to date the panels by any usable or suitable methods.

Steps would be taken to prevent vandalism during the study period and continue to protect the panels from vandalism as long as evidence of the panels remain. Fences and signs could be used depending upon the extent of public use and vandalism. These steps would preserve the scientific, aesthetic, symbolic, and recreational values as long as possible and provide the opportunity to recheck details or add to the study as the need occurs.

An attempt would be made to remove all or portions of the panels for preservation and display in a public museum. Studies and observations would continue at the site as the reservoir fills to observe and record the effect the water has on these particular panels.

Other prehistoric sites in the region would be selected for study, to provide cultural context for the panels. Attempts would be made to locate and study other pictograph-petroglyphs in the region to establish comparative information.

Other salvage measures would be followed to fit this particular site as established during the salvage in consultation with the archeologist in charge of salvage, Bureau of Land Management, Wyoming Historic Preservation Office, and Advisory Council. The level of salvage or individual steps could be adjusted if agreeable to them.

6.8.2.2 Castle Rock Archeological Site

Suitable mitigating measures are available and feasible which could recover or salvage some of the scientific data contained within this site. These measures would recover only the scientific value and would not preserve the site itself. The site is situated such that there are no feasible or suitable measures which would prevent the loss of the actual site in an undisturbed form.

The salvage would be conducted by a professional archeologist and field crew approved by the Bureau of Land Management, Wyoming Historic Preservation Office, and the Advisory Council.

A full-scale excavation would be conducted, including all the steps required by this activity. Excavations would be complete since there is danger of total loss of the site. Carbon would be collected for use in C-14 dating. Other dating methods would be used best suited to the site. All material recovered would be placed in a public museum or University of Wyoming. The results would be published.

A regional study would be conducted to collect comparative data from other prehistoric sites. Other small sites which would be lost would be investigated for further comparative data.

Steps would be taken to prevent vandalism during the study period. Fences and signs could be used depending upon the extent of public use and vandalism. If any portion of the site was not excavated, it would be protected from vandalism.

The level or extent of excavation could be changed during the project if so determined in consultation with the archeologist in charge of salvage, Bureau of Land Management, Wyoming Historic Preservation Office, and the Advisory Council.

6.8.2.3 Dull Knife Battlefield

There are no clear cut or suitable mitigating measures which would easily or feasibly prevent the vandalism of the Dull Knife Battlefield. Full-scale excavations are not needed or warranted at this time, but protection of the site and its natural setting is important.

The Bureau of Land Management would develop a detailed management plan for this site, in cooperation with the private landowner, with a view of protection from vandalism; at some future date interpretive development may be needed along with a program of archeological investigations.

A system should be established for monitoring of public use both before and after construction of the reservoir to evaluate the extent of public use brought about by the reservoir.

6.8.2.4 Portuguese Houses

Suitable mitigating measures are available and feasible which could protect the Portuguese Houses and prevent any adverse effect.

If agreements are made not to develop this site for agricultural use or any other use not compatible with the historic remains, no further mitigation for the protection of this site would be required at this time.

The State of Wyoming should investigate the possibility of obtaining this site, for protection and development as required.

6.8.2.5 Cantonment Reno

Suitable mitigating measures are available and feasible for the protection of Cantonment Reno. The Bureau of Land Management would retain the site in federal ownership and develop a detailed management plan for the site.

6.8.2.6 Fort Reno

Suitable mitigating measures are available and feasible for the protection of Fort Reno. The State of Wyoming would maintain ownership of the site and perform the management needed for its protection.

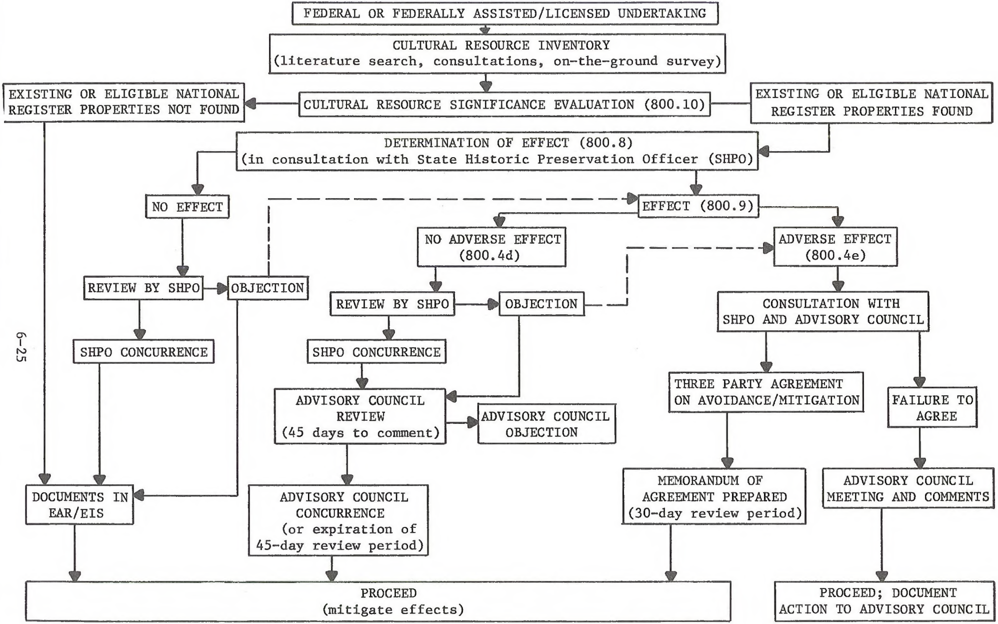

Figure 6.8.3-A

Agency Procedures for Compliance with National Historic Preservation Act, 1966

6.8.3 Compliance with National Historic Preservation Act, 1966

The National Historic Preservation Act, 1966, and E. O. 11593 (appendix 13.6) established procedures for the review of Federal actions which involve cultural resources listed in or eligible for nomination to the National Register of Historic Places. These procedures are graphically illustrated in figure 6.8.3-A. The Middle Fork EIS has incorporated these procedures to form a single document which meets all applicable requirements.

The following steps have been taken in compliance with the National Historic Preservation Act and E. O. 11593.

Preliminary inventories have been conducted for identification of cultural resources. Stipulations will be placed on the right-of-way, if approved, requiring further inventories.

The Federal Register has been consulted, and one site (Fort Reno) is listed in the National Register of Historic Places.

To establish the National Register potential of identified cultural resources for nomination to the National Register, the Wyoming Historic Preservation Officer has been consulted. The opinion of the Secretary of the Interior was requested respecting the eligibility of selected sites for nomination.

The Secretary of the Interior identified five sites as eligible for nomination:

a. Middle Fork Pictograph-Petroglyph Panels

b. Castle Rock Archeological Site

c. Dull Knife Battlefield

d. Portuguese Houses

e. Cantonment Reno

This determination is attached as Appendix 13.6.

Incorporated into this EIS are the detailed descriptions, discussion of impacts, and mitigating measures for the cultural resources in or eligible for nomination to the National Register of Historic Places.

The Wyoming Historic Preservation Officer will review this document, and his written comments expressing his views will be provided to the President's Advisory Council and included in the final EIS.

The Director of the Advisory Council will also review this document, and the Advisory Council's comments will be included in the final EIS.

This document covers:

1) The direct impact the proposed reservoir would have on the Middle Fork Pictograph-Petroglyph Panels and Castle Rock Archeological Site by destroying or damaging all of these properties through flooding.

2) The indirect impact and potential impacts to the Dull Knife Battle Field and Portuguese Houses.

3) Documentation of no adverse effect resulting from the proposed project to Cantonment Reno and Fort Reno for the review of the Executive Director.

6.9 Aesthetics

Aesthetic impacts of the proposed action would be caused primarily by an increase of visual contrast, which would make the project highly visable. Mitigation of aesthetic impacts, therefore, could best be accomplished through reduction of this contrast. The greatest opportunities for mitigation of these impacts, therefore, relate to reduction of contrast in the basic scenic elements (form, line, color, and texture) in the structures created by the project (dam and emergency spillway).

In the final construction stage, these structures should be surfaced with materials (rock and vegetation) native to the site, which would allow them to blend with the existing landscape as much as possible, thus reducing the visual contrast. Any cuts and fills which would be above the normal high water line should be made to conform as closely as possible to existing adjacent terrain features, yet at such slopes that vegetation can be reestablished and erosion prevented. These same principles would apply to any recreational or other facilities constructed around the reservoir. In addition, such facilities should be developed at a distance from the reservoir so that a "green belt" would be maintained around the reservoir. This also would help reduce the visual contrast of the total project.

Since aesthetic impacts of the proposed action would be caused by the primary impacts the action has on other resource values such as air quality, topography, vegetation, and wildlife, mitigation of adverse aesthetic impacts would be, in large part, dependent upon mitigation of the primary impacts on these other resource values. The reader is referred to the discussion of mitigation measures in the appropriate sections. With the exception of the following modification, mitigating measures discussed in these other sections would be considered suitable for mitigation of aesthetic impacts.

Vegetation (6.6). The use of waterbreaks and terraces should be avoided since they would increase the contrast in landforms, constituting an adverse aesthetic impact.

Noise pollution during construction and clearing phases would be partially mitigated by enforcement of the Wyoming Health and Safety Act of 1974. These regulations, patterned after the Federal Occupational Safety and Health Act of 1970 (84 Stat. 1593), contain provisions for maximum permissible noise levels for mechanical equipment based on time of exposure to workers.

6.10 Recreation

The single mitigating measure which could best enhance recreation opportunities and decrease adverse recreation impacts would be reduction of reservoir fluctuation. However, due to the purposes of the reservoir, such a measure would be viewed as impractical by the applicants for reasons of economics and operating efficiency. The following measures are suggested as other means available to mitigate recreational impacts.

Formulate a recreation management plan prior to construction which would identify potential recreation sites and evaluate possibilities for enhancement of their recreational potential. If possible, this plan should be coordinated with the reservoir construction plan to locate construction roads in such a manner that they would serve as recreation access roads after construction is complete. As much of the existing state secondary road as possible should be maintained and left open to provide public access to the reservoir shorelines. In addition, facilities which would enhance recreation opportunities and visitor convenience should be constructed, such as launching ramps, toilets, etc.

Implement suggested mitigating measures for fish and wildlife impacts (6.7) which could indirectly enhance wildlife-based recreation opportunities.

Implement those mitigating measures for cultural resources (6.8) which would serve to protect and enhance recreation values and opportunities derived from these resources.

6.11 Agriculture

6.11.1 Reservoir area

6.11.1.1 Inundation and embankment area

The monetary or other compensation to land and property owners in the acquisition program is considered a mitigating measure. Compensation provides a financial base for owners to relocate if necessary and possibly resume agricultural production on other lands. In some cases compensation would make it possible for carrying out other mitigating measures on the same land impacted by the project. Therefore, just compensation is cited as an important mitigating measure. However, quantifying just compensation in monetary or other terms is considered beyond the scope of this document.

The acquisition program is in progress and some agreements have been reached between the ranch owners and the reservoir corporation. The adequacy of compensation offers or agreements which have been reached is considered beyond the scope of this document.

The mitigating measures cited under "Vegetation," section 6.6, are recommended to mitigate agricultural impacts as well, for the basic reason that benefits to vegetation growth for the most part will increase available forage for livestock considering both the short and long-term aspects.

Each ranch operation will have its individual mitigating measures including the optimum placement of fences and range improvements to facilitate livestock grazing and related ranch activities during and after construction. A cooperative study could be made with BLM with regard to the national resource land involved.

Reduction of water level fluctuation would aid ranch operation by reducing mud flat areas and the corresponding hazard to livestock.

The lowest water levels feasible in the overall operation would be most beneficial to the local agricultural interests (recognizing that this would increase other impacts which may override the agricultural interest).

Borrow areas outside the reservoir could be designed to serve as watering areas for livestock.

6.11.1.2 Proposed relocated road

Mitigating measures cited in the "Vegetation" section would also apply to "Agriculture" since, in general, benefits to vegetation would increase livestock forage.

In addition, the livestock grazing utilization plans for the land involved and adjacent private, state, and federal lands could be studied to determine the best location for livestock underpasses or cattle-guards, if needed.

6.11.2 Agricultural water transportation route

Diversion of the industrial water downstream from the dam just above the confluence of the Red Fork instead of at the damsite could be considered. This would provide an additional 30-plus cubic feet per second of constant flow which would benefit streambank vegetation, provide reliable stock water, and help insure the stability of water tables in this segment of the stream between the damsite and the confluence of the Red Fork, thereby benefiting agriculture.

6.11.3 Agricultural water use area

Since impacts here would be mainly beneficial effects, the mitigating measures are largely oriented toward enhancement. Progressive farming methods could be used, including growing more improved types of crops, such as corn for ensilage, larger applications of commercial fertilizer, and installation of sprinkler systems. These practices would probably become more common due to the greater security of the water supply.

The detrimental effects of greater water table problems could be mitigated by further study of the drainage problem areas, considering the potential for gain through more and deeper drainage ditches and/or installation of more sophisticated drain systems.

6.12 Transportation networks

The impacts to the highway systems can be mitigated through the improvement of existing systems in advance of anticipated needs for greater capacity and by phasing construction of the road relocation to minimize disruption of local traffic patterns.

6.13 Land tenure

6.13.1 Johnson County, Buffalo, and Kaycee

Impacts on land use from population growth resulting from construction and operation of the reservoir could be mitigated to some extent through planning and the institution and enforcement of land use controls, such as zoning, subdivision regulations, etc., by local government.

The Buffalo-Johnson County Planning Office provides planning services to the county and Buffalo and could expand its services to include Kaycee. While the state statutes relating to planning and zoning are limiting to a degree, sufficient authority exists to allow local governmental entities to act to influence changing land use patterns. This could take the form of designating specific areas for specific uses, such as commercial areas as distinct from residential areas, and thus reduce the impacts that could result from random growth and mixing of incompatible land uses.

6.13.2 Reservoir area

While much of the land affected by the reservoir would be inundated and no longer usable, some mitigation is possible for isolated parcels. There parcels would be separated from the base property by water as the reservoir fills. Mitigation could be accomplished through land exchanges between private landowners where separated parcels would become part of adjacent base property in exchange for property adjacent to the base property suffering the separation. Land required for the road would be committed to that use, but location of the road might be changed to minimize damage to the land affected.

6.14 Socio-economic conditions

Measures to mitigate socio-economic impacts seem to revolve primarily around additional manpower and facilities, whether doctors and hospitals, teachers and classrooms, or policemen and jails. Short-term mitigation could take the form of more "efficient" use of existing facilities, as in year-round school use or ambulance service to use medical facilities with excess capacity. Most mitigating measures seem to depend upon money to recruit manpower and build facilities. Sources of funds for this type of mitigation appear to be government or private assistance in some form.

6A. Mitigating measures - Assumed industrial use of water

Chapter 5A dealt with the probable impacts resulting from the establishing of two 375 million standard cubic foot per day (MMSCFD) coal gasification plants in the study area. Many of these impacts may be mitigated using the authorities, both in law and regulation, as they apply. Impacts can be reduced, in some cases, by the application of technologies or precautions designed to mitigate the effects on the environment. In other cases, impacts cannot be mitigated.

The proposed industrial use is the assumed construction, operation, and shutdown of two 375 MMSCFD plants along with their associated access systems. No sites can be specified, hence these two plants could be located almost anywhere in the study region. Recommended measures are therefore of a general type, applicable to most sites in the area. More specific mitigation would be discussed for a definite industrial development proposal.

6A.1 Climate

Potential climate modification is closely related to air quality and surface disturbance, and more detail as to mitigation is contained within these chapters. Emission controls--electrostatic precipitators and sulfur dioxide scrubbers as well as controls on vehicles--used in conjunction with dust control and revegetation of disturbed surfaces will help to reduce alteration of the ambient air.

A further effect on weather is the introduction of heat (from hot gases) and water vapor (mostly from cooling) into the ambient air. Escaping heat may be reduced by more efficient heat exchange--a better recovery of heat--in the plant. Evaporation may be reduced by a more efficient recouping of the heat in the cooling water.

6A.2 Air quality

The principal impact on air quality will be various substances introduced into ambient air in concentrations higher than normal such as sulfur dioxide, nitrogen oxides, hydrocarbons, particulates, and possibly hydrogen sulfide and carbon monoxide. The enforcement of all applicable Federal and State laws and regulations concerning air quality standards for control emissions will reduce the cumulative effects on air quality of the assumed development. These include:

1. Federal Clean Air Act, as amended in 1970;
2. National Ambient Air Quality Standards;
3. New Source Performance Standards (NSPS);
4. National Emission Standards for Hazardous Air Pollutants;
5. Wyoming Environmental Quality Act of 1973; and
6. Wyoming Ambient Air Quality Regulations (1975).

Development and utilization of reliable emission control equipment on new equipment, vehicles, and plant stacks (both electrostatic precipitation and sulfur dioxide scrubbing will be employed) will reduce the cumulative amount of pollutants entering the area atmosphere.

Air quality standards

National Ambient Air Quality Standards (NAAQS) for suspended particulate matter, sulfur oxides, nitrogen oxides, photochemical oxidents, carbon monoxide, and hydrocarbons were promulgated by the Environmental Protection Agency (EPA) on April 30, 1971, under provisions of the Clean Air Act, as amended in 1970. Figure 6A.2-A lists these standards. It is the responsibility of the Wyoming Department of Environmental

Quality to insure that these standards are attained and maintained. If the State does not carry out this responsibility, EPA must take action to enforce the standards. Primary standards are health related and, in most cases, must be achieved by July 1975. Secondary standards are welfare related (material, vegetation, visibility, etc.) and must be achieved as expeditiously as possible. In rural areas, this may mean July 1975, whereas in urban areas it may mean well beyond July 1977.

Wyoming ambient air quality air standards were promulgated in accordance with the Wyoming Environmental Quality Act of 1973. Under Article 2 of the Act, the Wyoming Department of Environmental Quality, Air Quality Division, is empowered to enforce standards. Figure 6A.2-B contains the Wyoming ambient air quality standards. Wyoming has also adopted emission regulations for coal fired steam generators; these standards are shown on Figure 6A.2-C.

Figure 6A.2-A

National Ambient Air Quality Standards

Pollutant	Primary Standard	Secondary Standard
1. Sulfur Oxides	80 ug/m^3 (0.03 ppm) annual arith. mean 365 ug/m^3 (0.14 ppm) max. 24 hr. conc. not to be exceeded more than once a year.	1300 ug/m^3 (0.5 ppm) max. 3 hr. conc. not to be exceeded more than once a year.
2. Particulate Matter	75 ug/m^3 annual geom. mean 260 ug/m^3 max. 24 hr. conc. not to be exceeded more than once a year.	60 ug/m^3 annual geom. mean*, 150 ug/m^3 max. 24 hr. conc. not to be exceeded more than once a year.
3. Carbon Monoxide	10,000 ug/m^3 (9 ppm) max. 8 hr. conc. not to be exceeded more than once a year.	Same as primary.
	40,000 ug/m^3 (35 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary.
4. Photo Chemical Oxidants (corrected for NO_2 and SO_2 interference.	160 ug/m^3 (0.08 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary.
5. Hydrocarbons (corrected for CH_4)	160 ug/m^3 (0.24 ppm) max. 3 hr. conc. (6 to 9 a.m.) not to be exceeded more than once a year.	Same as primary.
6. Nitrogen Oxides (as Nitrogen Dioxide)	100 ug/m^3 (0.05 ppm) annual arith. mean.	Same as primary.

*To be used as guide in assessing State Implementation Plans.

Figure 6A.2-B

Wyoming Ambient Air Quality Standards

Pollutant	Standard						
	Annual	Month	24-hour	8-hour	3-hour	1-hour	1/2 hour
Particulate, ug/m^3	60 G.M.	-	150**	-	-	-	-
, COH/1000 feet	0.4	-	-	-	-	-	-
SO_2, ug/m^3	60	-	260**	-	1.300**	-	-
, sulfation mg $SO_3/100\ cm^2/day$	0.25	0.50	-	-	-	-	-
CO, mg/m^3	-	-	-	10**	-	40**	-
NO_x, ug/m^3	100 A.M.	-	-	-	-	-	-
HC, ug/m^3	-	-	-	-	160**	-	-
Oxidants, ug/m^3	-	-	-	-	-	160**	-
HF, total, ppb	-	-	1	-	-	-	-
HF, forage - ppmw	25	-	-	-	-	-	-
HF, gaseous - ug/cm^2	-	0.3	0.8	-	-	-	-
H_2S, ug/m^3	-	-	-	-	-	-	40*** 70*

*Not to be exceeded more than
**Not to be exceeded more than once per year
***Not to be exceeded more than twice per five days

Figure 6A.2-C

Wyoming Emission Standards

Fuel Combustion

Particulate Matter

0.10 lb. particulate/10^6 Btu

Nitrogen Oxides (NO_x)

0.70 lb. $NO_x/10^6$ Btu

Sulfur Dioxide (SO_2)

0.20 lb. $SO_2/10^6$ Btu

Visible Emissions

20 percent opacity

Hydrocarbon Emissions

Smokeless flare control or equally effective device

6A.3 Topography

The topography of 2,000 acres may be altered by the earthmoving activities necessary in constructing the gasification plants, and, in addition, the topography of an undetermined number of acres may be disturbed by earthmoving necessary to build community facilities, roads, powerlines, pipelines, and railroads. Mitigation for this disturbance is restoration of the topography to a somewhat natural state as quickly as possible.

In view of all the possibilities as to sites and methods, preplanning is necessary to assure successful surface protection and land rehabilitation. A determination must be made in the preplanning stage of the use to which land might be committed after plant shutdown, and consideration given to the land's suitability and capability to respond to rehabilitation.

Land use objectives should be selected and decided upon before construction. Objectives should be compatible with controlling physical conditions such as climate, soils, and local topography and must be realistically attainable.

The reshaping of disturbed areas should conform to adjacent terrain and the topography should be reshaped to achieve the best ecological conditions, meet proper drainage and hydrologic conditions, and present a pleasing landscape. Unusual, objectionable, or unnatural landforms should be avoided.

Limits on machinery operation and erosion potential are considered essential to the rehabilitation success and maintenance of surface land values (U.S.D.A. Soil Conservation Service, 1971). Some other limitations of various slope classes are listed below.

Level to gentle slopes can be reclaimed for irrigated cropland and urbanization. Moderate slopes (up to 20 percent) can be used for grazing, wildlife habitat, and recreation, including water impoundments. Various land use values may be limited to some extent within this slope class. Erosion hazards and influence on vegetation are minimal. Mechanical treatment and seeding are not limited by steepness of slope.

Moderately steep slopes 20-33 percent (5:1-3:1) can be reclaimed for grazing, woodland, orchards, recreation, and wildlife habitat, including water impoundments. Light agricultural machinery can be used for rehabilitation. Moderate erosion hazards are experienced. Revegetation can be successfully established and maintained.

Quite steep slopes 33 percent plus (3:1 and steeper) have limited use potential. Grazing may be permitted and suitable wildlife habitat may be established. Use of machinery is restricted. Revegetation of these slopes may be difficult and severe erosion hazards persist, unless stabilizing structures are used.

The placement and final grading should be accomplished in such a manner that a natural and compatible topography can be achieved. The landform will provide conditions conducive to land surface stability, adequate drainage and surface conditions capable of supporting the desired vegetation. No cut slope should exceed a 33 percent (3:1) grade after rehabilitation.

6A.4 Soils

In the process of building the two gasification plants, community facilities, and all accompanying access systems, some 4,000 acres, and an undetermined acreage along the rights-of-way for the access systems, will be disturbed. Much of the soil on this acreage will be disturbed by construction activities. A proper mitigating measure is reclamation of areas where soils are disturbed.

Vegetative establishment cannot succeed without a proper medium for plant growth. The soil-forming process is slow in semiarid climates, and topsoil is thin on most hilltops and steep hillsides. However, drainages may contain several feet of alluvial materials which can more quickly support vegetation than can the subsurface materials from hill sides and hilltops.

If possible, topsoil should be returned immediately to disturbed areas that have been graded and shaped to the desired landform and topography since live seeds, rhizomes, and soil microorganisms in removed topsoil are lost if soil is stockpiled for any length of time. Stripping and respreading of topsoil shall be considered as part of the seedbed preparation and should be timed to coincide with this phase of rehabilitation. Reinoculation of stored topsoil may be accomplished by addition of manure or mixing with fresh topsoil.

Shaping of material to manage water is an important aspect of rehabilitation. During reshaping and final grading, provision will be made for adequate drainage through reestablishment of drainage systems that are compatible with the natural drainage system of adjoining lands.

Runoff from disturbed areas should be prevented from causing siltation, erosion or other damage to streams or natural water courses. When desirable, downstream erosion control structures would be required prior to construction. All water impoundments should be properly designed and constructed for that purpose with suitable outlet structures and spillways installed if appropriate.

Surface hydrology is affected materially by the surface of disturbed areas. Surface design is fundamental in intercepting and impeding runoff flows. Runoff from precipitation is reduced by a roughened surface or increased porosity of fill materials. Surface manipulation may be used to retard runoff erosion and relieve compaction caused by heavy machinery. Terracing, pitting, ditching, listing, deep chiseling, and discing or leaving a roughened surface may be required to reduce excessive runoff, increase soil moisture, and reduce erosion. These practices should not be performed on saline soils since accumulation and concentration of salts would create alkali spots in surface pits and hinder revegetation.

Surface soil textures influence the amount of moisture available for plant growth. Materials composed largely of sandy material exhibit good aeration and percolation properties but are apt to be droughty. Clay materials compact easily from machinery operations and crust during dry periods. Loams and silty material usually have enough fine materials to hold moisture. The textures of the soil materials are important to the types of vegetation to be established and the success of revegetation.

6A.5 Mineral resources

The conversion of 810,000,000 tons of coal and an indeterminant amount of sand, gravel, and other construction materials are irretrievable commitments of resources and are discussed in section 10.

The location of plant sites and rights-of-way for plant access systems may interfere with operations attempting to retrieve other mineral values. Oil and gas leases are in effect for much of the area. Priorities for mining or drilling for oil and gas on public lands are established by the Conservation Division of the U.S. Geological Survey. Impacts on oil and gas areas can be mitigated largely by agreements among operators where significant impact on oil well siting or pipeline location arises. In extreme instances of conflict, technology is adequate through directional drilling, drainage practice, recovery of wells lost and pipeline and flowline relocation to adequately mitigate impacts which might arise.

6A.6 Water resources

The 25,000 acre-feet per year consumed by the gasification plants is an irretrievable commitment of the resource. Since it is assumed that the plants will yield no liquid effluents, no mitigation is suggested for surface waters. However, use for community expansion will impact the water resource, drawing approximately 3,000 acre-feet per year from alternative uses and generally reducing water quality.

The enforcement of applicable Federal and State water laws and regulations concerning water quality standards will reduce the cumulative effects of domestic development on water quality. These include:

1. Federal Water Pollution Control Act, as amended in 1972, and as it may be hereafter amended;
2. Wyoming Environmental Quality Act of 1973; and
3. Water Quality Standard for Wyoming, Wyoming Department of Health and Social Services, State of Wyoming, June 28, 1973.

In the event that gasification plants are producing liquid effluents, monitoring programs will be instituted. Water samples will be collected to determine if water quality is being changed by gasification, and if so, changes will be instituted to bring water quality to the standards outlined in the acts listed above.

Ground water may leach toxic or deleterious substances from buried wastes or surface waste pits. Disposal systems for solid and liquid wastes will be designed so as not to cause damage to adjoining lands or drainages. Solid waste should be buried or disposed of between impervious overburden layers to prevent its reaching surface water courses or aquifers. Liquid disposal pits containing toxic, deleterious materials will be lined or constructed so as to avoid downward percolation and contamination of ground water aquifers.

6A.7 Vegetation

Vegetation will be impacted in three ways--loss from land disturbance, loss as a result of airborne emissions, and possible loss from increased recreational use.

Revegetation is the third step in mitigation of land disturbed by construction activities. After the topography and soils have been rehabilitated, vegetation is reestablished by seeding in conjunction with mulching and fertilizing if necessary.

Vegetation can be established only with difficulty on soils being rapidly eroded. Replaced topsoil is characteristically loose, friable, and susceptible to both wind and water erosion. Mulches increase infiltration, reduce erosional soil movement and evaporation, and materially enhance revegetational potential, especially where poor soil conditions exist. Mulches are effective in areas where annual precipitation is between 9 and 14 inches (National Academy of Science, 1974).

Mulch composed of plant residues or other suitable materials will be required as part of seedbed preparation. Acceptable mulching materials are grass, hay, manure, and small grain straw. The mulch material should be applied at two tons or more per acre and anchored by discing, special mulch machine, or a Colter type machine to a depth of two inches. Other types of mulch material such as straw mat, fine wood fiber, excelsior mesh, plastic mesh, wood chips, gravel, and jute mesh can be used. The type, rate, and anchorage of mulch will be specified.

The time of planting is critical for dryland seeding. In the Northern Great Plains area, early spring or late fall seedings are the most reliable. Planting of cool-season grasses that are capable of germinating under very cold conditions and can survive in a dormant state when soil moisture is depleted is desirable (Hodder, 1970).

Most land reclamation seeding will take place under dryland condition unless irrigation water is available. Snow or spring rains provide moisture for germination, initial growth, and establishment. New seedlings, when producing rudimentary root systems and a primary leaf, cannot tolerate extended drought. Supplying irrigation water will be required when drought conditions threaten seed germination and plant survival.

The dryland farming practice of summer fallowing prior to seeding may be required to allow for an adequate accumulation of soil moisture reserves to assure successful vegetation establishment. If such a practice is used, adequate erosion controls on unprotected areas (such as surface manipulation and mulching) will be provided.

The species selected for planting must be adapted to local soil and climatic conditions. Native species may be desirable since they now exist on the site and are adapted to local climatic and soil conditions. The unavailability of seed and unreliability of seed sources limit the use of native species.

Hodder, 1970, considered that some introduced species possessed superior qualities essential for rapid establishment. Many species of introduced grasses and legumes have been used successfully for stabilizing road cuts and arid ranges (National Academy of Science, 1974).

Trees and shrubs may be used on lands being reclaimed. Most woody species should be planted from stock rather than seed for best success. Hodder (1973) lists several innovations or techniques being tested for tree and shrub establishment such as condensation traps, supplemental root transplanting, and tubelings. Sites selected for woody species should be capable of supporting this type of vegetation. Some shrubs such as big sagebrush and fourwing saltbush have been seeded successfully. A mixture of native shrubs, trees, grasses, forbs, and introduced species of vegetation may be required on suitable areas where soils and topographic conditions are varied. This mixture would provide a greater opportunity for diverse land uses such as recreation, livestock grazing, and wildlife habitat.

Several seeding methods are available for planting grasses and legumes. Drilling the seed by readily available farm equipment has proven to be the most successful method of planting. Seed distribution and coverage are assured and uniform. Broadcast seeding is satisfactory for small or relatively inaccessible areas. Broadcast seed should be covered by raking, harrowing, or other means.

Rehabilitation of disturbed land is usually performed under less than ideal farming conditions. Standard seeding rates are usually doubled or increased significantly to allow for seed and seedling mortality due to adverse conditions present on rehabilitation areas. Revegetation failures will occur. The operator will be required to attempt revegetation as many times as necessary to achieve reasonable success.

Maintenance of vegetation on disturbed areas depends to a large extent upon soil development. Applying manure, sewage sludge, or other organic material will materially enhance the soil's capability to supply plants with water and nutrients. Commercial fertilizers are convenient to handle and easy to obtain. The effectiveness of nitrogen fertilizers, however, is dependent on the amount of moisture available. It is generally considered that annual precipitation should be at least 10 to 12 inches to receive benefit from commercial fertilizer on rehabilitation areas. The type of fertilizer and rate of application should be specified when appropriate.

Plants may be damaged or destroyed by airborne emissions from the gasification plants. Damage from particulates, sulfur dioxide, and nitrogen oxides is mitigated to some extent by emission and ambient air quality standards (see Air quality). Salt drift from cooling tower water evaporation may be mitigated by devising a catchment or screening device to catch the drift.

The problem of vegetative damage from increased recreational use can be mitigated by restricting, at least in part, the damaged areas from recreational use and establishing a revegetation scheme similar to that which would be implemented for disturbed lands.

6A.8 Fish and wildlife

Principal impacts on fish or wildlife result from disruption or destruction of habitats. Industrial and community development will remove 4,000 acres, plus a number of acres for access rights-of-way, from potential use as wildlife habitat. Measures which result in a degree of mitigation of impacts on some wildlife species are primarily those which will come about incidental to attempts to reestablish topography, soils, and vegetation. The potential may exist to significantly improve the habitat for some species. Existing State and Federal air, water, and land quality laws will insure some mitigation of impacts through broad requirements of revegetation, nondegradation of water quality, and limitation of gross air pollution. These legal authorities may reduce total and long-term impacts on fish, waterfowl, some birds, rodents, and invertebrates. They can be expected to have only slight mitigating effects on total impacts on other species.

Opportunities for mitigation of wildlife losses, as opposed to legal requirements, are available. Attempts to provide a variety of topography, reestablish shrub and riparian land ecosystems, and expand quality aquatic habitats could be expected to meet with sufficient success to reduce at least part of total long-term impacts on a variety of species. Due to the nature of gasification plant operations and the long time-period required to reestablish these vegetative types, their mitigation would be a long-term project, probably extending beyond the operational phase of the plant.

A variety of native species representing shrub, forb, and grass groups should be well represented. Palatable varieties of big sagebrush and rabbitbrush as well as skunkbush sumac, chokecherry, and juniper would help mitigate losses of deer, antelope, sage grouse, and nongame species. Varied topography would increase habitat diversity and result in greater variety and abundance of wildlife.

Powerlines constructed as needed for the plants and other facilities may be designed to minimize dangers to raptors and other species of wildlife.

Fencing barriers and hazards to deer and antelope movement could be reduced by using less fencing, using fences passable to antelope and deer, and using various crossing structures. These measures should be planned and located on the ground with the State Game and Fish Department as the development proceeds.

Reestablished riparian vegetation along drainage courses and around aquatic habitats would eventually result in reestablishment of many animals associated with this habitat type. Potential also exists to enhance offsite habitat which would offset losses created by industrial development.

6A.9 <u>Cultural resources</u>

The threat to cultural resources--archeological, historical, and paleontological--values lies in the accidental unearthing and destruction of cultural items during construction of the plants or access systems. Cultural sites which exist on the effected acreage may be damaged or destroyed, and even off-site cultural values may be impacted by increased population levels.

Authorities and obligations which establish guidelines for protection of cultural resources are the statute commonly referred to as Antiquities Act of 1906 (34 Stat. 225, 16 U.S.C. 431-433); Wyoming statutes relating to archeological and paleontological sites (sections 36-11 to 56-13 and 18-330.7 W.S. 1957); Wyoming Environmental Quality Act of 1973 (section 35-502.12(a)(v)); an act for historic preservation (80 Stat. 915, 16 U.S.C. 470-470m); National Environmental Policy Act of 1969 (83 Stat. 852, 42 U.S.C. 4321 et seq); and Executive Order 11593, May 13, 1971 (36 F.R.-8921).

Both Federal and State antiquities acts regulate antiquities excavation and collections, and both protect historical values on public lands. They provide for fine and/or imprisonment for violators of their provisions. The Wyoming Environmental Quality Act protects areas of the State designated unique, irreplacable, historical, archeological, scenic, or natural. The Historic Preservation Act established a system of historic preservation in the nation and requires that certain Federal undertakings be submitted for review by the National Advisory Council on Historic Preservation. NEPA states in Section 101(b)(4) that one objective of national environmental policy is to "preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment which supports diversity and variety of individual choice." Finally, Executive Order 11593 affects Federal agencies most intimately in that they are instructed to cooperate with the nonfederal agencies, groups, and individuals and to insure that Federal plans and programs contribute to the preservation and enhancement of nonfederally owned historic and cultural values. Agencies are directed to inventory, evaluate, and nominate properties in their jurisdiction to the National Register of Historic Places.

Under the mandate of the Executive Order, Federal agencies must insure that until inventories and evaluations are completed, the agencies will use caution to assure that federally owned properties which might qualify for nomination to the National Register of Historic Places are not inadvertently transferred, sold, demolished, or substantially altered and that Federal plans and programs contribute to the preservation and enhancement of nonfederally owned sites.

The Antiquities Act of 1906 prohibits damage, collection, or excavation of plant and animal antiquities on Federal lands without a permit (see 43 CFR Part 3). The Wyoming statutes require that permits be obtained before excavation of any archeological or paleontological deposits on either State or Federal public lands (sec. 36-11 W.S. 1957).

Archeological and paleontological values on Federal lands will be protected by surveys and salvage excavations. The Wyoming Antiquities Act similarly requires a permit for excavation of antiquities on State lands, permission to be granted by the State Board of Land Commissioners.

To protect historic values, the approving Federal agencies will insure that permits include a program for historic inventory, evaluation, and nomination of sites, districts, buildings, and objects in cooperation and consultation with the State Historic Preservation Officer.

Surface surveys for evidence of archeological values in the alluvium are fundamental to establishing responsible stipulations for their protection. Therefore, those stipulations in the permit that require surveys will be followed to insure archeological and paleontological protection.

No permits or rights-of-way will be approved until the company has coordinated its archeological surveys with the Wyoming State Historic Preservation Officer. Company survey reports will be submitted to the State Historic Preservation Officer with a copy to agencies approving plans and permits. The report will be certified by the Preservation Officer and forwarded to the approving agencies with a statement that surveys have been conducted by competent, professional archeologists and a recommendation for additional surveys to be required before permits are approved. These additional surveys may be necessary if surface evidence indicates further evaluation is necessary. In addition, approvals will be conditioned to require notification to the appropriate officer of the surface administrating agency of sites discovered during right-of-way construction prior to disturbance. The Antiquities Act of 1906 and Wyoming statutes make it unlawful to excavate sites which are discovered without a permit.

Furthermore, it will be required that the alluvium to be displaced during the construction operation be surveyed and that all surveys be coordinated with the Wyoming State Historic Preservation Officer to insure competent, professional inventories, salvage, and preservation of archeological and paleontological data.

6A.10 Aesthetics

The gasification plants will impair the aesthetic values of the sites visually through construction and later through the existence of structures, access systems, and air contaminants; and audibly through increased noise levels. Much of this impairment would be mitigated if the plants were located where no one would see them, but this may not be feasible.

Construction plans should contain stipulations requiring dust abatement and noise control devices on construction equipment.

Development plans should contain stipulations guided by Federal visual resource standards. These stipulations will provide that construction design blend with the natural landscape, keeping a low profile for process structures and facilities to the extent possible.

Probably the most critical factor in reducing the impact of a lineal project--railroad, powerlines, etc.--is location in relation to naturally occurring lines in the landscape. Lineal projects will be located where natural lines already occur to the extent possible, following contours and depressions and avoiding a crossing at the crest of a hill.

Air contaminants will be mitigated to some extent by the air emission and ambient air standards outlined under Air quality.

Noise should be abated in the plant using noise control devices and baffles wherever possible.

6A.11 Recreation resources

The chief effect on recreation resources, other than the withdrawal from recreation of the plant sites and access systems rights-of-way, is the increased load on recreational facilities from population increase.

Mitigation of the expected increase in demand for recreation, with anticipated decrease in supply due to more private land being closed and posted, can be partially accomplished by a program to rehabilitate lands disturbed by plant or access system construction. Programs may be instituted with area communities such as Gillette or Douglas to provide funds or aid to upgrade and establish facilities and ease the recreation load.

Stipulations should be issued providing for return of disturbed areas to a natural and scenically attractive state. This again would likely be part of the program to rehabilitate disturbed lands.

Disruption of air quality and aesthetics of the area may reduce the visitor's sightseeing enjoyment, and hence reduce visitors. Air quality reduction is mitigated to some extent by emission and ambient air quality requirements (see Air Quality), and aesthetic value reduction is mitigated to some extent by visual resource stipulations (see Aesthetics).

6A.12 Agriculture

Principal impacts on agriculture are the withdrawal of lands from agricultural purposes to be used for plant sites, access systems, and anticipated population growth. Two principal agricultural activities, livestock grazing and farming, are pursued in the area, and both could potentially be impacted.

Measures that may be taken to minimize the effects of industrial development on livestock grazing should be initiated at the appropriate stages of the development. Temporary fences should be erected around the areas actively involved in construction so that the remainder of the area will be available for livestock use and the hazards from excavation and construction equipment to livestock minimized.

All operations will be conducted to avoid wildfire and spontaneous combustion. Open burning of all materials will be in accordance with suitable practices for fire prevention and control.

Metal and all other nonmineral material waste will be disposed of, buried, or removed. Noxious and toxic species of invader plants will be controlled by using approved herbicides. The owner will be reimbursed at the appraised price for the loss of all facilities destroyed by construction activity. Disturbed areas will be revegetated within one year following topsoiling and reshaping. Revegetation will be accomplished by a standard acceptable method. Revegetation shall be attempted until a satisfactory stand and cover of perennial vegetation is achieved and maintained.

Measures that will minimize the effect of development activity on farming must be adequately timed. The following measures will be considered minimal in an adequate development plan.

Acreages to be disturbed by construction should be posted one year prior to anticipated activity to prevent economic loss due to unnecessary summer fallow operations or destruction of growing crops. Written notification to operator of cropland will be sufficient.

No less than one access route will be maintained to each cropped field. Temporary fencing will be installed to protect crops from destruction by drifting livestock when permanent fencing is destroyed by development activity.

Cut slopes, materials piles, and denuded areas will be mulched to reduce accelerated erosion and sedimentation due to wind or water. The mulch shall be disked into the material surface. Active areas, such as haul roads, will be treated to reduce windblown mineral particles to an acceptable level.

6A.13 <u>Transportation networks</u>

The establishing of two gasification plants, in conjunction with the associated access systems, will result in two new transportation networks for the study area. In some cases, these new transportation networks will be built over, under, or through existing networks. This will interfere with existing traffic patterns and perhaps cause a safety hazard. The effects can be mitigated to some extent using good planning, adequate traffic routing around construction areas, and safety measures when construction can not be avoided. It will be necessary to provide alternate routes of access to any ranching or other local operations that will be isolated due to obliteration of roads during site or access system construction.

Existing traffic networks will receive increased use due to industrial activities and population increase, leading to a decrease in their quality. Mitigation is possible if these routes are upgraded by the industrial developers, or sufficient company aid is supplied to allow the respective street or highway department to maintain them. New transportation facilities may be necessary, for example, an airport, which might be, at least in part, financed by the company.

Rights-of-way will have to be established for the new access systems. These will not be located across high erosion hazard areas or areas of unique values. Construction will be conducted in a manner that will minimize soil erosion. Rights-of-way will not be used for "short cut" trails or roads unless properly constructed for such purposes. Deep vertical cuts and long fill slopes of clinker pits, roads, pipelines, or other construction sites will be graded by reducing slopes, backfilling to conform to the adjacent terrain. To prevent erosion, waterbreaks, terraces, or diversion ditches should be installed and the water spilled onto areas relatively resistant to erosion.

6A.14 Land use controls and constraints

In the study area, a large number of separate jurisdictional entities exercise certain types of land and resource use controls. The Federal sector includes the National Park Service, Bureau of Reclamation (withdrawn lands in Natrona County), Forest Service (Big Horn, Medicine Bow, Black Hills National Forests and Thunder Basin National Grasslands), and Bureau of Land Management (national resource lands and mineral estate under certain private lands).

Development, management, use, and control of use on Federal lands have been delegated to these agencies. With certain exceptions, uses and controls come under the discretionary authority of the agency head. Controls are effected through issuance or nonissuance 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. In certain situations, there is a joint or multiagency sharing of particular management and control functions and responsibilities. The surface and subsurface estate vested in private or State ownership would normally be governed by applicable State of Wyoming statutes.

A number of State agencies have development and administrative authority over State of Wyoming owned lands. Additionally, under State of Wyoming statutes the State is authorized to perform, administer, and control certain surface land use development and planning activities on State, county, municipal, and privately-owned properties. Control does not apply to Federal properties except as provided by law.

State air and water quality laws and regulations control industrial air emissions and all discharges of water, or into water, in the State. Solid waste disposal is also controlled by State legislation, the basic authority for all the foregoing being the Environmental Quality Act of 1973.

The 1975 State Industrial Facilities Siting Law requires application for a permit for construction of such major facilities as power plants and synthetic fuels plants, plus any other facility estimated to cost over 50 million dollars; control includes the authority to deny a permit for any of certain specified reasons.

The 1975 State land use planning legislation provides State oversight to local planning activities, authorizes grants to local governments for planning, and mandates such governments to develop local land use plans.

Under Wyoming statutes, counties have the authority to effect a wide variety of controls in matters not specifically reserved to the State. The authority applies only to those portions of the county that are unincorporated. A county may regulate and restrict location and use of buildings and structures and use, condition of use or occupancy of lands for residency, recreation, agriculture, industry, commerce, public use and other purposes.

Less than 1 percent of the lands in the study area is owned by county governments. Use and control of these lands would be governed by State law and county ordinances.

Where a county or city lacks a specific authority, provisions of the Wyoming Joint Powers Act are available to enable joint exercise of power, privilege or authority. This legislation enables, specifically, two or more agencies to jointly plan, create, finance and operate (control) water, sewage, or solid waste facilities; fire protection agency facilities; transportation systems facilities; and public school facilities.

In summary, all of the respective jurisdictions (Federal, State, and counties) have authority to impose land and resource use controls as mitigating measures.

6A.15 Socio-economic conditions

Socio-economic impacts can best be mitigated by establishing additional manpower--doctors, teachers, and policemen--in conjunction with facilities--hospitals, schools, and jails. Impacts may be temporarily mitigated by a more intensive use of existing manpower and facilities, but long-term mitigation will require funds to lure trained and professional manpower and build adequate facilities. This type of mitigation would indicate some form of government or private assistance.

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7.1 Air quality

Some impact on air quality resulting from construction activity would be unavoidable. During the construction period, temporary degradation of air would result locally from dust, vehicle emissions, emissions from concrete or asphalt plants, and possibly smoke from burning vegetation.

A possible long-term source of blowing dust would be the exposed mud flats resulting from reservoir drawdown. Long-term, but minimal pollution would result from mechanical cultivation of additional land.

7.2 Topography

Alteration of natural features of the landscape would be unavoidable. Cliffs and abrupt breaks, now part of the natural scene, would be eroded and altered by periodic inundation and drainage of the reservoir.

Changes in topographic features caused by cuts and fills along the bed of the proposed new road would be unavoidable.

Some drainage and erosion problems would probably arise along the road bed during unusually intense storms. These could not reasonably be avoided.

7.3 Mineral resources

The extraction and consumption of construction materials could not be avoided under present plans and proposals. Potential material extraction sites located within the confines of the reservoir would no longer be available for use.

7.4 Soils

Unavoidable adverse impacts at the reservoir site would include some increased erosion and loss of permeability and productivity due to compaction by heavy equipment.

7.5 Water resources

Unavoidable adverse environmental effects on water resources will probably occur as a result of the modification of the streamflow regime and increased use of water for irrigation.

Several unavoidable adverse environmental effects will occur. The degree of the effects of some of these can be quantified. For others, quantification will be possible only after intensive and extensive study. For these latter impacts, the discussion is therefore in qualitative terms.

7.5.1 Surface water resources

The storage of spring runoff in the Middle Fork Reservoir will result in a reduction of peak flows. During May, the month of highest average runoff, the average runoff is 13,750 acre-feet. The average reservoir release, assuming the industrial water is diverted downstream, will be approximately 3,000 acre-feet. Even if all water is released and diverted downstream, the reduction in peak flows represents an adverse, unmitigated impact in that the flushing of sediments deposited during the year by these flows will no longer occur. Accumulation of sediments will aggravate damage by future floods because of decreased channel capacity.

The release of relatively clean water from the reservoir will result in channel degradation below the dam, probably down to the Red Fork. This will occur as the clean water reentrains sediment up to the stream's carrying capacity. This will occur until the streambed is composed of particles whose size exceeds the sediment size that the stream is capable of carrying. Because of the resultant lowering of the

Middle Fork Channel, headcutting in tributary channels between the dam and the confluence with the Red Fork will probably occur.

Storage in the reservoir and subsequent irrigation of new lands will result of an estimated 2,350 acre-feet-per-year evaporation loss. This represents a loss of water from the Powder River Basin that could have been available for other purposes. Of this, 1,625 acre-feet represents reservoir evaporation and 725 acre-feet is consumptive use on 363 acres of irrigated land.

Reservoir storage will result in an increase in mean total dissolved solids. Present flow weighted mean total dissolved solids is 560 mg/l. Because of concentration due primarly to evaporation from the reservoir, the mean total dissolved solids will be increased to 580 mg/l. The significance of this increase will be increased salinity of the irrigation and industrial water. For irrigation, water requirements for leaching will increase approximately 20%. In general, it represents a decrease in water quality.

Accompanying the increased availability of irrigation water will probably be an increased use of agricultural chemicals including fertilizer (such as ammonium nitrate), herbicides (such as 2,4-D), and insecticides (such as malathion). Application of irrigation water or rainstorms soon after application may result in direct transport of a portion of these chemicals and their oxidation products to the stream, resulting in further degradation in water quality.

7.5.2 Ground water resources

Recharge of floodplain alluvial aquifers along some reaches of the Middle Fork and mainstem Powder River depends upon the head gradient between the surface of the stream and the water table in the aquifers. Reduction in the spring peak flows will reduce or eliminate the gradient slowing or ending recharge from the stream. The result may be a lowering of the water table, necessitating the deepening of wells that penetrate them. In some instances, a complete dewatering of the aquifer is possible, resulting in losses of wells.

Ground water quality in the vicinity of the irrigated areas may be degraded. Increased application of irrigation water with a moderate total dissolved solids content may result in the increased salinity of the local ground water as the salts are leached out of the profile and some are carried down to the water table. In addition, applied agricultural chemicals and their oxidation products could be carried down to the water table.

7.6 Vegetation

Existing vegetation would be lost on the lands to be inundated. Eventually some vegetation would return to the areas of infrequent inundation, but the composition would change to species more adapted to periodic flooding.

In the embankment and spillway area, vegetation would be almost completely destroyed by construction activities. Natural revegetation by native species on disturbed soil would probably require decades.

The proposed road would eliminate vegetation on 40 acres. Native vegetation would require years to reestablish on unpaved disturbances.

Salt accumulation around the shoreline would limit vegetative growth at the edge of the reservoir, depending on its concentration.

The only unavoidable adverse effect identified with the irrigated lands is an added drainage problem which could be expected to occur despite efforts at mitigation.

7.7 Wildlife and fish

Construction of the reservoir would mean unavoidable loss of 1,160 acres of excellent habitat, along with most or all of the resident fauna, including 130 deer, 30 turkeys, unknown numbers of rabbits and furbearers, a few partridge and pheasants, and numerous non-game mammals, amphibians, and reptiles.

Six and one half miles of the free flowing Middle Fork Powder River, plus about two miles of Beaver Creek would be lost.

7.8 Cultural resources

No matter how complete or thorough the stages of mitigation outlined earlier are followed, there would be adverse impacts upon cultural resources as a result of the Middle Fork Reservoir. If the mitigating measures are not carried out, the loss of cultural resources would be far greater. During mitigation or salvage operations, selected cultural resources would be excavated; by the nature of salvage excavations and current methods, not all the available scientific data could be recovered from each site excavated. Further, some of the sites not selected for excavation could contain valuable information not identified in preliminary investigations. Not all the cultural resources would be identified by surface indications, and thus an unknown number of sites could be lost.

The introduction of physical and visual elements which are out of character with the historic setting could not be avoided if the reservoir is constructed. The actual visual and physical remains of many sites in undisturbed context could not be maintained. Vandalism will continue to have adverse impacts no matter how strongly existing laws are enforced.

7.9 Aesthetics

Unavoidable adverse effects on aesthetic resources would arise from the construction phases of the proposed dam and road. Noise levels from heavy equipment, dust, smoke, and water quality degradation would temporarily detract from aesthetic values.

The relocated road and accompanying surface disturbance would unavoidably alter the scenic factors of line, form, texture, color, and scale, even with rehabilitation of disturbed areas.

Vegetation would be lost due to removal or by flooding.

The reservoir would result in permanent loss of the riparian scene and block the free-flowing Middle Fork Powder River. The river downstream from the dam would undergo a drastic change in natural flow patterns. Quality of the winter scene would be especially affected due to the low water release planned for that period.

Wide annual fluctuations in the reservoir level are unavoidable under any of the proposed operational plans. The exposed portion of the pool area would probably be unsightly and a source of blowing dust.

Overall, the visual contrast created by the project would increase significantly and would be considered an adverse environmental impact.

7.10 Recreation

Construction of the proposed dam and reservoir would result in the loss of approximately 90 hunter days annually as an indirect result of habitat destruction. Opportunities for observation of certain species would be lost.

The potential for 36 visitor days of stream fishing from the reservoir inlet to the dam would be lost permanently. From the dam downstream, the stream fishery would be seriously limited by the proposed low winter flows.

With construction of the dam and reservoir there would be an unavoidable loss of sightseeing and scenic values of the existing riparian setting.

There would be unavoidable adverse effects on recreational access to the reservoir caused by annual drawdowns and exposure of mud flats. Vehicular access would be especially difficult.

7.11 Agriculture

The acreages cited in Figure 5.12-A would be removed from agricultural production by construction of the reservoir, and an estimated total of from 900 to 1,000 animal units of carrying capacity would be reduced from the eight ranch units involved.

7.12 Transportation networks

Increased traffic on the highways providing access to the proposed reservoir site during and after construction for recreational use of the reservoir cannot be avoided. This would probably result in increases in traffic accidents and in unavoidable increases in road maintenance.

Inconvenience and poor travel conditions during the construction period are unavoidable.

7.13 Land tenure

The loss of agricultural and grazing land to the reservoir and the road right-of-way cannot be avoided.

Population growth and increased demand for services resulting from recreational use of the reservoir could result in conversion of land from agricultural and grazing use to residential and commercial uses.

7.14 Socio-economic conditions

Unavoidable adverse effects would depend to a large degree upon when the proposed project is constructed. If it is initiated before 1980, additional demands should be minimal and can probably be absorbed by existing social facilities. On the assumption that the project would precede regional development, the anticipated adverse effects would be a temporary housing shortage and perhaps some local disruption resulting from behavioral patterns of a construction force anticipated to be largely young, single males and unaccompanied married men.

Should the project begin when anticipated regional development is underway, probably in the 1980's, adverse effects would be more keenly felt on social services already expected to be overtaxed.

7A. Probable adverse environmental effects which cannot be avoided - Assumed industrial use of water

7A.1 Climate

Since emissions cannot be completely controlled, an increase of atmospheric particulates is anticipated.

Vehicle and equipment emissions, airborne dust resulting from construction activities, and emissions from the gasification plants would result in a decline in air quality which may result in unavoidable impacts to the climate. Specific impacts are unknown.

7A.2 Air quality

Construction and operation of the two coal gasification plants together with the related activities such as transportation systems and the residential and commercial development associated with the population increase would have an unavoidable adverse effect on local and regional air quality. Increases in particulates, sulfur dioxide, nitrogen oxides, trace elements, and hydrocarbons will occur even though emission controls are employed and air quality standards are enforced. These emissions will decrease the ambient air quality in parts of the Wyoming and Casper intrastate air quality control regions.

Deleterious stack emissions cannot be completely eliminated with existing technology so adverse impact to air quality is unavoidable. Figure 7A.2-A gives total estimated stack emissions for comparison to Wyoming Emission Standards given in section 6A.2.

Figure 7A.2-A

Estimated Stack Emissions

Tons of Emissions	Particulates*	Sulfur** Dioxide	Scrubbed*** SO_2	Nitrogen Oxides	Hydro-carbons
24 hours	10	44	22	66	20
1 year	3,600	16,000	8,000	24,000	7,500
30 years	108,000	480,000	240,000	720,000	225,000

*With electrostatic precipitator.
**Without scrubbing for SO_2.
***With 50 percent efficient scrubbing to meet Wyoming emission standards.

7A.3 Topography

Alteration of the natural features of the landscape is unavoidable where grading and leveling is required for construction of plant and transportation facilities. The exact shape and slope of the present topography is unrestorable.

Drainage pattern changes and possible creation of new patterns is unavoidable. Even though these changes may be minimized by utilization of sound planning of operations, a certain amount will still occur.

7A.4 Soils

Disturbance of topsoil on approximately 4,000± acres for plant and community development cannot be avoided. In addition, disturbance of top soil on approximately five acres per mile on lineal rights-of-way cannot be avoided. Loss of productivity from the acreage of topsoil occupied by facilities is unavoidable. This acreage will be occupied by roads, railroads, buildings, and gasification plants. The disturbance of topsoil will lower to some degree the natural soil productivity of the area by compaction, mixing natural soils, and causing accelerated soil erosion. An undetermined amount of soil disturbance would occur as a result of increased activity on the land from the increased population. One of the principal activities would be increased recreation use.

Reduction of soil productivity, permeability, and infiltration rates is unavoidable. Increase in erosion and sedimentation rates will occur, but amount of soil loss through time cannot be determined.

7A.5 Mineral resources

The consumptive use of mineral materials necessary for construction and operation of the plant sites and associated facilities (including the necessary residential and commercial development) cannot be avoided.

Coal reserves, a nonrenewable mineral commodity, will be depleted. An estimated 27 million tons per year of coal would be consumed by the two plants.

The consumption of energy fuels by construction and operation equipment is unavoidable.

7A.6 Water resources

The increased use and consumption of water cannot be avoided. This includes the 25,000 acre-feet per year for the two coal gasification plants, approximately 3,000 acre-feet per year to meet the culinary water needs of the population increase, and an undetermined amount for other uses which would result from the "growth" in the area.

Water used to meet the needs of the population increase and resultant growth would decrease water available for other uses such as grazing, recreation, and fish and wildlife populations.

Reduction in water quality would result from increased erosion, sedimentation, overtaxed sewage facilities, and toxic substances which may be discharged or leached into surface and ground water supplies.

7A.7 Vegetation

Existing vegetation will be destroyed on the plant sites, housing sites for increased population, transmission line and pipeline rights-of-way, raods, and railroad rights-of-way. There will be an unavoidable permanent loss of vegetation on an undetermined acreage due to construction of permanent facilities.

Areas disturbed by rights-of-way will be reclaimed shortly after disturbance. With the semiarid climate prevalent for the study area, successful revegetation on the severely disturbed areas is unknown at this time.

All plant succession is unavoidably destroyed at the time of disturbance. Fifty years or more of plant succession will be required for these areas to return to their present state as the existing soil structure and microclimate have been changed and altered.

Adverse impact of stack emissions, especially sulfur dioxide, on vegetation is unknown. Increased population will intensify recreation use which will destroy or decrease the vegetative cover depending on the amount of use an area receives.

7A.8 Fish and wildlife

Unavoidable loss of habitat and reductions in population will occur as a result of the assumed industrial development. As specific site locations are unknown, quantification of populations and acres of habitat which would be lost cannot be determined.

The estimated increase in population will result in more intense human activity on existing wildlife habitat. This increased activity will cause some species to abandon their immediate habitat.

Hazards introduced into the environment such as increased vehicular traffic, fences, off-road vehicle use, and power transmission lines will cause further losses in population numbers.

7A.9 Cultural resources

Subsurface material and sites will be damaged or destroyed under the most responsible construction program, with much more lost from surface activities of population expansion. Losses to expansion could be expected from lack of surface evidence, time, money, and trained personnel to conduct surveys.

Impact on the historical sites from increased population with attendant increase in vandalism and pot hunters cannot be totally avoided. Some damage to these sites will undoubtedly occur as a result of development.

Visual impacts resulting from construction of rail lines, power transmission lines, pipelines, and the gasification plants are unavoidable. Increased access will increase the use pressure on all historical sites and could result in unavoidable damage.

7A.10 Aesthetics

The change in scenic characteristics cannot be avoided. The major changes will take place in the plant site areas and along the lineal rights-of-way for transportation systems. The landscape will be crossed by transmission lines, new roads, and pipelines. Vegetative patterns will be altered on rights-of-way and other disturbed areas. New vertical intrusions will be added to the landscape (plant buildings, power transmission line poles or towers).

Increased noise levels and air contaminants such as dust and plant emissions would unavoidably have adverse impacts on aesthetic qualities.

7A.11 Recreation resources

The increased population will intensify recreation demand. The increased demand could cause deterioration and overuse throughout the area and on existing facilities. The generally unavoidable adverse effect is the lowering of recreation quality within the study and adjacent areas.

7A.12 Agriculture

There will be an unavoidable loss of agricultural land, primarily for livestock grazing. Loss of irrigated and non-irrigated croplands cannot be determined as specific site locations are unknown.

Agricultural lands could be reduced by approximately 4,000 acres to accommodate plant sites and community development. Acreage of agricultural land which would be lost to transportation systems is unknown. If the 4,000 acres lost are grazing land, the annual loss of livestock forage could range from 600 to 700 AUMs.

Increased population and accessability to agricultural lands will further affect agricultural land use. Other uses such as recreation will increasingly compete for land area.

Increased vandalism of livestock watering facilities and fences cannot be avoided. Separation and alteration of ranching operations would occur. Livestock water sources could be affected, and ranchers would be inconvenienced by changes in access patterns and use patterns. Increased mortality and molestation of cattle and sheep would take place.

7A.13 Transportation networks

Increased traffic on existing transportation facilities cannot be avoided. This increased use would result in increased maintenance costs, possible upgrading of systems, and in some cases relocation of sections of particular routes.

In some cases, construction of the new transportation networks would result in conflicts with existing systems such as disruption of use on an existing facility while new ones are being constructed which cross or in some other way affect those systems in operation.

7A.14 Socio-economic conditions

Population

The estimated population increase of 18,750 is not necessarily adverse; however, the impact of population growth would generate unavoidable secondary effects which are discussed in the following sections.

Employment

The growth in industrial employment will attract labor from other sectors of the economy, which could create labor shortages in those sectors such as agriculture and services.

Income

Industrial growth may induce inflation of local prices and property values, which would be particularly adverse on that portion of the population living on fixed incomes such as disabled, aged, and welfare recipients.

Housing

Industrial development will induce new population that will demand housing. As housing probably will not be immediately available, the adverse impact of the incoming population having to accept inferior quality housing cannot be avoided. Other unavoidable impacts would be inflated prices for housing and a shortage of housing.

Public education

Population growth would increase student enrollments which in turn would impact enrollment capacities of existing school district facilities and teaching staffs.

Health and social services

Quality of health care and social services would be reduced due to shortages of manpower, overcrowding of facilities, and an overextension of service capability.

Law enforcement

Quality of law enforcement would be adversely affected due to manpower shortages and inadequate facilities.

Fire protection

Inability of communities to respond to deficiencies in manpower and facilities could result in increased property damage and loss of life.

Water and sewer facilities

Population increases could render existing water and sewer systems inadequate, creating water shortages, water treatment and distribution problems, and sewage treatment deficiencies resulting in reduced water quality.

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8. Alternatives

This section documents the conclusions of the study of possible alternatives. In 8.1 the situation considered was the need for an additional and better timed water supply on the irrigated and irrigable lands involved. The conclusion was that no reasonable alternatives exist which would satisfy this need. The no action alternative is discussed in 8.2 involving either rejection or delaying of action on the right-of-way application.

In 8.3 the road relocation alternatives are discussed even though they are not full alternatives to the proposed action. The road relocation must be authorized by a separate action but it is still considered a part of and essential to the proposed project.

Section 8A deals with the alternatives on assumed industrial use of the water.

8.1 Alternative agricultural water sources

8.1.1 Reservoirs

The possibility of an impoundment of Powder River in Johnson County near the point of emergence from the Big Horn Mountains has been the subject of considerable study for many years. The first report on a reservoir on the Middle Fork of Powder River dates back to 1940, and the subject was under consideration before this. The conclusion of all studies is that the proposed location is the most feasible one because of the geology and topography of the area and quality of the water. The North and Red Forks of Powder River were eliminated because of geology and topography. Other reasons were that much of the available water on the North Fork is already appropriated in connection with the Dull Knife Reservoir and the Red Fork carries a high load of sediment.

Other reservoir sites exist which are located farther from the mountains, but they would not have the advantages of this location. Advantages are the ease of water transport to the irrigated land, better water quality for industrial use due to lower dissolved solids and sediment loads, and topography favorable for dam construction.

Another alternative considered was the use of underground reservoirs. If an aquifer possessing the necessary hydrologic characteristics could be found, water from high runoff periods could be diverted and stored in the aquifer (underground "reservoir"). The aquifer would be charged through wells or infiltration ponds. The recharge method selected would depend upon the infiltration rates and hydraulic conductivity of the overlying soil, water quality, and aquifer type. During low runoff periods, the required water would be obtained by pumping the aquifer. This alternative is highly conjectural and would require further study to determine conclusively whether it is feasible. Based on what is known about the area and the needs and capabilities of the people involved it is highly unlikely that any reasonable possibilities could be found.

8.1.2 Water wells

The initiative of filing for a water right was taken to insure a substantial supply. This water right is very valuable in this area of water shortage because of appropriate rights, based on filing date. Alternative sources of irrigation water would be considered if this initiative were lost and the reservoir not constructed. To be used, the water must be impounded so that it can be applied to the land when needed.

The only other source of irrigation water in this area is through the drilling of irrigation wells. The Bureau of Reclamation evaluated this possibility in their 1967 Report on the Kaycee Unit and concluded: "The development of ground water for irrigation on the Kaycee Unit appears to be unfeasible. Ground water is not considered as a potential supply, and no further investigations are planned." According to the Geological Survey Water Supply Paper 1360-E, the amount of water obtainable by pumping from wells ranges up to a maximum rate of about one cubic foot per second. This is inadequate production for irrigation wells. It appears that the ground water potential could only supply a small proportion of the quantity needed for irrigation.

8.1.3 Flood water diversion

As considered here, this alternative would involve further development and sophistication of the existing practice of utilizing flood waters. The problem would be to divert high flood flows in the peak season from the Middle Fork into storage in areas near the land to be irrigated. This would necessitate large diversion structures at strategic points on the river, each with a canal or canals leading to rougher terrain away from the flood plain where earthen dams could be constructed for storage until later in the season. Other canals and facilities would be needed to move water to the irrigated lands when needed.

Considerable expense and surface disturbance would be necessary, since fairly long distances are present between the stream channel and the draws and ravines above the flood plain. Large water losses could be expected since water would be transported relatively longer distances by canal, and evaporation and seepage rates would be high in the smaller reservoirs.

The only other variation to accomplish utilization of the high flood flows in the peak flow period would be further development of the flood irrigation system to actually irrigate without storage. Alternatives along these lines would not have the advantages of providing water late in the growing season when most needed.

8.2 Alternative of no action

8.2.1 Reject right-of-way application

If the Bureau of Land Management were to refuse to grant the right-of-way the reservoir could not be constructed. National resource land is located at low elevations near the dam site, and a dam at the proposed site small enough to eliminate the need for a Bureau of Land Management right-of-way would not store sufficient water for serious consideration.

This alternative of no action would cause the applicants and the industrial firms to consider their alternatives for water supply. As far as industrial use of water is concerned, the no action alternative could possibly contribute to the eventual adoption of a larger scale alternative of transporting coal to distant areas where water is more abundant. Under this alternative, utilization of large quantities of water in an area of water shortage would not be necessary. The influx of new people would be reduced somewhat and the effect of increased population on the economy would not be felt as strongly. However, the other water supply sources would have to be eliminated by similar non-development decisions. The reservoir company would consider alternative construction sites. Since all other sites were considered unfeasible, the project would probably be abandoned.

Few irrigation wells would be attempted due to the small potential benefit. The ranchers would probably continue as they have for many years in the past with their present water supply. BLM's refusal to grant the right-of-way might also cause the State of Wyoming to refuse to grant the loan to the Middle Fork Reservoir Company and the State Engineer's Office to terminate the water rights based on the inability to make use of the water.

The alternative of no action would make it possible to avoid adverse impacts on the cultural resources at the reservoir site. Fish and wildlife resources would be maintained on their existing level. Riparian habitat on the free-flowing condition of the water body would continue in its present condition subject to natural changes. (See the existing environment for a description of this present condition.)

8.2.2 Delay action until specific information is received

More specific information on the reservoir operation and agricultural water use could be available within a short time since an agreement appears imminent on the already-formulated most probable operation plan.

The amount of delay in the availability of information on the industrial use would depend upon how specific the information needs to be. Detailed plans on specific sites may not be formulated for several years.

The significant item in consideration of this alternative is that both the loan application and the water right would still be in jeopardy if the right-of-way application were placed in a holding status. The strong demand from other potential users for the water under this particular right and the strong demand for the funds involved in the loan would cause considerable pressure on the State Engineer's Office and the Farm Loan Board to take adverse action.

8.3 Alternatives of highway relocation

The no action alternative of the proposed state secondary Highway 190 cannot be considered with the proposed reservoir site. This site would cause inundation of the existing highway when the reservoir becomes operational and the major borrow area, the emergency spillway cuts the existing highway at one point.

Neither the applicant nor any of the preceding investigations, Bureau of Reclamation or J. T. Banner and Associates, did any road alternative studies and at least two other routes appear reasonable enough for consideration. These alternative routes are depicted on Figure 8.3-A and for purposes of discussion are designated the proposed route which the applicant submits, the north bank route which follows the north edge of the reservoir as close as topography permits, and the south route which lies south of the reservoir and proceeds south up Arminto Draw to its divide then drops down into and follows Bar C Draw to the Bar C Road.

Approximate distances were estimated for a length comparison of the three routes. Since these routes do not begin nor terminate at the same points, the common junctures of the Brock Road and Highway 190 and the town of Barnum were selected to compare the overall distance.

	New Construction	Brock Road and Highway 190 Junction to Begin Route	Terminus of Route to Barnum	Total
Proposed Route	6 miles	1.2 miles	2	8.2
North Bank Route	5 miles	.9 miles	3	8.9
South Route	7 miles	.5 miles	5	12.5

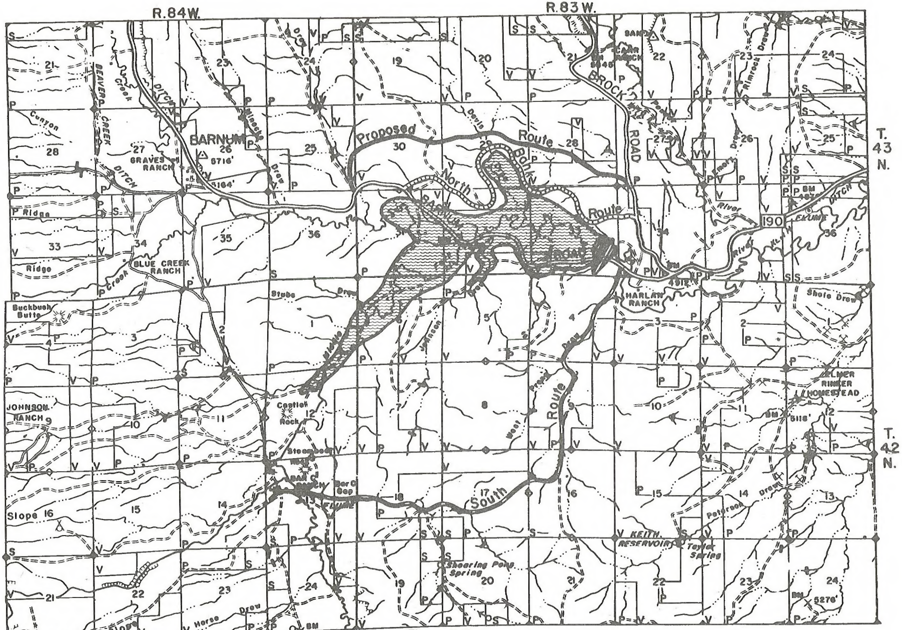


Figure 8.3-A
ROAD ALTERNATIVES

Alternative road impacts

Impacts of the proposed route can be found in Section 5 in the individual functions. Some comparisons with the proposed route will be made where significant differences occur.

The north bank route generally follows the sandstone outcrop, the most suitable roadbed formation of the other two routes.

Although none of the routes have been systematically invertoried for cultural resources, this route has the greatest potential for disturbance for both prehistoric and historic sites. This sandstone bench provided a good location for past use and contains more evidence than the other routes to substantiate this observation. Wildlife such as deer, which use the reservoir for watering, may cause more accidents between vehicles and animals.

The south route would least serve the recreational use of the reservoir. Since this route completely skirts the primary use area, close to the minimum pool, an additional road would be required to provide for recreational use.

Wildlife would be affected to similar degrees by this route as compared to the proposed route. In each case, habitat would be dissected and disturbed to a greater extent than the north bank route.

Although this route has the opportunity for the best alignment, due to the gentle curvilinear draws, additional distance is 3.6 miles to Barnum, as compared to the next longest or proposed route.

The quality of the roadbed materials for the south road are not as good as the north bank route, but appreciably better than the proposed route. The south route has about 2 miles of the unstable Thermopolis shale as compared to 3 miles of shale on the proposed route and less than 1 mile on the north bank route.

8A. Alternatives - Assumed industrial use of water

The industrial development of coal and water resources offers several alternatives to the developer. The production of synthetic natural gas by the process of coal gasification is discussed as the probable use of industrial water. The synthesis of crude oil from coal is possible using the coal liquefaction process; however, this process is still in the pilot stage and requires more development work. Coal fired steam generation of electricity is a quite common process (Jim Bridger plant or Dave Johnston plant); however, neither of the companies buying the water is traditionally in the business of electric power generation. Coal can be finely crushed, slurried with water, and transported through a pipeline to a market not in the area of study, but, again, this has not been the usual method for these companies.

Coal liquefaction, coal fired steam electric generation, and the coal slurry transport system are therefore discussed as alternative uses of the industrial water. Each process is described in some detail followed by an analysis of the probable impacts. Generally, these impacts are similar to those engendered by the gasification plants. If a substantially different impact seems likely, it will either be classed as an unavoidable impact, or a method of mitigation will be suggested.

8A.1.1 Assumptions and analysis guidelines for alternatives

Coal Liquefaction - 2 Plants

1.	Product	70-150,000 BPD/plant 4-8,000,000 tons/year/plant
2.	Coal Use	18,000,000 tons/year/plant
3.	Water Use	16,275,000 tons/year/plant 12,500 acre-feet/year/plant 0.16 acre-feet/year/person
4.	Water Evaporation	10,000,000 tons/year/plant
5.	Waste Ash and Dust	1,500,000 tons/year/plant
6.	Emissions:	
	sulfur dioxide	Uncertain
	nitrogen oxides	Uncertain
	particulates (with dust control)	Uncertain
7.	Transport Systems:	
	coal	5-6 round trips/unit train/plant 600 round trips/100 ton truck/plant 3.5 foot slurry pipeline/plant
	product	1.5 foot pipeline/plant
	water	3 foot pipeline/plant
8.	Land Use	1,000 acres/plant 0.16 acre/family 6 acres/pipeline mile 10 acres/transmission line
9.	Population:	
	construction labor	peak) 2,500-3,500/plant or higher average) 1,500-2,000/plant or higher
	operational labor	1,000/plant
	population multiplier factor	4-5
	construction population	10,000-17,500/plant
	operational population	4,000-5,000/plant
10.	Time Frame;	
	construction	5 years
	operation	30 years

8A.1.1.1 Coal liquefaction

The chemical process behind coal liquefaction is similar to that used in gasification, the principal difference being that in gasification the carbon to hydrogen ratio is adjusted to 1:4, whereas in liquefaction the ratio is only increased to roughly 1:2.

The product from the liquefaction process is a synthetic crude oil substance which is made up of compounds known as hydrocarbons. These hydrocarbons consist of varying numbers of carbon atoms, chemically bound to form chains, each carbon atom also bound to two hydrogen atoms. Octane, a typical hydrocarbon found in crude oil, is a chain of eight carbon atoms and can be schematically represented as follows:

```
   H H H H H H H H
   | | | | | | | |
 H-C-C-C-C-C-C-C-C-H
   | | | | | | | |
   H H H H H H H H
```

A typical symbol used to represent a hydrocarbon is $(CH_2)n$ where n stands for the number of carbon atoms in the chain. Using this symbol, the typical liquefaction reaction can be written as follows:

$$nC + nH_2 \longrightarrow (CH_2)n$$

where C is carbon and H_2 is hydrogen gas. The carbon is provided by coal and the hydrogen would most generally be provided using a partial coal gasification technique. The coal is first gasified to form a raw gas product consisting of carbon monoxide and hydrogen:

$$C + H_2O \longrightarrow CO + H_2$$

Then the gas is enriched in hydrogen using the shift conversion reaction.

$$CO + H_2O \longrightarrow CO_2 + H_2$$

The carbon dioxide (CO_2) is separated from the hydrogen, and the hydrogen is fed to the liquefaction reaction.

There are some advantages to liquefying coal as an alternative to gasification. These include:

(1) Liquefaction requires less water per unit of coal processed. Since lower hydrogen enrichment is required, and hydrogen is supplied from water, less water is required.

(2) Synthetic crude oil can be transported in a variety of ways (truck, rail, pipeline, etc.).

(3) Synthetic crude can be used to make many diversified products (petroleum products, petrochemical products, etc.).

(4) Synthetic crude oil is easy to store for future use.

Two processes are typical of coal liquefaction technology, each representing a class of liquefaction processes. The COED process is low pressure liquefaction which yields not only a liquid product but also some gas and solid products. THE SRC process is a high pressure liquefaction which yields almost entirely liquid product.

8A.1.1.2 Plant disposition assumptions

Very little is known about coal liquefaction, and at this time little can be projected as to what a commercial scale liquefaction plant would look like, what requirements it would have for feed materials, and what sort and quantity of products could be expected. Coal liquefaction is similar to gasification in many respects, and the plants would resemble each other, sharing many of the same component systems.

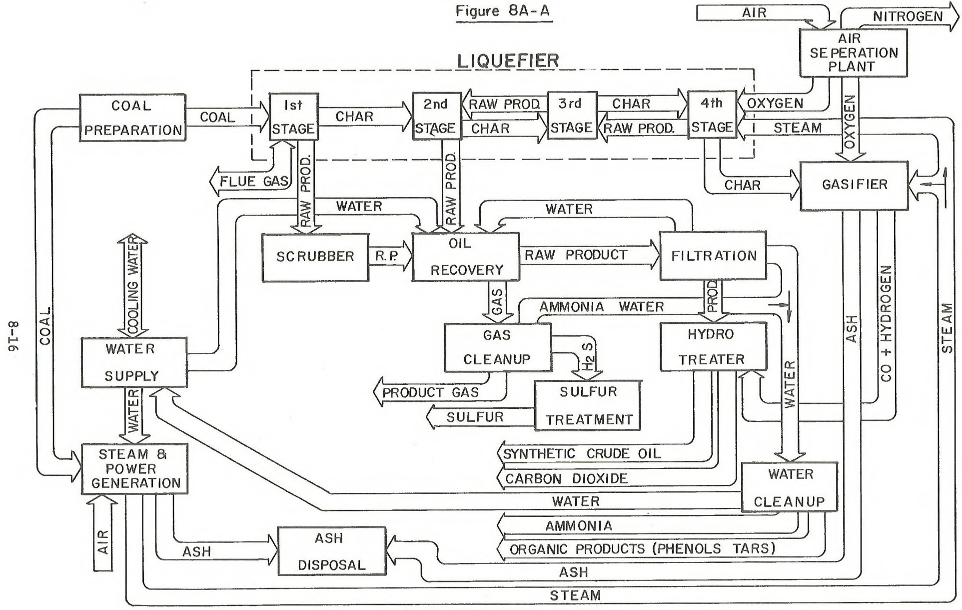
As in the case of coal gasification, the size of a liquefaction plant is related to the amount of water available. The quantity of water determines the amount of coal which can be processed. Coal liquefaction should use less water per ton of coal processed than the typical gasification process. Thus, with the 12,500 acre-feet water per year each company has available, a plant capable of processing approximately 50,000 tons of coal per day is possible. A plant of this size would probably yield between 70 and 150 thousand barrels per day (BPD) of synthetic crude oil type products. A liquefaction plant capable of converting 50,000 tons per day would likely require about 1,000 acres for the plant site.

8A.1.1.3 The coal liquefaction plant

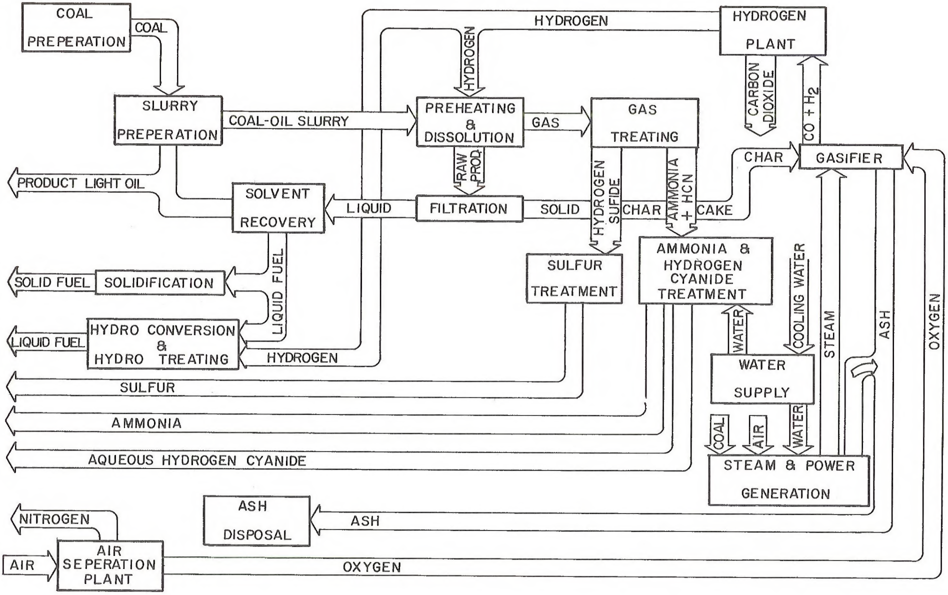
There are many processes projected which will convert coal to a synthetic crude oil product. These fall into two classes, one typified by the COED process, and the other by the SRC process. Likely any liquefaction process that might be built would resemble one of these two processes with some slight engineering changes.

The following two pages illustrate typical flow diagrams for both the COED and the SRC processes. As in a gasification plant, these plants would consist of related components, combined to complete the process. These are broken down into two principal divisions--process components and support components.

Figure 8A-A



COED PROCESS TYPE
COAL LIQUEFACTION



SOLVENT REFINED COAL LIQUEFACTION

8A.1.1.3.1 <u>COED process</u>

<u>Process components</u>

Coal Preparation - this is where the coal fed into the process is supplied and prepared. This includes coal mining, crushing, transport, and storage. Coal is mined, then transported to the plant by some means such as truck, rail, conveyor, or slurry pipeline. Then the coal may have to be crushed to a useable size. Finally, the coal may need to be stored until used.

Liquefier - The liquefier consists of four stages, each stage at a successively higher temperature. Coal is introduced into the first stage where, as it flows through the liquefier, it is first devolatized and converted to char, the carbon substance required in liquefaction. Oxygen and steam are introduced into the fourth stage of the liquifier and react with the char, yielding a raw product which further reacts in the other staging yielding a gaseous liquefaction raw product consisting of a mixture of hydrocarbons.

Scrubber - The raw product drawn from the first stage of the gasifier may contain some particulate matter dust loading. This is removed from the gas stream using some device for dust collection. Some of the raw product may be condensed and the nonproduct gas may be separated and sent to gas cleanup.

Oil Recovery - In the oil recovery system, the raw product gas is condensed to a liquid by cooling it with a water spray. The raw product then floats on the water and forms a water-oil emulsion. The nonproduct bearing gas is not condensed and is, thereby, separated and sent to gas cleanup.

Filtration - The raw product oil and water mixture is sent to the filtration plant where the water is separated and a liquid, water free raw product results. The water leaving the filtration stage may have considerable ammonia dissolved in it. This water would be combined with ammonia bearing water from the gas cleanup plant and sent to water cleanup.

Hydrotreater - The liquid product from filtration is enriched in hydrogen to yield the synthetic crude oil product. This may be accomplished using a catalyst and enough hydrogen to bring the carbon:hydrogen ratio up to 1:2. If carbon monoxide (CO) is present in the hydrogen feed, it will be oxidized to carbon dioxide and exhausted.

Gasifier - The hydrogen supply for the process is produced in the gasifier. Unreacted char left from the fourth stage of the liquefier is reacted with steam and oxygen to form hydrogen and carbon monoxide. In some processes this gas mixture would then undergo a shift conversion reaction to convert more water to hydrogen and carbon monoxide to carbon dioxide. Ash from the gasifier unit is sent to the ash disposal unit.

Support components

Gas Cleanup - Gases from the scrubber and oil recovery units are treated to recover by-products and wastes. Hydrogen sulfide (H_2S) is separated from the gas stream and sent to the sulfur treatment unit. The ammonia is dissolved in water and sent to water cleanup. The COED process produces little hydrogen cyanide (HCN), thus it may not be necessary to implement hydrogen cyanide treatment.

Sulfur Treatment - Acid sulfur gas can be converted to elemental sulfur much as it was in the gasification process. The gas leaving the sulfur unit may be incinerated to oxidize any remaining hydrogen sulfide to sulfur dioxide, which can then be controlled using a SO_2 scrubber.

Water Cleanup - Water from filtration and water from gas cleanup are treated in this component. Filtration water may contain dissolved organic products such as phenols and tar acids which are separated and saved as by-products. Ammonia dissolved in water can be separated and yielded as an anhydrous ammonia by-product. The purified water can be sent to the water supply unit and reused.

Water Supply - In this component, the incoming water for the process is purified and sent to steam and power generation to be used as boiler feed, or sent to the oil recovery unit to recover product gases. Water is also circulated through the plant for cooling purposes. Evaporation ponds and cooling tower structures are used to reclaim cooling water.

Power and Steam Generation - Heat, steam, and electricity needs for the plant are supplied in this area. Coal may be burned to provide process heat. Ash from coal combustion can be disposed of along with gasifier ash. Some heat from steam generation is recovered from cooling water by heat exchange. The gases yielded from coal combustion generally cause the greatest impact on air quality; thus, they must often have emission controls on the stacks from the power and steam generation area. The emission controls are discussed in more detail later in this section.

Ash Disposal - Residual ash (inorganic residue) from coal processing is quenched in water, thickened, allowed to settle into a thick, high density slurry, and finally disposed of--generally as fill in the coal mine.

Air Separation - Oxygen is required for the liquefier and in the gasifier to sustain the high temperatures required in the gasification reaction. This oxygen is supplied by cryogenic fractionation of air (separation of oxygen and nitrogen in the air by rapid cooling). The nitrogen created is vented back to the atmosphere.

Emission Control Systems - As in gasification, two air quality problems are presently dealt with using emission control devices. Particulate matter or dust can be removed from stack gases leaving the plant, generally the power and steam generation area, with better than 99 percent efficiency using the electrostatic precipitator. Other methods of dust collection such as baghouses or cyclones may be used.

The other emission control problem is countered by sulfur dioxide (SO_2) scrubbing. Primary sources of SO_2 are the steam and power generation area and the incinerated tail gas from the sulfur treatment area. SO_2 is scrubbed by using a chemical absorbent (limestone, dolomite, etc.) or oxidizing to SO_3 and converting to sulfuric acid, just as described in the gasification process.

Ancillary systems

The above mentioned systems are the principal features in a coal liquefaction plant. In addition, any plant will have pumps for moving liquids; values and piping to control gas flow; fans to direct air flows and combustion areas; stacks to vent exhaust gases; tanks, ponds and silos for storage; maintenance and construction equipment, buildings for laboratories and offices; and parking lots and loading areas.

8A.1.1.3.2 SCR Process*

Process components

Slurry preparation - In the slurry preparation component, finely crushed coal is mixed with light oil to form a thick coal-oil slurry.

Preheating and Dissolution - The coal-oil slurry is treated under high pressure with hydrogen gas to dissolve the coal in the oil and form a mixture of hydrocarbons. Gas is formed which is then sent to gas treatment.

Filtration - In this component, any undissolved char is filtered from the liquid raw product. This solid char cake is sent to be used in the gasifier.

Solvent Recovery - The liquid raw product is treated to separate light oil from heavier hydrocarbons. This light oil is then either recycled to prepare more slurry, or if enough is produced, some may be split out as a product light oil.

Solidification - The remaining heavier hydrocarbons may be split into two streams. One of these streams could be sent through solidification in which it would be converted to a solid fuel product.

Hydroconversion and Hydrotreating - Remaining heavier hydrocarbons could be sent through this component where they are reacted with hydrogen to bring the carbon:hydrogen ratio up to the desired 1:2. The

*Only components not common to both SRC and COED processes are described here to avoid duplication.

product liquid fuels from this component would be somewhat similar to synthetic crude oil.

Gasifier - See COED process.

Hydrogen Plant - The hydrogen plant may include a shift convertor to enrich the gasification product gas in hydrogen if this unit is not a part of the gasifier. The hydrogen plant will also remove any carbon dioxide in the hydrogen using a specific carbon dioxide absorbent. The product from this component is a high purity hydrogen gas.

Support components

Gas Treatment - See COED process.

Sulfur Treatment - See COED process.

Ammonia and Hydrogen Cyanide Treatment - Both ammonia and hydrogen cyanide (HCN) are dissolved in water solution. Ammonia can then be separated from the solution and produced as anhydrous ammonia. Hydrogen cyanide is concentrated in water solution and yields aqueous hydrogen cyanide as a product.

Water Supply, Steam and Power Generation, Ash Disposal, Air Separation Plant, Emission Control Systems, and Ancillary Systems - See COED process.

8A.1.1.4 Material and energy balances

Since the various processes of coal liquefaction are in such an early stage of development, no commercial scale material or energy balances are available. However, from the bench scale work which has been done, an approximate idea has been obtained of what raw materials and in what quantity may be required. Some of the products, by-products, and wastes have also been tentatively identified and quantified.

Raw materials

Water - Water is the limiting substance in this discussion. Each company has 12,500 acre-feet per year of available water.

Coal - The available water provides enough water to liquefy 50,000 tons of coal per day. If coal is used as a fuel for power and steam generation, or as feed for the gasifier, probably some additional 10,000 tons of coal would be required every day.

Air - A good deal of air will be required by the furnaces in power and steam generation, by the air separation plant, and by the gas treatment and sulfur treatment areas. Air should be readily available.

Chemicals - Some chemicals--catalysts, absorbents, biocides, corrosion inhibitors, pH controls, and various reaction media--will be required just as in gasification. This will be a relatively small item, amounting to something like one hundred tons per day.

Products

Synthetic crude oil - The various processes vary greatly in the amount of synthetic crude produced. The COED process would probably only yield some 70,000 barrels per day (BPD) or 11,000 tons per day because this process does not convert all the coal to liquid products but instead yields significant gas and solid products. The SRC process might yield up to 150,000 BPD or 24,000 tons per day of liquid products because this process yields nearly all the products in a liquid form.

Sulfur - The amount of sulfur recovery, again, depends on the process used and the amount of sulfur contained in the coal. The COED process recovers less sulfur, probably some 80 tons per day. The SRC process might yield something more like 140 tons per day.

Ammonia - The ammonia yield depends principally on the nitrogen content of the coal. It is not nearly so dependent on the process used, so regardless of the process, the yield might be something like 150 tons per day.

Tar acids and phenols - These are the organic products which tend to dissolve in the water used to condense the gaseous raw product from the liquefier in the COED process. In the SRC process, these compounds most likely will be incorporated in the main synthetic crude products and not show up as separate by-products. The COED type process may yield approximately 70 tons of tar acids and 140 tons of phenols per day.

Aqueous hydrogen cyanide - The COED process will not probably yield a large amount of hydrogen cyanide (HCN), possibly not even enough to constitute a by-product. Nominal HCN yield from the COED process might be some 3 tons per year (0.01 ton/day). The SRC process tends to produce more HCN, probably more like 30 tons per year (0.12 ton/day).

Ash - Based on the amount of coal being used each day and the amount of ash contained in the feed coal, approximately 4,500 tons of ash will be produced each day.

Air emissions - Emissions--sulfur dioxide, nitrogen oxides, and dust--are too conjectural to estimate, but if they are too high to meet Federal and State requirements, air emission controls may be necessary.

Heat balance - No heat balance for commercial scale coal liquefaction is yet available, but the Office of Coal Research has estimated that the thermal efficiency of liquefaction is approximately 70 percent.

8A.1.1.5 Physical plant

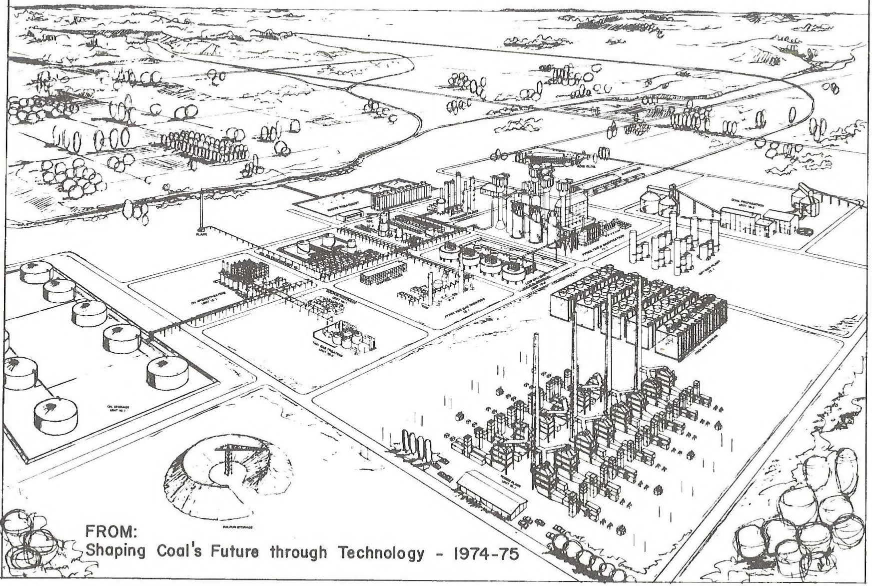
The coal liquefaction plant will most likely resemble the gasification plant previously described or a large oil refinery. Each plant site should cover approximately 1,000 acres, or some one and one-half square miles. As with the gasification plant, there are three phases during the lifetime of the plant--construction, routine operation, and phase out or shutdown.

Plant construction

Construction of the liquefaction plant will resemble gasification plant construction. Principle considerations are plant access and transport systems, site preparation and setup, and the labor force. The labor force will probably reach a peak of 3,000 to 3,500 individuals with some projections predicting a force of 6,000 people. Likely, most of the 1,000 acres will be disturbed or altered during construction.

Access to the plant is critical during all three phases of plant life. During construction, the site must be accessible to both equipment (caterpillars, scrapers, draglines) and labor, and provisions must be made for transport of large process components (reaction vessels, boilers, compressors, etc.) which cannot be assembled on site. Transport systems must be supplied for raw materials--coal, water, chemicals--as well as products, by-products, and waste products. If coal is to be shipped by rail, access must be provided, most probably, for five or six

Figure 8A - C
ARTIST's CONCEPT of COED TYPE PROCESS



FROM:
Shaping Coal's Future through Technology - 1974-75

ARTIST's CONCEPT of SRC TYPE PROCESS

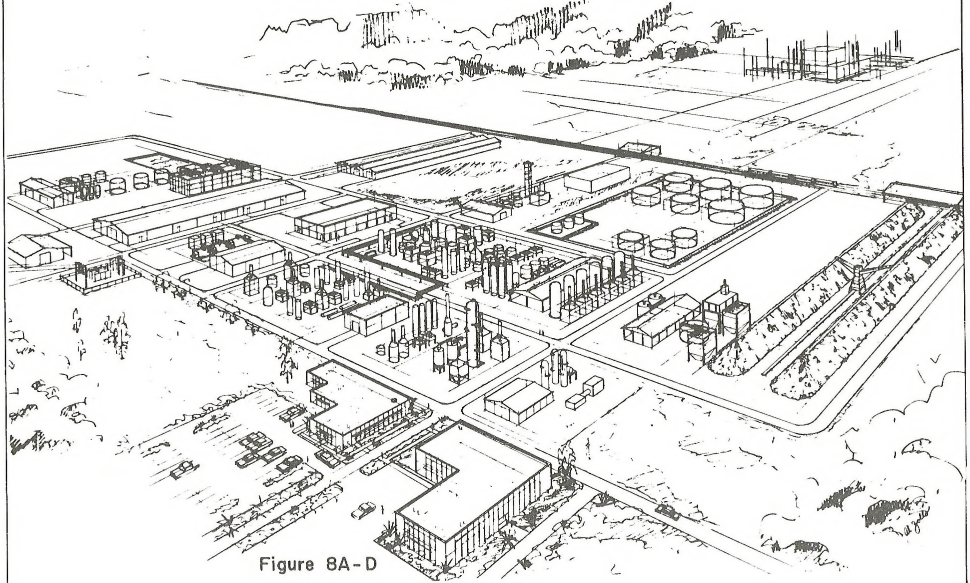


Figure 8A-D

FROM: Shaping Coal's Future through Technology - 1974-75 round trip, 100 car unit trains per day. Coal hauled by large, 100-ton, off-road trucks would require a road system capable of handling approximately 600 round trip truck hauls per day. Another alternative would be moving coal in a slurry pipeline. This would require approximately a three and one-half foot pipeline. The pipeline carrying raw water would be nearly as big as the slurry pipeline. Another one and one-half foot pipeline would have to be built to carry the synthetic crude oil to its market. Additional trains and/or trucks would need access to the plant to bring chemicals and haul away products, by-products, and wastes. Waste ash could be hauled back to the mine in the empty unit trains or in a pipeline paralleling the slurry pipeline. The right-of-way for the access systems would have to be cleared, leveled, and finally the system itself would be built. Also, before the plant becomes operational, access must be provided for employee roads, electric transmission lines, and telephone lines. The construction activities will resemble most nearly the construction of a two lane highway. Bulldozers, scrapers, trucks, and draglines, in addition to some specialized railroad or pipeline laying equipment, would generally be used. Crews would be fairly small and mobile.

During site preparation and setup, most of the 1,000-acre site will be leveled, storage and holding ponds dug, and finally buildings, storage structures, and processing equipment will be moved in and assembled. Many bulldozers, scrapers, trucks, draglines, cranes, and other vehicles will work at leveling the site.

The labor force may well reach over 3,500 workers. During various periods during the construction schedule, the force will include, in addition to a large number of manual workers, many equipment operators, welders, masons, iron workers, and pipe fitters. The construction schedule will likely resemble the schedule diagrammed for the gasification plant.

Routine plant operation

As construction of the site draws to a close, the operating crews will be trained and the plant systems will be tested and brought into production. When the plant is operating at a steady level, the labor force will stabilize. The operational phase time frame is somewhat dependent on economics and availability of raw materials, but a thirty-year life is a reasonable approximation. For the liquefaction plant, the operating crew will be approximately 1,200-1,500 workers. With the plant operational, a constant level of heavy duty commercial (rail and road) and light duty private traffic will persist.

Phase out and shutdown

Process plants are designed to run at full rated capacity or, occasionally, a bit higher and are often uneconomical to operate at reduced capacity. Thus, a plant will generally be run at as near full capacity as possible until the critical resource is depleted. When this happens, it is more economically sound to suddenly shutdown rather than gradually phase out operations. In the case of a liquefaction plant, product price and demand in addition to governmental policies can determine whether plant operation is economically feasible. However, this rather sudden closeout would not likely happen, a gradual phaseout being more likely.

Unless some sort of plant deconstruction plan is implemented, the plant may be abandoned. However, some of the equipment and structures may have salvage or second-hand value. The plant site can then be cleared of any remaining structures and the site may be returned to a natural topography. This would mean a short-term, several months, period of heavy vehicular traffic somewhat similar to the construction phase. Access systems may also be removed if no longer needed for transport systems. These rights-of-way can also be returned to a somewhat natural aspect.

8A.1.1.6 Typical liquefaction project summary

1.	Process used	Generalized from SRC and COED processes
	Synthetic liquid fuels	70-150 thousand BPD depending on the process
2.	Coal consumption	18 million tons per year
3.	Coal reserves required (assumed 30-year life)	540 million tons
4.	Water requirements	12,500 acre-feet
5.	Land needs	1,000 acres
6.	Employment	1,200-1,5000
7.	Construction employment (five years)	a) peak - 2,500-3,500 or higher b) average - 1,500-2,000 or higher
8.	Total plant investment (order of magnitude, 1975 dollars)	\$300-\$500 million(?) (too conjectural to estimate)
9.	By-products	sulfur - 30,000-50,000 tons/year ammonia - 50,000 tons/year tar acids - 24,000 tons/year phenol - 49,000 tons/year aqueous hydrogen cyanide - 3-30 tons/year ash - 1,600,000 tons/year particulate matter - too conjectural sulfur oxide - to nitrogen oxides - estimate
10.	Utilization factor	90 percent
11.	Thermal efficiency	70 percent (OCR estimate)

8A.1.2 Probable impacts of coal liquefaction

The impacts described below are those which can be anticipated as a result of the construction, operation and maintenance, and phase out of two 70-150 thousand barrel per day (BPD) coal liquefaction plants with related transportation systems and community facilities. Again, in view of other major energy development proposals in the area, the impacts of coal liquefaction must be reviewed as part of the cumulative impact of all of the potential projects in the Eastern Powder River Basin. As specific plant sites have not been identified, impacts described are those which would be common to most any future plant site(s) within the study area.

8A.1.2.1 Climate

The coal liquefaction plants would likely result in some minor changes in the micro-climate of the immediate plant areas, such as slight increases in air temperature and humidity.

In conjunction with other proposed and projected development in the Eastern Powder River Basin, climate could be affected to a significant degree.

As mentioned before, recent studies indicate that large urban-industrial areas affect precipitation. However, studies have not been conducted in semiarid climates; therefore, potential effects are inferred from theoretical studies of climate modification in other areas. Some evidence indicates that changes of atmospheric particulate loading and alteration of the earth-atmospheric energy balance may contribute to creation of drought conditions in semiarid climates.

8A.1.2.2 Air quality

Development of two coal liquefaction plants, transportation systems, residential areas, and disturbances of relatively large areas of land would create multiple sources of air pollutants which, with prevailing upper level wind direction (northwest), could affect existing communities to the south and east of the sites.

Potentially, the most serious cumulative impact on air quality, with possible adverse impact on humans, animals, and vegetation, is from gases emitted by the two liquefaction plants. Emissions include sulfur oxides, nitrogen oxides, carbon monoxide, hydrocarbons, hydrogen sulfide, and particulates. Relative amounts of emissions are too uncertain to predict.

The industrial development and attendant population increase (15-20,000) would increase use of internal combustion engines of all types. Engine emissions would result in the addition of carbon monoxide, hydrocarbons, particulates, nitrogen oxides, and sulfur oxides in the basin air.

Increases in airborne dust and similar particulate matter would result from development activities. Airborne particulate matter could reduce visibility and possibly cause traffic accidents during periods of inversions and periods of high winds. Particulate matter could also contribute to human allergies and similar irritations and coat vegetation with potentially harmful chemicals.

Present ambient air quality in the area is good, but it would decline with the development of complex pollution sources.

8A.1.2.3 Topography

The land surface would be altered during site preparation for the two assumed plants, which would require approximately 2,000 acres. Another 2,000 acres would be disturbed to accommodate community growth. Construction of roads, powerlines, pipelines, and railroads would result in alterations of the land surface. The disturbance would consist of earthwork and grading to facilitate construction of facilities.

8A.1.2.4 Soils

Soil disturbance would result from construction of the liquefaction plants, community development, and associated transportation systems. The soils on the majority of over 4,000 acres would be disturbed.

As sites are unknown, the length of rights-of-way for the transportation systems is also unknown. However, construction of these facilities will result in additional soil disturbance. An average disturbance of five acres per lineal mile for the various transportation facilities is estimated.

Disturbances on the construction sites would result in fine grained soil and parent material being exposed to wind and water actions. Soil productivity, permeability, and infiltration rates would be reduced, increasing runoff, soil erosion, and sedimentation. Wind action, which is almost constant over the entire area, would cause fine soil, silt, and clay particles to be lifted into the atmosphere, reducing air quality and adding to soil loss. Prior to revegetation of exposed soils, soil erosion resulting from high intensity storms would remove fine materials and 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, adding to soil loss and sedimentation.

8A.1.2.5 Mineral resources

The primary impact on mineral resources in the area is the removal and subsequent use of 1,080,000,000 tons of coal during the projected thirty-year life of the liquefaction plants. Significant amounts of sand, gravel, fill dirt, and limestone may be used for construction purposes. Energy fuels would be consumed by the equipment used during construction and plant operations.

Depending upon the ultimate location of the plant sites and transportation facilities, there could be a conflict if construction occurs on mineralized areas, hampering the development of those minerals.

8A.1.2.6 Water resources

The consumptive water use for the assumed coal liquefaction plants would be approximately 25,000 acre-feet per year.

Other impacts on water resources in the Eastern Powder River Basin would result from the approximately 3,000 acre-feet/year required for the increased population supporting coal liquefaction developments. Water presently being used for other purposes such as agricultural use, recreation, and fish and wildlife populations would be needed to support added population.

8A.1.2.7 Vegetation

Vegetation would be destroyed in three principal areas--the two liquefaction plant sites (approximately 1,000 acres per site), the land area required for the transportation systems (roads, railroads, pipelines, etc.), and the land area required for residential and commercial development (2,000 acres) to meet increased population needs.

In addition to the loss of vegetation from physical disturbance, the potential would exist for damage to occur as a result of air contamination consisting mainly of particulates, salt drift from cooling tower water evaporation, sulfur dioxide (SO_2), and nitrogen oxides (NO_x).

Increased population would intensify recreation use which would destroy or decrease the vegetative cover. Secondary impacts from loss of vegetation would result, such as increased soil erosion (wind and water), loss of cover for wildlife, loss of livestock forage, and adverse effect on aesthetic values.

8A.1.2.8 Fish and wildlife

Liquefaction development would result in impacts on the fish and wildlife in that wildlife and its habitat would be destroyed and overall populations would be reduced. Also, the increased human activity would affect wildlife and its habitat.

There is a direct cause-effect relationship involved with impacts on fish and wildlife as a result of industrial development. Direct mortality is rare on big game and other types which have the ability to flee. The direct action of industrial development destroys or impairs habitat. This impact on habitat then translates itself into an impact on fish and animal residents, resulting in loss of population.

Each wildlife species in the study area would be subject to the cumulative effects of several of the different categories of impacts caused by industrial development. These include:

--Direct destruction of animals.

--Permanent destruction of habitat.

--Initial destruction of habitat followed, in time, by some degree of recovery in habitat value.

--Impairment or reduction in value of habitat near human development or activities.

--Increased introduction of hazards into the wildlife environment.

--Off-site and secondary impacts caused by displaced animals, disrupted food chains, changed land and water uses, etc.

--Improvement of habitat.

8A.1.2.9 Cultural resources

There would be approximately 4,000 acres disturbed during construction of the plants, community facilities, and access systems. If cultural sites exist in this acreage, they would be damaged and/or destroyed, making the values unavailable for future study and salvage. Besides the direct impact of construction, indirect impacts would result from population increase generated by construction and operation of the facilities. Recreational use associated with this population would impact known as well as unknown sites throughout the study area. Arrowhead hunters, rock collectors, pot hunters, and off-road vehicle users would disturb additional surface acreage, destroying evidence which could provide information on cultural sites. Beneficial impacts would result from inventory and recognition of the cultural values.

8A.1.2.10 Aesthetics

Construction, physical presence, and operation of liquefaction facilities, transportation systems, and residential and commercial development would generally have an adverse effect on the aesthetics of the area through alteration of the landscape, increased noise levels, and air contaminants such as dust and plant and vehicular emissions.

8A.1.2.11 Recreation resources

Impacts on recreation resources would primarily result from increased population within the region due to construction and operation of coal liquefaction plants. Another potential source of impact would be the loss of land base committed to recreation use. Development of material sites, replacement agriculture lands, and increased recreational use, such as off-road vehicle use, would alter additional recreational land. Private land normally available for this type of use may be closed and posted, further reducing the recreation land base.

Much of the sand, gravel, and clinker material may be mined from stream courses, alluvial mountain slopes, or limestone outcrops within the study area. This would impact scenic recreation lands, either directly (streambeds) or indirectly (sightseeing).

The anticipated population growth would generate increased demand on recreation facilities. Recreation facilities near the population centers of Gillette and Douglas would experience the greatest demand and be subjected to greatest impacts.

Reduction in air quality from industrialization would impact the recreational sightseer. During inversion periods and high winds, visibility would be reduced, obscuring to some extent the scenic views of the area and reducing the visitor's enjoyment. Additional powerlines would also impact the sightseer and reduce his enjoyment of the view. It may also affect long-term economic strength for certain sectors by reducing nonresident recreation days. Increased use of recreation resources outside the area could result in the lowering of recreation quality in an ever-widening circle.

8A.1.2.12 Agriculture

Agricultural use is a dominant use on lands within the area; therefore, industrial development would ultimately reduce available agricultural lands. Land use changes which would occur to accommodate plant sites, community development, and access systems are estimated at over 4,000 acres.

With regard to livestock grazing in the area of consideration, a loss of approximately six acres would represent an estimated loss of one animal unit month of grazing (AUM). An AUM is a measure of forage or feed requirement to maintain one animal (cow or five sheep) for a period of thirty days. Using the above acreages, which excludes the transportation systems, the annual loss of livestock forage could range from 600 to 700 AUMs.

Besides direct loss of livestock forage, secondary impacts associated with population increases would occur due to construction and related development. Vandalism and accidental property damage may increase due to larger numbers of hunters and outdoor recreationists. Animals may be harassed or harmed by recreation use, such as off-road vehicles.

Construction and fencing of railroads, highways, and service roads will lead to land separation and alter present ownership patterns. This would lead to separation and isolation of ranch properties, disruption of established use patterns, and access problems for watering and livestock care. Small isolated tracts could result which are too small in size to be used profitably. Livestock drifting during severe weather may be trapped by fences and lost. Physical separation of adjoining private land from federal grazing leases and division of grazing allotments by fenced rights-of-way may cause loss or realignment of leases.

Some grazing lands could be affected by increased erosion, sedimentation, and headcutting in productive drainage bottoms, resulting in additional losses of livestock forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

8A.1.2.13 Transportation networks

Impacts on transportation networks result from construction and operation of the plant sites, associated transport systems, and increased employment and population, all of which create additional use of existing networks likely requiring modification and/or upgrading.

Roads and highways would be affected throughout all phases of the development. Increased use of the existing roads and highways requires increased maintenance expenditures, upgrading to higher road standards in some cases, and possibly relocation of sections of particular routes.

Construction of the new transportation networks would result in conflicts with existing systems such as disruption of an existing facility while new ones--crossing or affecting systems in operation--are under construction. Once built, though, the new transportation facilities may complement or improve the existing facilities.

8A.1.2.14 Land use controls and constraints

Liquefaction development may precipitate a need to revise or develop land use controls and constraints, as existing planning may not adequately guide development.

8A.1.2.15 Socio-economic conditions

The assumed industrial development with associated increases in employment and population would have varying impacts on the socio-economic conditions of the area.

Population

The following population figures are estimates of population growth that might result if liquefaction plants are constructed. These figures do not reflect population and employment for coal mining.

Potential Population Growth in the Study Area

PROCESS	LIQUEFACTION 70-150,000 BPD (2 plants)
Low estimate, new permanent employment	2,000
Induced non-industrial employment 1/	2,000
Total new employment	4,000
Additional population 2/	12,000
Low estimate, average temporary construction employment	3,000
Induced non-construction employment 3/	1,500
Total new construction related employment	4,500
Additional population 4/	6,750
All new employment	8,500
All additional population	18,750

1/ Assumes 1 new non-industrial employee per each new industrial employee.
2/ Assumes 3 persons per each new employee.
3/ Assumes 1/2 new non-construction employee per each construction employee.
4/ Assumes 1-1/2 persons per each new construction related employee.

While the addition of 18,750 people is not necessarily adverse, the impact of population growth may generate negative secondary effects which are discussed in the following sections.

Employment

An employment growth of 8,500 is possible as a result of construction of the liquefaction plants. Construction labor per plant could vary from 1,500 to a peak of 3,000. Construction could take three years per plant. Permanent employment to operate each liquefaction plant is estimated at 1,000.

The assumed industrial development would provide a large number of basic and secondary jobs which would compete for the available labor supply. Skilled labor shortages for construction peak may be severe and could be worsened by simultaneous plant construction.

The growth in industrial employment would attract labor from other sectors of the economy--agriculture, services, etc.--which could create at least short-term labor shortages in those sectors.

Jobs in the services sector (such as enforcement) would be difficult to fill, as salaries tend to be fixed with no allowarnce for areas of inflated incomes. The consequences could be recruitment problems, inferior personnel, and understaffing.

Income

Income levels for the entering industrial worker would probably range from $10,000 to $15,000 per year. Whether or not these incomes are sufficiently attractive to lure employees to the Eastern Powder River Basin is unknown. While incomes of the industrial workers would be high, incomes of the work force in supportive employment, e.g., government services and consumer services, may be relatively lower. The average income of the induced labor force would be greater than or at least equal to that of the region ($10,900). The effects of rising incomes, and probably inflation of prices and property values, would be particularly adverse on that portion of the population living on fixed incomes, such as disabled, aged, and welfare recipients. Although this condition is almost universal, rapid industrial growth could likely worsen the situation.

Housing

Based on an assumed 3.5 persons per household and an estimated population increase of 18,750, there could be a demand for approximately 5,000 to 5,500 housing units to meet the needs of the population influx as a result of the development of the two coal gasification plants.

The influx of a work force with associated families would create an immediate housing demand in whichever community or communities the increased population located. The present supply of housing would be inadequate to meet the projected housing demands. Consequently, new housing would be required if the demand is to be met.

Impacts likely to occur as a result of this housing demand are a shortage of housing, inflated prices for housing, and the use of substandard housing units.

Public education

The rise in population levels and immigration of various work forces with associated families would cause an increase in public school enrollments. Increasing student enrollments in turn would impact enrollment capacities of existing school district facilities and teaching staffs.

If timely accommodations are not provided for the increasing enrollments, the following impacts could result:

1. Classroom sizes would quickly reach capacity and necessitate very high students to teacher ratios;

2. Due to overcrowded conditions and the lack of classrooms in existing school facilities, it may be necessary to use temporary structures such as mobile trailers and modular units;

3. The lack of classrooms and adequate space (gymnasium, play areas) could cause a school district to operate certain schools on a double session basis;

4. Inter-county bussing of students between school districts could result and become necessary; and

5. The quality of education could be affected adversely.

Health and social services

The county or counties affected by the population increase would experience an increase in demand on their health and social services. As a result, health and social services manpower requirements would increase and shortages in manpower would likely occur.

Facilities and services would also receive increased demands. As a result, overcrowding of facilities and an over-extension of service capability may occur, ultimately causing a reduction in quality of health care.

Law enforcement

Population growth would create a need for increases in police manpower and facilities. If this increased need could not be met in a timely manner, crime incidence would rise.

Fire protection

As with law enforcement, additional manpower and facilities would be required for fire protection. Inability of communities to respond to deficiencies in manpower and facilities could result in increased property damage and loss of life.

Water and sewer facilities

If water and sewer facilities are not expanded in a timely fashion to meet the demands of an expanding population, significant secondary impacts could develop. If water is not treated properly, serious health hazards could develop. Use of a poor quality water could result in a higher incidence of disease and possibly to epidemics of major diseases.

Overuse of the sewage facilities could result in more sewage being dumped into stream channels. This would lower water quality and impact fish and wildlife populations. The polluted water could also act as the source of diseases, especially if ground water aquifers become contaminated.

8A.1.3 References

1. Clean Energy from Coal - Pittsburgh Energy Research Center - Energy Research and Development Administration, March 1975.

2. Clean Energy from Coal Technology, Department of the Interior, Office of Coal Research.

3. Coal Development Alternatives - An Assessment of Water Use and Economic Implications, David D. Freudenthal, Peter Ricciardelli, Michael N. York, Wyoming DEPAD, December 1974.

4. Environmental Impacts of Alternative Conversion Processes for Western Coal Development, Old West Regional Commission, Dr. Steven Miller and Thomas E. Carroll and Associates, October 1974.

5. Shaping Coal's Future through Technology, Office of Coal Research, Department of the Interior, 1974-75.

6. Solving the SO_2 Problem - Where We Stand with Applications and Costs, J. Jonakin, Coal Age, May 1975.

8A.2.1 Assumptions and analysis guidelines for alternatives

Coal Fired Steam Electric Generation - 2 Plants

1.	Product	1,000 megawatts/plant
2.	Coal Use	3-4,000,000 tons/year/plant
3.	Water Use	16,275,000 tons/year/plant 12,500 acre-feet/year/plant 0.16 acre-feet/year/person
4.	Water Evaporation	14,000,000 tons/year/plant
5.	Waste Ash and Dust	500,000 tons/year/plant
6.	Emissions:	
	sulfur dioxide	21,000 tons/year/plant
	nitrogen oxides	28,000 tons/year/plant
	particulates (with dust control)	1,100 tons/year/plant
7.	Transport Systems:	
	coal	1-2 round trips/unit train/plant 100 round trips/100 ton truck/plant 1.5 foot slurry pipeline/plant
	water	3 foot pipeline/plant
8.	Land Use	100-500 acres/plant 0.16 acre/family 6 acres/pipeline mile 10 acres/transmission line mile
9.	Population:	
	construction labor	peak) 2,000-4,000/plant average) 2,000/plant
	operational labor	150-350/plant
	population multiplier factor	4-5
	construction population	8,000-20,000/plant
	operational population	600-1,800/plant
10.	Time Frame:	
	construction	4 years
	operation	30 years

8A.2.1.1 Coal fired steam electric generation

Electricity can be generated by transferring the energy from coal to a working medium which in turn operates an electric generation device. The energy in the coal is released by the process of combustion in air. First, the volatile fraction of the coal, the hydrocarbons (CH_2), are combusted to yield carbon dioxide (CO_2), water vapor (H_2O), and heat energy:

$$CH_2 + \frac{3}{2} O_2 \text{ (from air)} \longrightarrow CO_2 + H_2O + \text{heat}$$

The fixed carbon (C) then burns to yield carbon dioxide and heat energy:

$$C + O_2 \longrightarrow CO_2 + \text{heat}$$

Some sulfur and nitrogen in the coal are oxidized to sulfur dioxide (SO_2) and nitrogen oxides (NO_x):

$$S + O_2 \longrightarrow SO_2$$

$$N + \frac{x}{2} O_2 \longrightarrow NO_x$$

The inorganic ash portion of the coal is not combusted but remains as a fine, dusty waste material, while the moisture in the coal is vaporized to water vapor. There are three commonly discussed systems which accomplish conversion of heat energy to electricity.

Steam Turbine (ST) - In this system, the working fluid, water, is heated until it becomes a high temperature steam. The steam is allowed to expand against a turbine, causing it to turn and thereby converting the heat energy to rotational energy. This rotational energy is transferred to an electriogenerator which in turn converts the energy to electrical energy. As soon as the steam passes through the turbine, it is cooled as much as possible. This cooling is important because the efficiency of energy conversion in the turbine increases as the difference between the steam temperatures on the inlet and outlet sides of the turbine. Typically, the efficiency of a coal fired steam turbine operation will run from 35 to 40 percent, meaning that 35-40 percent of the energy available in the coal has been converted to electrical energy.

Gas Turbine (GT) - In the gas turbine system, the hot gases from combustion are used as the working medium. These gases expand directly against the turbine to impart rotational energy to the electric generator. A problem with coal combustion in GT units is that the combustion gases contain high amounts of water vapor, sulfur dioxide, and particulate ash matter which tend to be very abrasive to turbine blades. Therefore, natural gas (with minimum particulates and SO_2) is preferable to using coal as fuel. The gas turbine system is of roughly the same efficiency as the steam turbine; its big advantage over steam being that it does not require the rather complex steam generating system.

Magnetohydrodynamics (MHD) - The MHD system uses coal as a fuel to provide heat which propels an electrically charged gas through channels containing electrodes. Surrounding the channels are large magnets which cause current to be induced in the charged gas as it passes through. This current is drawn off by the electrodes to supply a direct electrical voltage source.

The MHD system would be run most likely in series with either a steam or gas turbine because a great deal of the heat in the gas coming through the MHD channels is still available to drive a steam or gas turbine. Although the MHD system is still in an early stage of development, it has been estimated that this system could yield an efficiency as high as 65 percent.

Likely, within the area of study, and considering the state of the art of coal fired electric generation, the steam turbine system would be used if electric generation is considered as an alternative. In the study area, the steam turbine has been used traditionally by most companies. Gas turbines do not lend themselves well to using coal as fuel owing to the abrasive qualities of the combustion gas, and MHD systems are still in an early stage of commercial development.

8A.2.1.2 Plant disposition assumptions

A number of coal fired steam electric generation plants have been built, and the technology is well understood. Requirements of feed materials and the nature and amounts of products can be predicted with some accuracy. However, there are engineering modifications which make various plants differ as to particular coal or water usages. For example, where coal is expensive and water cheap, cooling water may be excessively used, with little concern for recycle, in an attempt to increase efficiency and thereby lower coal consumption.

The size of the electric generation plant is dependent to some extent on the amount of water available. Since most of the water used in a steam electric generation plant is used for cooling, and cooling

ARTIST's CONCEPT of 860 MW PLANT

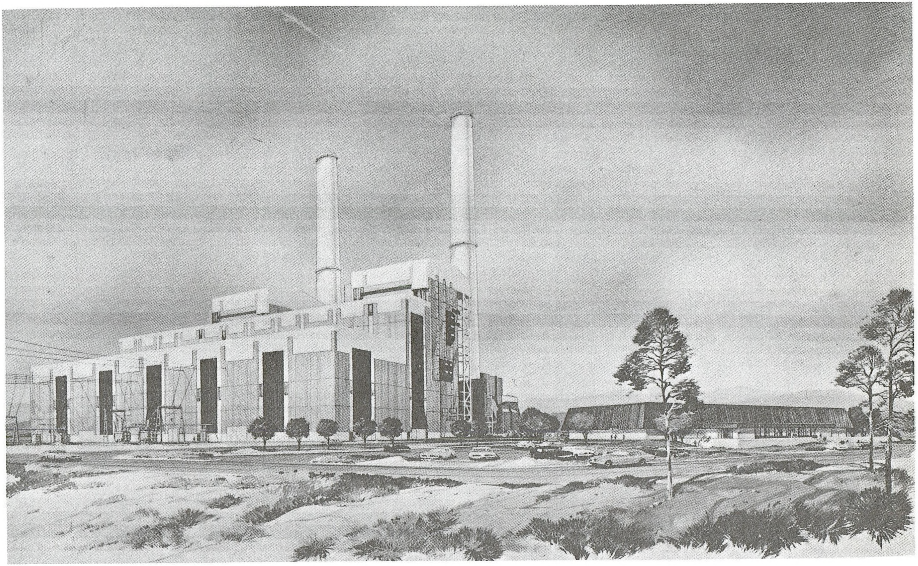


Figure 8A-E

FROM: Naughton Units 4 and 5 Environmental Impact Statement methods are somewhat variable, water needs are flexible. But, with 12,500 acre-feet/year of water available to each company, a reasonable assumption as to plant capacity is 1,000 megawatts (MW). This would require about 10,000 tons of coal per day or some 3,500,000 tons per year. Land use for a plant this size is quite variable because land requirements are not necessarily related to the capacity of the plant. A reasonable assumption for the land needs of a 1,000 MW plant is somewhere between 100 and 500 acres.

8A.2.1.3 The coal fired steam electric generation plant

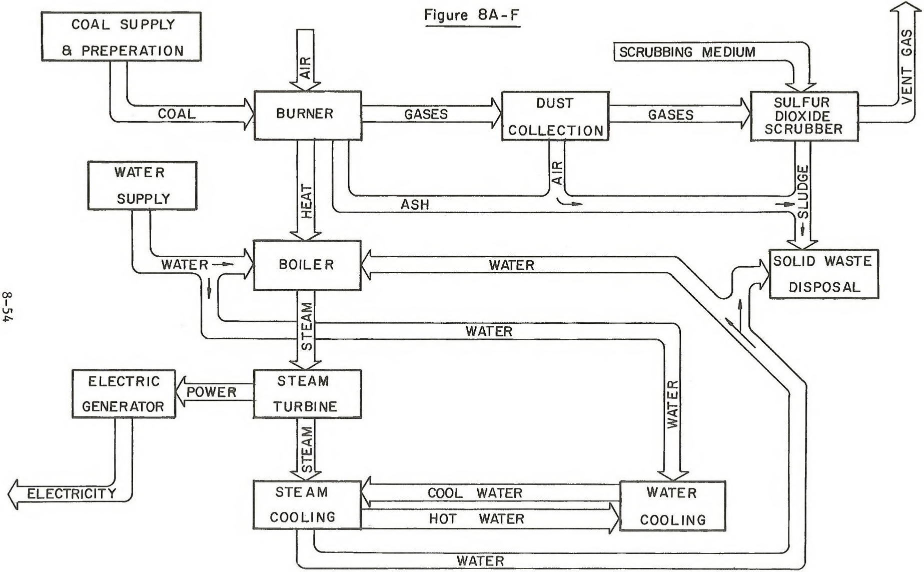
In building the generation plant, several engineering modifications or alternative subcomponents could be used. However, the process is still the same, basically, and the generation plant will follow the flow diagram on the following page. As in the other process descriptions, the process can be broken down into two sets of components--process components and support components.

Process components

Coal Preparation and Supply - This component includes the mining, crushing or grinding, transport, and storage of the coal. After mining, coal is transported by some means such as truck, rail, conveyor, or slurry pipeline. Then the coal will likely be crushed to a fine size for burner feed. Finally, if the coal is not to be immediately used, it may need to be stored.

Burner - Here the coal is mixed with air and combusted. A great deal of heat is generated and then transferred to the boiler. Combustion gases and ash are the by-products of coal burning, and both are sent from the burner for further processing.

Figure 8A-F



COAL FIRED STEAM ELECTRIC GENERATION FLOW DIAGRAM

Boiler - The boiler consists of a network of tubes through which water or steam can run. The heat generated by coal combustion is transferred to the water in the tubes, causing it to vaporize and form a high temperature steam.

Steam Turbine - This component resembles, most nearly, a large fan with many blades. The high temperature steam from the boiler is allowed to expand against the blades of the turbine, causing the turbine to rotate rapidly. This rotary power can then be transferred to the electric generator. The steam is exhausted from the turbine to the steam cooler.

Steam Cooling - In passing through the turbine, the steam loses considerable energy and becomes cooler. The more the steam can be cooled, the more energy it loses and, therefore, the more energy it transfers to the rotation of the turbine. The steam is cooled by passing it through a network of tubes containing cool water. The steam is cooled by giving its heat to the water in the tubes. The water thereby is heated in the tubes and is exhausted from the cooling unit as hot water. Another function of steam cooling is the condensation of the steam to water which can be recycled to the boiler or some other water-requiring unit in the plant.

Electric Generator - The generator converts the rotary power supplied by the turbine to electrical power for public consumption. The unit consists basically of an electrode coil device which is surrounded by a large magnet. The electrode is rapidly spun in the magnetic field, which induces an electric current. This current is drawn from the electrode and provides a source of electric power.

Support components

Water Supply - In this component, water is supplied for all the various needs of the plant. Water to be used in the boilers must be treated to remove dissolved salts and other impurities. Makeup water to replace water lost in the water cooling component and water to slurry the solid wastes must also be supplied.

Water Cooling - Water cooling is commonly accomplished in four ways. The "once through" method is sometimes used when the plant is near a lake or river. Water is diverted from the body of water, run through the steam cooling unit once and allowed to reenter the water body. The fact that water reenters somewhat warmer than when it left and a much greater supply of water is required make this method unlikely. The evaporation pond method involves the use of a large holding pond from which water is pumped into the steam cooler, heated, and returned to the pond. As the name implies, considerable evaporation occurs as the water cools in the pond. The third method involves cooling towers which are structures over which the heated water from the steam cooler can be cascaded. As the water cascades, it is cooled by air contact and evaporation. Thus, the cooling tower method also loses considerable water to evaporation. The fourth method involves the "dry cooling towers" which are similar to the cooling towers above except that they are enclosed to prevent evaporation loss. These towers are very inefficient and thus require more towers to cool the same amount of water. Also, each cooling tower is more expensive than a regular tower. Therefore, these units are generally only practical where water is very expensive, over $200/acre-foot/year according to one estimate.

Dust Collection - Particulate matter or dust can be removed from stack gases leaving the plant, generally the power and steam generation area, with better than 99 percent efficiency using the electrostatic precipitator. Other methods of dust collection such as baghouses or cyclones may be used.

Sulfur Dioxide Scrubber - If sulfur dioxide (SO_2) emissions are above permitted standards, control will be necessary. SO_2 is scrubbed using a chemical absorbent or scrubbing medium (limestone, dolomite, etc.) or oxidizing SO_2 to SO_3 and converting SO_3 to sulfuric acid. SO_2 scrubbing using a scrubbing medium will yield a scrubber sludge which would be disposed of with the ash. A more complete discussion of SO_2 scrubbing is included in the gasification process description.

Solid Waste Disposal - Residual ash (inorganic residue) from coal combustion is quenched in water, thickened, allowed to settle into a thick, high density slurry, and finally disposed of along with dust from dust collection and scrubber sludges if SO_2 scrubbing is required.

Ancillary systems

The above mentioned systems are the principal features of a coal fired steam generation plant. In addition, any plant will have pumps for moving liquids; valves and piping to control gas flow; fans to direct air flows to combustion areas; stacks to vent exhaust gases; ponds and silos for storage; maintenance and construction equipment, buildings for shops and offices; and parking lots and loading areas.

8A.2.1.4 Material and energy balances

Since the amount of water available to each company has been set at 12,500 acre-feet per year and since this would make feasible the consideration of a plant of roughly 1,000 megawatt capacity, it is possible to use available technical data to extrapolate a material balance for a hypothetical plant. The material balance represents a method to determine about how much raw material is required to produce all the various products, by-products, or wastes.

Raw materials

Coal	10,000 ton/day
Water	46,500 ton/day
Air	104,400 ton/day
Total	160,900 ton/day
If SO_2 control is necessary:	
Scrubbing medium . . . . ($CaCO_3$, CaO)	275 ton/day
Water	1,600 ton/day
Total with SO_2 scrubber .	162,775 ton/day

Coal - 10,000 tons of coal are processed in the plant each day. All the coal is burned to produce process heat, along with combustion gases and ash. The sulfur content of the coal will be the determining factor as to whether SO_2 scrubbing will be required. The inorganic ash content of the coal determines the amount of ash to be expected in coal combustion.

Water - Of the 46,500 tons of water used each day, approximately 40,000 tons will go to cooling to make up evaporation loss. The remaining 6,500 tons is split between use as boiler feed water and solid waste disposal water.

Air - Over 160,000 tons of air are used in the process every day. This air is used primarily as the oxygen source for coal combustion, although the nitrogen in the air helps to significantly dilute the sulfur dioxide and nitrogen oxides which are products of the coal combustion.

If SO_2 control is necessary:

Scrubbing Medium - Assuming the use of a mixed calcium oxide-calcium carbonate (CaO-$CaCO_3$) chemical absorbent used for SO_2 scrubbing, something like 275 tons of finely ground material per day might be required. Calcium carbonate is limestone, and calcium oxide is limestone that has been treated or calcined at a high temperature.

Water - An additional 1,600 tons of water per day may be required to mix the scrubbing medium into the watery slurry required for sulfur dioxide control.

Products

Electricity	1,000 megawatts
Ash	1,000 ton/day
Dust	280 ton/day
Water evaporation	40,000 ton/day
Vent gas:	
Carbon dioxide	24,100 ton/day
Water vapor.	4,900 ton/day
Nitrogen	85,000 ton/day
Oxygen	5,300 ton/day
Sulfur dioxide	60 ton/day
Nitrogen oxides	80 ton/day
Particulates	3 ton/day
Total	119,543 ton/day
Miscellaneous Loss	77 ton/day
Total	160,900 ton/day
If SO_2 control is necessary:	
Scrubber sludge	500 ton/day
Recovered wastes	1,375 ton/day
Total with SO_2 scrubber	162,775 ton/day

Electricity - the saleable product from this process will be electrical power, some 1,000 megawatts. This would likely be more than enough power for the local area; therefore, much of this power will likely be exported to a more distant market.

Ash - The 1,000 tons of ash produced each day is the by-product of coal burning. This will be mixed with the other solid wastes and watered to form a thick slurry which will probably have to be buried, either in the coal mine or at the plant site.

Dust - Dust is the fine particulate which is caught by the precipitator. This dust has the texture of talcum powder, and hence is not easy to handle dry. Generally, dust is combined with the ash, then wetted to form a slurry and buried in the mine or at the plant.

Water Evaporation - A great deal of the water used in the plant is lost to evaporation during the cooling process, either in evaporat ponds or in the cooling towers.

Vent Gas - The vent gas is somewhat typical of a combustion gas resulting from coal burning. This gas has been cleaned of a significar amount (99 percent) of the dust using an electrostatic precipitator. However, the sulfur dioxide has not been controlled, but if regulations require, this could easily be accomplished.

Vent gas composition	(percent)
Carbon dioxide	20.2
Water vapor	4.1
Nitrogen	71.2
Oxygen	4.4
Sulfur dioxide	0.04
Nitrogen oxides	0.06
Particulates	0.002
Total	100

If SO_2 control is necessary:

Scrubber Sludge - This is the product of the reaction of the lime-limestone (CaO-$CaCO_3$) scrubbing medium and the SO_2 gas. The product is calcium sulfate ($CaSO_4$) with some calcium sulfite and some other sulfates. The sludge is generally combined with the ash and dust and disposed along with them.

Recovered Water - The scrubbing medium is introduced into the scrubber in a very watery slurry. After the medium is converted to the sludge product, the solids are allowed to settle out into a very thick slurry. In this way, much of the water can be recovered to use again.

Energy Balance - Many of these plants have been in operation for some time, and much energy balance data has been gathered. The plants run with thermal efficiency generally between 35 and 40 percent. Since the exact energy balance and conversion efficiency depend on the final plant design, no example energy balance is presented here.

8A.2.1.5 Physical plant

The coal fired steam electric generation plant will resemble, at least to some extent, a land-locked steamship. It consists of a rather large building or buildings, the most notable features being large, tall smokestacks, which in the case of a 1,000 MW plant could be, for example, 600 feet tall. The plant site is somewhat variable but should be somewhere between 100 and 500 acres depending where the solid wastes are disposed. The electric generation plant passes through three periods in its lifetime--construction, operation, and phase out.

Plant construction

Principle construction considerations are plant access and transport systems, site preparation and setup, and labor force. The labor force will probably reach a peak of 4,000 individuals and possibly higher. Likely, most of the 100-500 acres will be disturbed or altered during construction.

Access to the plant is critical during all three phases of plant life. During construction, the site must be accessible to both equipment (caterpillars, scrapers, draglines) and labor, and provisions must be made for transport of large process components (turbines, boilers,

ARTIST's CONCEPT of 760 MW PLANT

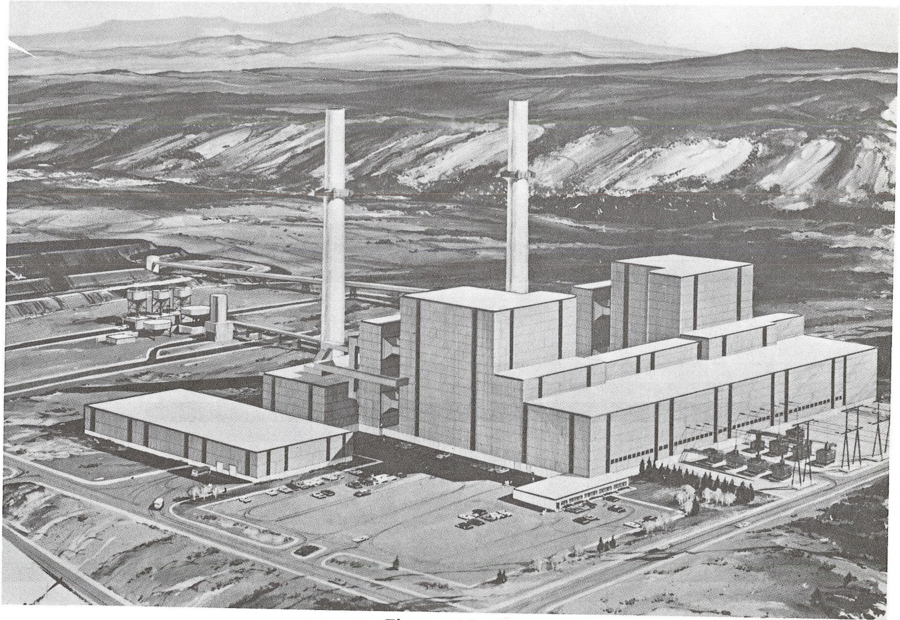


Figure 8A-G

FROM: Yampa Project Environmental Impact Statement compressors, etc.) which cannot be assembled on site. Transport systems must be supplied for raw materials--coal, water--as well as electric power by-products or waste products. If coal is to be shipped by rail, access must be provided, most probably, for one or two round trip, 100 car unit trains per day. Coal hauled by large, 100-ton, off-road trucks would require a road system capable of handling approximately 100 round trip truck hauls per day. Another alternative would be moving coal in a slurry pipeline. This would require a one and one-half foot pipeline. The pipeline carrying raw water would be about three feet in diameter. A transmission line system would be necessary to get the electrical power to consumers. Additional trains and/or trucks would need access to the plant to deliver scrubbing media materials if SO_2 control is required. Waste solids could be hauled back to the mine in the empty unit trains or in a pipeline paralleling the slurry pipeline. The right-of-way for the access systems would have to be cleared, leveled, and finally the system itself would be built. Also, before the plant becomes operational, access must be provided for employee roads, electric service lines, and telephone lines. The construction activities will resemble most nearly the construction of a typical two lane highway. Bulldozers, scrapers, trucks, and draglines, in addition to some specialized railroad or pipeline laying equipment, would generally be used. Crews would be fairly small and mobile.

During site preparation and setup, most of the 100-500 acre site will be leveled, storage and evaporation ponds dug, and finally buildings, storage structures, and steam-generation equipment will be moved in and assembled. Many bulldozers, scrapers, trucks, draglines, cranes, and other vehicles will work at leveling the site.

This labor force may well reach over 4,000 workers. During various periods during the construction schedule, the force will include, in addition to a large number of manual workers, many equipment operators, welders, masons, iron workers, and pipe fitters. The construction schedule will likely resemble the schedule diagrammed for the previous plant descriptions.

Routine plant operation

As construction of the site draws to a close, the operating crews will be trained and the plant systems will be tested and brought into production. When the plant is operating at a steady level, the labor force will stabilize. The operational phase time frame is somewhat dependent on economics and availability of raw materials, but a thirty-year life is a reasonable approximation. For the generation plant, the operating crew will be approximately 150-350 workers. With the plant operational, a constant level of heavy duty commercial (rail and road) and light duty private traffic will persist.

Phase out and shutdown

Process plants are designed to run at full rated capacity or, occasionally, a bit higher and are often uneconomical to operate at reduced capacity. Thus, a plant will generally be run at as near full capacity as possible until the critical resource is depleted. When this happens, it is more economically sound to suddenly shutdown rather than gradually phase out operations. In the case of coal fired steam generation, product price and demand in addition to governmental policies can determine whether plant operation is economically feasible. However, this rather sudden closeout would not likely happen. This represents very poor public relations for the company involved.

Unless some sort of plant deconstruction plan is implemented, the plant may be abandoned. However, some of the equipment and structures may have salvage or second-hand value. The plant site can then be cleared of any remaining structures and the site may be returned to a natural topography. This would mean a short-term, several month period of heavy vehicular traffic somewhat similar to the construction phase. Access systems may also be removed if no longer needed for transport systems. These rights-of-way can also be returned to a somewhat natural aspect.

8A.2.1.6 Typical steam electric power project summary

1.	Process used	Coal fired, steam electric power plant
	Capacity	1,000 megawatt
2.	Coal consumption	3-4 million tons/year
3.	Coal reserves required (assumed 30-year life)	90-120 million tons
4.	Water requirements	12,500 acre-feet/year
5.	Land needs	100-500 acres
6.	Employment (full production)	Without scrubber: 150-250 With scrubber : 200-350
7.	Construction employment (four years)	a) peak - 2,000-4,000 b) average - 2,000
8.	Total plant investment (order of magnitude, 1975 dollars)	\$400-\$600 million
9.	By-products:	
	a) waste	ash - 350,000 tons/year
	b) emissions	particulate matter - 1,000 tons/year sulfur oxide - 20,000-25,000 tons/year nitrogen oxides - 30,000 tons/year
10.	Utilization factor	80 percent - varies with demand
11.	Thermal efficiency	35-40 percent

8A.2.2 Probable impacts of coal fired steam electric generation

Impacts described below are those which can be anticipated from the construction, operation, and phase out of two 1,000 megawatt (MW) coal fired steam electric generating plants, related transportation systems, and community facilities. Again, in view of other major energy development proposals in the area, the impacts of two coal fired electric generation plants must be reviewed as part of the cumulative impact of all the potential projects in the Eastern Powder River Basin. As specific plant sites are unknown, impacts described are those which would be common to nearly any future plant site(s) within the study area.

8A.2.2.1 Climate

Generation plants would likely have the greatest effect of all the alternatives on the micro-climate of the immediate plant areas, emitting larger amounts of sulfur dioxide, nitrogen oxides, and water evaporation from cooling. Increases in air temperature and humidity could result. In conjunction with other proposed and projected development in the Eastern Powder River Basin, climate could be affected to a significant degree.

As with gasification and liquefaction processes, recent studies indicate that changes of atmospheric particulate loading and alteration of the earth-atmosphere energy balance may contribute to decreased precipitation and creation of drought conditions in semiarid climates.

8A.2.2.2 Air quality

Development of two generating plants, transportation systems, residential areas, and disturbances of relatively large areas of land would create multiple sources of air pollutants which, with prevailing upper level wind direction (northwest), could affect existing communities to the south and east of the sites.

Potentially, the most serious possible adverse impacts on humans, animals, and vegetation are from gases emitted by the generating plants. Emissions include sulfur oxides (42,000 tons/year), nitrogen oxides (56,000 tons/year), and particulates (2,200 tons/year).

The industrial development and attendant population increase (10-12,000) would increase use of internal combustion engines of all types. Engine emissions would result in the addition of carbon monoxide, hydrocarbons, particulates, nitrogen oxides, and sulfur oxides in the basin air.

Increases in airborne dust and similar particulate matter will result from development activities. Airborne particulate matter could reduce visibility, possibly cause traffic accidents during periods of inversions and periods of high winds, contribute to human allergies and similar irritations, and coat vegetation with potentially harmful chemicals.

Present ambient air quality in the area is good, but it would decline with the development of complex pollution sources.

8A.2.2.3 Topography

The land surface would be altered during site preparation for the two assumed plants, which would require approximately 200-1,000 acres. Another 1,000 acres would be disturbed to accommodate community growth. Construction of roads, transmission lines, and railroads would result in alterations of the land surface. The disturbance would consist of earthwork and grading for construction of facilities.

8A.2.2.4 Soils

Soil disturbance would result from construction of the generation plants, community development, and associated transportation systems. The soils on the majority of some 1,600 acres would be disturbed.

As sites are unknown, the length of rights-of-way for the transport systems is also unknown. However, construction of these facilities will result in additional soil disturbance. An average disturbance of five acres per lineal mile for the various transport facilities is estimated.

Disturbances on construction sites result in fine grained soil and parent material being exposed to wind and water actions. Soil productivity, permeability, and infiltration rates would be reduced, increasing runoff, soil erosion, and sedimentation. Wind action, which is almost constant over the entire area, would cause fine soil, silt, and clay particles to be lifted into the atmosphere, reducing air quality and adding to soil loss. Prior to revegetation of exposed soils, soil erosion resulting from high intensity storms would remove fine materials and 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, adding to soil loss and sedimentation.

8A.2.2.5 <u>Mineral resources</u>

The primary impact on mineral resources in the area is the removal and subsequent use of 210,000,000 tons of coal during the projected thirty-year life of the generation stations. Significant amounts of sand, gravel, fill dirt, and limestone may be used for construction purposes. Energy fuels would be consumed by equipment used during construction and plant operations.

Depending upon ultimate location of plant sites and transportation facilities, there could be a conflict if construction occurs on mineralized areas, hampering development of those minerals.

8A.2.2.6 <u>Water resources</u>

The consumptive water use for the coal fired steam electric generation plants would be approximately 25,000 acre-feet per year.

Other impacts on water resources in the Eastern Powder River Basin would result from the approximately 1,800 acre-feet/year required for the increased population supporting plant development. Water presently being used for other purposes--agricultural use, recreation, and fish and wildlife populations--would be needed to support population growth.

8A.2.2.7 <u>Vegetation</u>

Vegetation would be destroyed on the two plant sites (100-500 acres per site), the land area required for the transportation systems (roads, railroads, pipelines, etc.), and the land area required for residential and commercial development (1,000 acres) to meet increased population needs.

In addition to the loss of vegetation from physical disturbance, the potential would exist for loss to occur due to increased atmospheric loading of particulates, salts from cooling water evaporation, sulfur dioxide (SO_2), and nitrogen oxides (NO_x).

Increased population would intensify recreation use, possibly destroying or decreasing vegetative cover. Secondary impacts from loss of vegetation would result--increased soil erosion (wind and water), loss of cover for wildlife, loss of livestock forage, and adverse effect on aesthetic values.

8A.2.2.8 Fish and wildlife

Electric generation development would result in impacts on the fish and wildlife; habitats would be destroyed and overall animal populations would be reduced. Increased human activity would affect wildlife and habitat.

Industrial development destroys or impairs habitat. This impact on habitat then translates itself into an impact on fish and animal residents, resulting in loss of population. Each wildlife species in the study area would be subject to the cumulative effects of several of the different categories of impacts caused by industrial development which include direct destruction of animals; permanent destruction of habitat; initial destruction of habitat followed, in time, by some degree of recovery in habitat value; impairment or reduction in value of habitat near human development or activities; increased introduction of hazards into the wildlife environment; off-site and secondary impacts caused by displaced animals, disrupted food chains, changed land and water uses, etc.; and improvement of habitat.

8A.2.2.9 Cultural resources

There would be some 2,000 or more acres disturbed during construction of the plants, community facilities, and access systems. Cultural sites on this acreage would be damaged and/or destroyed, making the values unavailable for future study and salvage. Besides the direct impact of construction, indirect losses would result from population increase. Recreational users--arrowhead hunters, rock collectors, pot hunters, and off-road vehicle users--would disturb additional surface acreage, destroying evidence which could provide information on known as well as unknown cultural sites. However, beneficial impacts could result from inventory and recognition of cultural values.

8A.2.2.10 Aesthetics

Construction, physical presence, and operation of generation facilities, transportation systems, and residential and commercial development would have an adverse effect, although generally less than gasification or liquefaction, on the aesthetics of the area through alteration of the landscape, increased noise levels, and air contaminants such as dust and plant and vehicular emissions.

8A.2.2.11 Recreation resources

Impacts on recreation resources would primarily result from increased population due to industrial development. Another source of impact would be the loss of land base (potentially over 2,000 acres) committed to recreation use. Development of material sites, replacement agricultural lands, and increased recreational use would also decrease recreational land. Private land normally available for this type of use may be closed and posted, further reducing the recreation land base.

Much of the sand, gravel, and clinker material may be mined from stream courses, alluvial mountain slopes, or limestone outcrops, possibly impacting scenic recreation areas.

The anticipated population growth would generate increased strain on recreation facilities. Recreation facilities near population centers would experience the greatest demand and be subjected to greatest impacts.

During inversion periods and high winds, visibility would be reduced, obscuring to some extent the scenic views of the area and reducing the visitor's enjoyment. Transmission lines would also reduce the sight-seer's enjoyment of the view. Decreased scenic value may also affect long-term economic strength for certain sectors by reducing nonresident recreation. Increased use of recreation resources outside the area could result in the lowering of recreation quality in an ever-widening circle.

8A.2.2.12 <u>Agriculture</u>

Agricultural land use changes which would occur to accommodate plant sites, community development, and access ssytems are estimated at over 2,000 acres.

With regard to livestock grazing, a loss of approximately six acres represents an estimated loss of one animal unit month (AUM) of grazing. Using the above acreages, which excludes the transportation systems, the annual loss of livestock forage could range from 300 to 350 AUMs.

Secondary impacts associated with population increases due to construction and related development would affect livestock grazing. Vandalism and accidental property damage may increase due to larger numbers of hunters and outdoor recreationists, and animals may be harrassed or harmed by recreation use.

Construction and fencing of railroads, highways, and service roads would lead to land separation and alter present ownership patterns, thereby separating and isolating ranch properites, disrupting established use patterns, and causing access problems for watering and livestock care. Small isolated tracts could result which are too small in size to be of economic use. Livestock drifting during severe weather may be trapped by fences and lost. Physical separation of adjoining private land from federal grazing leases and division of grazing allotments by fenced rights-of-way may cause loss or realignment of leases.

Agricultural lands could be affected by increased erosion, sedimentation, and headcutting in productive drainage bottoms, resulting in additional losses of forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

8A.2.2.13 Transportation networks

Construction and operation of the plants, transport systems, and increased population would create additional use of existing transportation networks causing likely modification and/or upgrading. Increased use of the existing roads and highways requires increased maintenance expenditures, upgrading to higher road standards in some cases, and possibly relocation of sections of some routes. Construction of the new transportation networks would result in conflicts with existing systems such as disruption of an existing facility while new ones--crossing or affecting systems in operation--are under construction. Once built, though, the new transportation facilities may complement or improve the existing facilities.

8A.2.2.14 Land use controls and constraints

Electric generation development may precipitate the need to revise or develop land use controls and constraints, as existing planning may not adequately guide development.

8A.2.2.15 Socio-economic conditions

Population

The following population figures are estimates of population growth that might result if coal fired steam electric generation plants are built. These figures do not reflect population and employment for coal mining.

Potential Population Growth in the Study Atea

PROCESS	POWER GENERATION 1,000 MW (2 plants)
Low estimate, new permanent employment	300
Induced non-industrial employment 1/	300
Total new employment	600
Additional population 2/	1,800
Low estimate, average temporary construction employment	4,000
Induced non-construction employment 3/	2,000
Total new construction related employment	6,000
Additional population 4/	9,000
All new employment	6,600
All additional population	10,800

1/ Assumes 1 new non-industrial employee per each new industrial employee.
2/ Assumes 3 persons per each new employee.
3/ Assumes 1/2 new non-construction employee per each construction employee.
4/ Assumes 1-1/2 persons per each new construction related employee.

While the addition of 10,800 people is not necessarily adverse, the impact of population growth may generate negative secondary effects which are summarized below and described in more detail in the analysis of socio-economic conditions for the liquefaction alternative (8A.1.2.15).

Employment - 6,600 new jobs would be created.

- construction labor varies from 2,000 to a peak of 4,000 laborers for each plant.
- operational labor varies from 150-350 workers per plant.

Income - entering industrial labor wages should range from $10,000 to $15,000 per year.

Housing - an additional 3,000 to 3,200 housing units may be required to meet demands.

Public education - student enrollments would increase in the areas of development; however, since electric generating plants produce only about half as large a population increase as assumed gasification or liquefaction, the impact should not be as great. Initial crowding during construction would be as great as gasification or liquefaction, however, since construction forces for generation, gasification, and liquefaction are of similar size.

Health and social services,

Law enforcement,

Fire protection, and

Water and sewer facilities - during construction, crowding and facility shortages would be as great as those experienced for liquefaction development. The operational phase impacts would be less than for liquefaction projects because power generation permanent crews are somewhat smaller.

8A.2.3 References

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8A.3.1 Assumptions and analysis guidelines for alternatives

Coal Slurry Transport - 2 Systems

1.	Product	17,000,000 tons/year/system
2.	Coal Use	17,000,000 tons/year/system
3.	Water Use	16,275,000 tons/year/system 12,500 acre-feet/year/system 0.16 acre-feet/year/person
4.	Water Evaporation	Uncertain
5.	Waste Ash and Dust	None
6.	Emissions:	
	sulfur dioxide	Uncertain
	nitrogen oxides	None
	particulates (with dust control)	Possible dust from coal handling
7.	Transport Systems:	
	coal	4-6 round trips/unit train/system 500 round trips/100 tons truck/system
	product	3½ foot pipeline/system
	water	3 foot pipeline/system
8.	Land Use	200 acres/system 0.16 acre/family 6 acres/pipeline mile (3-5 acres disturbed) 10 acres/transmission line mile
9.	Population:	
	construction labor	peak) 500-1,000/system average) 300-400/system
	operational labor	50-100/plant
	population multiplier factor	4-5
	construction population	2,000-5,000/system
	operational population	200-500/system
10.	Time Frame:	
	construction	1½-2 years
	operation	30 years

8A.3.1.1 Coal slurry transport

When a solid material is finely ground and mixed with water to form what is commonly called a slurry, that mixture acquires some of the properites of a liquid, principally, the mixture is able to flow through pipes and hence be transported for long distances. Many materials, even very heavy and dense materials, such as iron ore concentrates, have been moved in slurry lines, although most of these lines have been short lines, such as tailings pipelines in mineral concentration plants. Pipelines have been built which are almost 300 miles long, for example, the Black Mesa pipeline in Arizona transports coal over 270 miles.

To be transported as a slurry, the coal must be ground to the powdery consistency of talcum powder, then mixed with water, usually in a ratio of about one pound of coal to one pound of water. This is thoroughly mixed and agitated to keep the coal and water from separating. Then the slurry, a thick black liquid, is pumped into the pipeline. About every one hundred miles or so along the pipeline route, a pumping station is necessary to keep the slurry moving and keep it from slowing enough to begin separating into coal and water. When the slurry gets to its final destination, the water is removed by filtering and thermal drying, leaving dry coal for futher utilization.

8A.3.1.2 Plant disposition assumptions

Coal slurry transport is a commercially feasible process, and the properties necessary in the slurry to make transport efficient and economic are well understood. Typically, a slurry which is fifty weight percent coal--that is, the slurry contains one pound of coal for every one pound of water--has the necessary properties to be easily transportable by pipeline. Each company has some 12,500 acre-feet of water to use each year. This is the equivalent of seventeen million tons of water, enough water to transport seventeen million tons of coal.

The coal slurry pipeline process differs from some of the other processes previously discussed. There is really no main plant, instead there are smaller sub-plants arrayed along the pipeline route. At the beginning of the pipeline is the slurry preparation plant and first pump station, requiring about 100 acres. Then, every 100 miles along the line are other pumping stations, each requiring about 40 acres. At the end of the line is the slurry dewatering station, requiring probably another 100 acres. The pipeline itself will require approximately 3-5 acres per mile. More than likely, this entire area of study, and more realistically the preparation plant and maybe one or two pumping stations, will be built in the area, with the rest of the pipeline extending to a point where the coal is needed.

8A.3.1.3 The coal slurry pipeline system

The slurry pipeline system is spread over a large distance, much of which will not likely be built in the area of study. However, to get an adequate idea of what the system involves, the entire system will be described. In discussing construction and later, in discussing impacts, it is assumed that only the preparation plant, one or two pumping stations, and possibly one or two hundred miles of pipeline will be established in the area of study. The pipeline system can be thought of as consisting of three sets of components--preparation components, mainline components, and dewatering components.

Preparation components

Coal supply - This is the component where the coal is supplied to the preparation plant. Run of mine coal, coal as it comes from the mine, is crushed to pieces generally no larger than two inches and transported by either large truck or train to the coal washing plant.

Coal washing - In coal washing the coal is cleaned of noncoal material which may be associated with it. Sometimes shale or mineral material such as pyrites will be interbedded with the coal, and to bring the coal's value up, this material must be separated. The coal could be washed after transport, or be used unwashed, but it is generally bad economics to transport material which has little or no value and still costs the same to transport. The tailings derived from washing must be disposed of properly, especially if pyrites are present. When exposed to water, these pyrites may be altered to form aqueous acids, resulting in acid mine water.

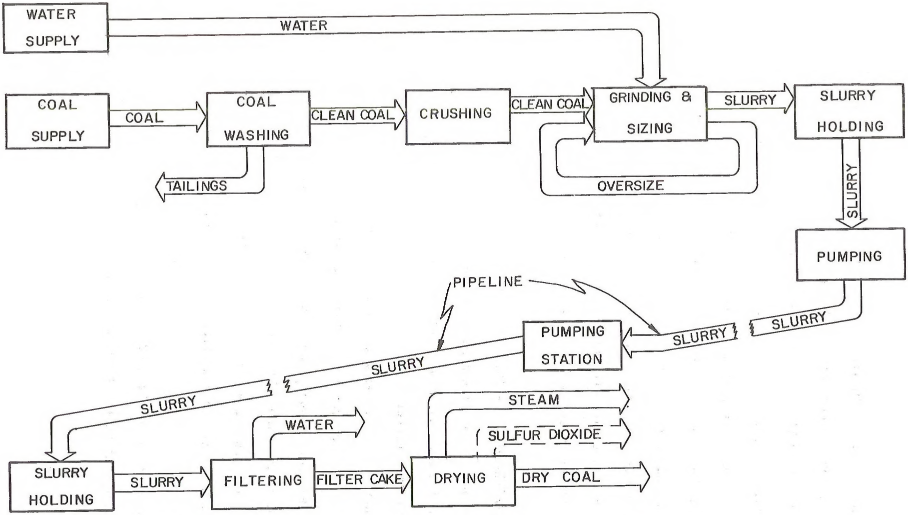


Figure 8A - H

COAL SLURRY PIPELINE
FLOW DIAGRAM

Crushing - In this component the larger chunks of clean coal are crushed down to an appropriate size for grinding feed. The coal will leave crushing generally of a top size no larger than one-fourth inch.

Water supply - This is the source of water with which to slurry the coal. This may be supplied to the preparation plant by means of a pipeline from the reservoir. This water may be purified if the concentration of dissolved solids is over 100 ppm (parts per million), although the Black Mesa pipeline uses water containing 400-500 ppm dissolved solids. It is theorized that dissolved solids in concentrations over 100 ppm might cause the slurried coal to pick up the solids and thereby reduce its quality.

Grinding and sizing - The coal from the crusher is mixed with water from water supply, then this mixture is fed into the grinding device, generally called a mill. Rod mills or ball mills are generally used in this application. Either of these mills resembles a large round drum which is roughly half filled with rods or balls. The coal and water are fed into one end, the drum is rotated to cause the rods or balls to fly against one another, trapping coal in between them and grinding the coal down to a very fine size. The coal and water exit the other end of the drum, the coal ground very fine and intimately mixed with the water into a slurry. This slurry is run through a size separation device in which the pieces of coal still too large to be sent into the slurry line are returned as oversize to the feed end of the mill to be reground. The remaining slurry is pumped to slurry holding.

Slurry holding - To prevent the coal and water from separating into two fractions before pumping, the slurry is held in a tank where the slurry is constantly mixed and held in suspension. This is generally accomplished using a "slurry tank" which is a large cylindrical tank with a propeller-like device mounted in the center. The propeller is rotated to swirl the slurry and keep it in suspension.

Pumping - In this component the slurry is pumped from the preparation plant into the beginning of the pipeline.

Mainline components

Pipeline - Special pipeline design is used in the slurry pipeline to allow for internal corrosion, abrasion, and pressure. The wall thickness is generally designed to allow for a suitable thickness to still remain after 50 years of use. The outside of the pipe is treated and covered to inhibit corrosion from the outside of the pipe. The pipe is generally also cathodically protected, a sort of chemical-electrical protection, against external corrosion.

Pumping station - The typical pumping station involves a 10- to 20-foot-deep water storage reservoir used to flush the line to the next station, a slurry pump pond for emergency use during system failure, a pump house building, water pump house, cooling system with tower, electrical substation, water well, and waste treatment facility. Forty acres of land are required for each pumping station facility, most of which is used for the slurry dump pond and water reservoir. Each station has about 5 to 10 electric-driven pump units. The pumping stations are situated roughly every 100 miles along the route of the pipeline.

Dewatering components

Slurry holding - This slurry holding tank will be similar to the tank used in the preparation stage.

Filtering - Much of the water is reclaimed from the coal by filtering. This is generally done using some sort of vacuum filter in which the slurry is pulled by vacuum through a filter cloth; the pores in the cloth are small enough to catch all but the very smallest particles of coal. The water passes through the cloth, is collected, and can then be possibly used in later processing. If the water is to be disposed of, it may be necessary to separate the very small coal particles from the water. The coal leaves the filter as a filter cake which resembles slightly moistened black dirt.

Drying - The filter cake is dryed, using a gentle heating, slow enough to avoid burning the coal but yet fast enough to economically dry the coal. The water in the coal is vaporized to steam, which may later be recondensed to water, if desirable. If the drying temperature and time are high and long enough, some of the sulfur in the coal may be converted to sulfur dioxide. The coal leaves drying as a dry cake ready for further conversion or consumer use.

8A.3.1.4 Material balance

The material balance for the slurry system is rather straightforward and easy to understand, since, basically, none of the raw materials are chemically altered into new products. You start the process with coal and water, and you end up with coal and water. There are some losses in the transport system--the magnitude of these losses being a determiner of the efficiency of the process. The balance sheet for raw materials going in and products coming out is presented in the following tabulation:

Raw Materials		
Clean Coal	-	46,500 ton/day
Water	-	46,500 ton/day
Total	-	93,000 ton/day
Products		
Dry Coal	-	44,600 ton/day
Water	-	40,100 ton/day
Losses	-	3,800 ton/day
Steam	-	4,500 ton/day
Total	-	93,000 ton/day

Raw materials

Clean coal - This is the coal which has been through the coal washer, if necessary, and is of high enough grade to warrant transport. Oftentimes, the coal will be of good enough quality, or grade, that it will not need to be cleaned. Then the 46,500 tons would be simply "run of mine" coal.

Water - This is the 12,500 acre-feet per year available to each of the two industrial participants. If this water is high in dissolved solids, it may have to be treated to bring the level of solids down to somewhere near 100 ppm (parts per million). However, this purity requirement is not absolute, and the water, even if it would be a little high in solids, could still be used without treatment.

Products

Dry coal - This is the amount of coal delivered at the end of the pipeline, dried, and ready to be further utilized in some coal conversion process. This coal is in the form of a dry cake, somewhat similar to a dry mudpie, which may have to be crushed before it can be used.

Water - This represents the water which is received in the filtering process. This water should be of fairly good quality, but it quite likely will contain very small coal particles which may need to be removed if the water is needed for a use requiring very good quality water. Water from filtering processes is often cleaned of the small particulate matter using chemical clarifiers or flocculants which cause the fine particles to cling together and settle out.

Losses - The 3,800 tons per day of losses are accounted for by the leaks and spills inherent to handling coal, water, and slurry. In pumping the slurry perhaps many hundred of miles, a small amount will be lost in the pumping stations and in handling the slurry on both ends. Occasionally, a section of the pipeline needs to be cleaned out, and some slurry will be lost. These losses are generally small, in this case amounting to four percent of the total throughput.

Steam - This is the steam generated in the final drying of the coal filter cake. It may be desired to recover the steam as water to be used in further processing, or possibly the steam itself could be used in coal conversion processing.

8A.3.1.5 Physical plant

The coal slurry pipeline system will not likely be very visually evident because it will be spread over the length of its route, and most of it will be underground. The slurry preparation plant will be small, involving 60 acres containing a few buildings, some large tanks and storage bins, conveyor belts, and unloading facilities. Each pumping station will be about 40 acres with a few buildings and a couple of holding ponds. The dewatering plant will be small, also, and will possibly be hidden among the plants which will further utilize the coal. Like the other processes, the pipeline system progresses through three phases--construction, operation, and phase out.

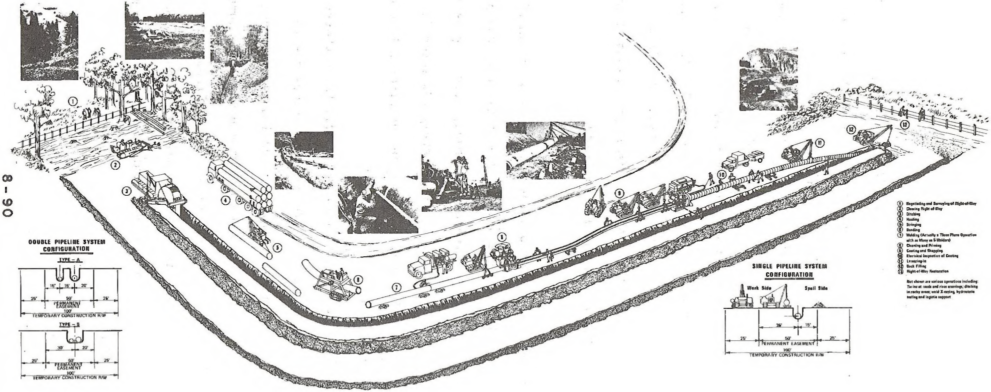
Plant construction

Principle construction considerations are preparation of plant and pipeline access and transport system, route preparation and plant setup, and labor force. The labor force will probably reach a peak of 1,000 individuals and possibly higher. Approximately 200 acres in addition to 3-5 acres/mile of pipeline will be disturbed or altered in the study area during construction.

Access to the system is critical during all three phases of system life. During construction, the route must be accessible to both equipment (caterpillars, scrapers, draglines) and labor, and provisions must be made for transport of large process components (mills, pumps, slurry tanks, etc.) which cannot be assembled on site. Transport to the preparation plant must be supplied for raw materials--coal and water. If coal is to be shipped by rail, access must be provided, most probably,

Figure 8A-I

TYPICAL PIPELINE CONSTRUCTION OPERATION



FROM: Description of Industrial Development Involved in the Proposal by E.T.S.I., Letter, January 1975.

for four to six round trip, 100 car unit trains per day. Coal hauled by large, 100-ton, off-road trucks would require a road system capable of handling approximately 500 round trip truck hauls per day. The pipeline carrying raw water would be about three feet in diameter. The slurry pipeline would need to be about three and one-half feet in diameter. Additional trains and/or trucks would need access to the plant if the tailings from coal washing need to be hauled away, for example, back to the mine. The right-of-way for the pipeline and access systems for the preparation plant would have to be cleared, leveled, and finally the system itself would be built. Also, before the system becomes operational, access must be provided for employee roads, electric service lines, and telephone lines. The construction activities will resemble most nearly the construction of a typical two lane highway. Bulldozers, scrapers, trucks, and draglines, in addition to some specialized railroad or pipeline laying equipment, would generally be used. Crews would be fairly small and mobile.

During route preparation, most of the 200 acres will be leveled, storage ponds dug, and finally buildings, storage structures, and preparation and pumping equipment will be moved in and assembled. Bulldozers, scrapers, trucks, draglines, cranes, and other vehicles may work at leveling the sites along the route.

This labor force may well reach over 1,000 workers. During various periods during the construction schedule, the force will include, in addition to a large number of manual workers, many equipment operators, welders, masons, iron workers, and pipe fitters.

Routine plant operation

As construction of the route draws to a close, the operating crews will be trained and the plant systems will be tested and brought into operation. When the system is operating at a steady level, the labor force will stabilize. The operational phase time frame is somewhat dependent on economics, availability of raw materials, and demand for coal, but a thirty-year life is a reasonable approximation. For the preparation plant, the operating crew will be approximately 50-100 workers, with an additional 5 people at each pumping station. With the system operational, a constant level of heavy duty commercial (rail and road) and light duty private traffic will persist.

Phase out and shutdown

The pipeline system is designed to run at full rated capacity or, occasionally, a bit higher and is often uneconomical to operate at reduced capacity. Thus, the system will generally be run at as near full capacity as possible until the critical resource is depleted. When this happens, it is more economically sound to suddenly shutdown rather than gradually phase out operations. In the case of the coal slurry pipeline system, product price and demand in addition to governmental policies can determine whether system operation is economically feasible. However, this rather sudden shutdown would not likely happen. This represents very poor public relations for the company involved.

Unless some sort of system deconstruction plan is implemented, the system may be abandoned. However, some of the equipment and structures may have salvage or second-hand value. The route can then be cleared of any remaining structures and the sites may be returned to a natural topography. The pipeline may be dug up and salvaged or may be left buried. This could mean a short-term, several month period of heavy vehicular traffic somewhat similar to the construction phase. Access systems may also be removed if no longer needed for transport systems. These rights-of-way can also be returned to a somewhat natural aspect.

8A.3.1.6 Typical coal slurry project summary

1.	Process used	Slurry transportation of coal
2.	Coal consumed	17 million tons/year
3.	Coal reserves required (assumed 30-year life)	510 million tons
4.	Water requirement	12,500 acre-feet
5.	Land needs	60 acres for preparation plant 40 acres for pumping station 3-5 acres/mile for pipeline
6.	Employment (full production)	a) plant - 50-100 b) pumping station - 5
7.	Construction (1½-2 years total)	a) peak - 500-1,000 b) average - 300-400
8.	Total investment (order of magnitude, 1975 dollars)	$200,000,000 in the study area
9.	By-products	Water and steam used at the receiving coal conversion plant
10.	Utilization factor	Variable - 17 million tons/year at 98 percent of capacity
11.	Efficiency	96 percent

8A.3.2 Probable impacts of coal slurry transport

Impacts described below are those which can be anticipated as a result of the construction, operation, and phase out of two 17 million ton per year coal slurry transport systems and related community facilities. As before, in view of other major energy development proposals in the area, the impacts of coal liquefaction must be viewed as part of the cumulative impact of all potential projects in the Eastern Powder River Basin. As specific routes have not been identified, impacts described are those which are common to most any future system routing within the study area.

8A.3.2.1 Climate

The coal slurry transport system would likely cause very little change in the micro-climate of the area. The only significant impact would be particulate emissions from dusty coal handling operations. Although other proposed and projected development in the Eastern Powder River Basin could affect climate to a significant degree, coal slurry transport would add little to this impact.

8A.3.2.2 Air quality

Development of two coal slurry transport systems and residential areas would create some minor sources of air pollutants which, with prevailing upper level wind direction (northwest), could affect existing communities to the south and east of the sites.

Increases in airborne dust and similar particulate matter would result from coal slurry activities. Airborne particulate matter could reduce visibility and possibly cause traffic accidents during periods of inversions and periods of high winds. Particulate matter could also contribute to human allergies and similar irritations and coat vegetation with potentially harmful matter.

The industrial development and attendant population increase (2,000) would increase use of internal combustion engines of all types. Engine emissions would result in the addition of carbon monoxide, hydrocarbons, particulates, nitrogen oxides, and sulfur oxides to the basin air.

Present ambient air quality in the area is good, but it would decline with the development of industrial pollution sources.

8A.3.2.3 Topography

Land surface would be altered during route preparation for the two systems, requiring approximately 200 acres for facilities and up to 1,000 acres for the actual pipeline. Another 200 acres would be disturbed to accommodate community growth. Construction of roads and railroads would result in alterations of the land surface. The disturbance would consist of earthwork and grading to facilitate construction of facilities and pipelines.

8A.3.2.4 Soils

Soil disturbance would result from construction of the slurry transport systems and community development. The soils on the majority of 1,000-1,500 acres would be disturbed. In addition, some 5 acres/mile will be disturbed in building facility access systems--roads, railroads, etc.).

Disturbances on the construction sites would result in soil and parent material being exposed to wind and water action. Soil productivity, permeability, and infiltration rates would be reduced, increasing runoff, soil erosion, and sedimentation. Wind action, almost constant over the entire area, would cause fine soil, silt, and clay particles to be lifted into the atmosphere, reducing air quality and adding to soil loss. Prior to revegetation of exposed soils, soil erosion resulting from high intensity storms would remove fine materials and 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, adding to soil loss and sedimentation.

8A.3.2.5 Mineral resources

The primary impact on mineral resources in the area is the removal and subsequent use of 1,020,000,000 tons of coal during the projected thirty-year life of the slurry transport systems. Small amounts of sand, gravel, fill dirt, and limestone may be used for construction purposes. Energy fuels would be consumed by the equipment used during construction and system operation.

Depending upon the ultimate location of routes and supporting facilities, there could be conflict if construction occurs on mineralized areas, hampering the development of those minerals.

8A.3.2.6 Water resources

The consumptive water use for the assumed coal slurry transport systems would be approximately 25,000 acre-feet per year.

Other impacts on water resources in the Eastern Powder River Basin would result from use of approximately 300 acre-feet/year required for the increased population supporting slurry transport developments. Water presently being used for other purposes such as agricultural use, recreation, and fish and wildlife populations could be used to support added population.

8A.3.2.7 Vegetation

Vegetation would be destroyed on the slurry facility sites (200 acres per system), the land area required for the pipeline and access systems (roads, railroads, etc.), and the land area required for residential and commercial development (200 acres) to meet increased population needs.

In addition to the loss of vegetation from physical disturbance, the potential may exist for loss to occur due to increased atmospheric loading of particulates.

Increased population would intensify recreation use, possibly destroying or decreasing vegetative cover. Secondary impacts from loss of vegetation would result--increased soil erosion (wind and water), loss of cover for wildlife, loss of livestock forage, and adverse effect on aesthetic values.

8A.3.2.8 Fish and wildlife

Slurry transport development would result in impacts on the fish and wildlife in that habitats would be destroyed and overall animal populations would be reduced on some 1,000-1,500 acres. Increased human activity would affect wildlife and habitat.

Industrial development destroys or impairs habitat which translates itself into an impact on fish and animal residents, resulting in population decrease. Each wildlife species in the study area would be subject to the cumulative effects of the different categories of impacts caused by industrial development, including direct destruction of animals, permanent destruction of habitat; initial destruction of habitat followed, in time, by some degree of recovery in habitat value; impairment or reduction in value of habitat near human development or activities; increased introduction of hazards into the wildlife environment; off-site and secondary impacts caused by displaced animals, disrupted food chains, changed land and water uses, etc.; and improvement of habitat.

8A.3.2.9 Cultural resources

There would be some 1,000 or more acres disturbed during construction of the systems and community facilities. Cultural sites on this acreage would be damaged and/or destroyed, making the values unavailable for future study and salvage. Besides the direct impact of construction, indirect losses would result from population increase. Recreational users would disturb additional surface acreage, destroying evidence which could provide information on known as well as unknown cultural sites. However, beneficial impacts could result from inventory and recognition of cultural values.

8A.3.2.10 Aesthetics

Construction, physical presence, and operation of slurry transport facilities, pipeline and access systems, and residential and commercial development would have an adverse effect, although generally less than gasification, liquefaction or electric generation, on the aesthetics of the area through alteration of the landscape, increased noise levels, and air contaminants such as dust and vehicular emissions.

8A.3.2.11 Recreation resources

Impacts on recreation resources would primarily result from increased population. Another source of impact would be the loss of land (potentially over 1,000 acres) committed to recreation use. Development of material sites, replacement agricultural lands, and increased recreational use would also decrease recreational land. Private land normally available for recreation may be closed and posted, further reducing the recreation land base.

Much of the sand, gravel, and clinker material may be mined from stream courses, alluvial mountain slopes, or limestone outcrops, possibly impacting scenic recreation areas.

Anticipated population growth would generate some strain on recreation facilities. Recreation facilities near population centers would experience the greatest demand and be subject to greatest impacts.

Dusty conditions near the slurry preparation plant may impair the sightseer's enjoyment of nearby scenic views. Decreased scenic value could affect long-term economic strength for certain sectors by reducing nonresident recreation. Increased use of recreation resources outside the area could lower recreation quality in an ever-widening circle.

8A.3.2.12 Agriculture

Agricultural land use changes which would occur to accommodate plant routes and community development are estimated at over 1,000 acres.

With regard to livestock grazing, a loss of approximately six acres represents an estimated loss of one animal unit month (AUM) of grazing. Using the above acreage, the annual loss of livestock forage could range from 150 to 200 AUMs.

Secondary impacts associated with population increases may be increased vandalism, accidental property damage, and animal harrassment due to larger numbers of hunters and outdoor recreationists.

Construction and fencing of pipeline rights-of-way, railroads, highways, and service roads would lead to land separation and alter present ownership patterns, thereby separating and isolating ranch properties, disrupting use patterns, and causing access problems for watering and livestock care. Small isolated tracts could result which are too small in size to be of economic use. Livestock drifting during severe weather may be trapped by fences, and lost. Physical separation of adjoining private land from federal grazing leases and division of grazing allotments by fenced rights-of-way may cause loss or realignment of leases.

Agricultural lands may be affected by increased erosion, sedimentation, and headcutting in productive drainage bottoms, resulting in additional losses of forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

8A.3.2.13 Transportation networks

Construction and operation of the systems and increased population would create some additional use of existing transportation networks, possibly necessitating modification and/or upgrading. Increased use of the existing roads and highways would require increased maintenance expenditure, upgrading to higher road standards in some cases, and possibly relocation of sections of some routes. Construction of the new transport networks would result in conflicts with existing systems such as disruption of an existing facility while new ones--crossing or affecting systems in operation--are under construction. Once built, though, new transport facilities may complement or improve existing facilities.

8A.3.2.14 Land use controls and constraints

Coal slurry transport system development may precipitate the need to revise or develop land use controls and constraints, as existing planning may not adequately guide development.

8A.3.2.15 Socio-economic conditions

Population

The following population figures are estimates of population growth that might result if coal slurry transport systems are developed. These figures do not reflect population and employment for mining.

Potential Population Growth in the Study Area

PROCESS	SLURRY 17 MILLION TONS (2 systems)
Low estimate, new permanent employment	100
Induced non-industrial employment 1/	100
Total new employment	200
Additional population 2/	600
Low estimate, average temporary construction employment	600
Induced non-construction employment 3/	300
Total new construction related employment	900
Additional population 4/	1,350
All new employment	1,100
All additional population	1,950

1/ Assumes 1 new non-industrial employee per each new industrial employee.
2/ Assumes 3 persons per each new employee.
3/ Assumes 1/2 new non-construction employee per each construction employee.
4/ Assumes 1-1/2 persons per each new construction related employee.

The addition of 1,950 people is not necessarily adverse, but population growth may generate some negative secondary effects which are summarized below and described in more detail in the analysis of socio-economic conditions for the liquefaction alternative (8A.1.2.15).

Employment - 1,100 new jobs would be created.

- construction labor varies from 300 to a peak of 1,000 laborers for each system.
- operational labor varies from 50-100 workers per system.

Income - entering industrial labor wages should range from $10,000 to $15,000 per year.

Housing - an additional 500 to 600 housing units may be required to meet demands.

Public education - student enrollments would increase in the areas of development; however, since coal slurry transport produces only about half as large a population increase as assumed gasification, liquefaction, or even electric generation, the impact should not be great. Initial crowding during construction would be somewhat lower than liquefaction since construction forces for liquefaction are somewhat larger.

Health and social services,

Law enforcement,

Fire protection, and

Water and sewer facilities - during construction, crowding and facility shortages would be somewhat lower than those experienced for liquefaction development. The operational phase impacts would be somewhat less than for liquefaction projects because slurry transport permanent crews are somewhat smaller.

8A.3.3 References

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2. Clean Energy from Coal Technology, Department of the Interior, Office of Coal Research.

3. Coal Development Alternatives - An Assessment of Water Use and Economic Implications, David D. Freudenthal, Peter Ricciardelli, Michael N. York, Wyoming DEPAD, December 1974.

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9. Some Economic Aspects of Mineral Slurry Pipelining, J. M. Link, Colorado School of Mines Research Institute, December 1974.

8A.4.1 Summary of Process Requirements

PROCESS	GASIFICATION 375 MMSCFD	LIQUEFACTION 70-150,000 BPD	POWER GENERATION 1,000 MW	SLURRY 17 MILLION TONS/YEAR
Water (AF/yr.)	12,500	12,500	12,500	12,500
Coal (million tons/yr.)	13.5	18	3 to 4	17
Land (acres)	1,000	1,000	100 to 500	200
Construction Employment				
a) peak	2,500 to 3,500	2,500 to 3,500	2,000 to 4,000	500 to 1,000
b) average	1,500 to 2,000	1,500 to 2,000	2,000	300 to 400
Product	synthetic pipeline gas	synthetic fuel	electric power	transported dry coal
By-products				
a) salable:				
sulfur 3/	32	30 to 50	-- 4/	--
ammonia 3/	62	50	--	--
tar 3/	600	--	--	--
tar oil 3/	335	--	--	--
phenols 3/	75	49	--	--
b) wastes:				
ash 3/	1,120	1,600	350	--
c) emissions:				
particulate matter	1,800	too conjectural	1,000	--
sulfur oxide	8,000	to	20,000 to 25,000	--
nitrogen oxides	12,000	estimate	30,000	--
Utilization factor (%)	85	90	80	98
Efficiency (%) - average	70 (thermal)	70 (thermal)	35 - 40 (thermal)	96 (mechanical)

1/ Can be as low as 300 to 500 AF/yr. with dry cooling.
2/ Water used for cooling and receiving power plant.
3/ Thousands short tons/yr.
4/ With electric precipitators, sulfur escapes as SO_2 or remains in ash. Introduction of wet scrubbers would permit recovering of sulfur.

8A.4.2 Potential population growth in the study area from industrial growth possible with 25,000 AF/Yr. additional industrial water

PROCESS	GASIFICATION 375 MMSCFD (2 plants)	LIQUEFACTION 70-150,000 BPD (2 plants)	POWER GENERATION 1,000 MW (2 plants)	SLURRY 17 MILLION TONS (2 systems)
Low estimate, new permanent employment	2,000	2,000	300	100
Induced non-industrial employment 1/	2,000	2,000	300	100
Total new employment	4,000	4,000	300	200
Additional population 2/	12,000	12,000	1,800	600
Low estimate, average temporary construction employment	3,000	3,000	4,000	600
Induced non-construction employment 3/	1,500	1,500	2,000	300
Total new construction related employment	4,500	4,500	6,000	900
Additional population 4/	6,750	6,750	9,000	1,350
All new employment	8,500	8,500	6,600	1,100
All additional population	18,750	18,750	10,800	1,950

1/ Assumes 1 new non-industrial employee per each new industrial employee.
2/ Assumes 3 persons per each new employee.
3/ Assumes 1/2 new non-construction employee per each construction employee.
4/ Assumes 1-1 1/2 persons per each new construction related employee.

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9. <u>The relationship between local short-term use of man's environment and the maintenance and enhancement of long-term productivity - Agricultural use of water</u>

Within the scope of this analysis, the short term is considered as the construction and filling period for the reservoir, and establishment of reasonably successful rehabilitation of disturbed areas. The long-term would include the life of the reservoir, its downstream effect on water, and the effect on the agricultural water use area.

The short-term adverse effect to productivity by construction would be offset by initial positive benefits accrued at the reservoir site when the reservoir is completed and when water is available for agricultural use. These benefits would generally decline at a relatively slow rate over the long-term life of the reservoir. The accumulation of sediments, 4,000 acre-feet in a 50,000 acre-foot reservoir in 100 years, would very gradually reduce the available water in the reservoir. The positive increases in production in the agricultural water use area would have its peak shortly after the increased water becomes available, then a decline, at a rate dependent upon the management of these lands.

9.1 <u>Soils</u>

The effect during the short term would be the loss of soils for vegetative production within the reservoir area. This adverse effect would continue through the long term on 1,160 acres inundated and 40 acres along road relocations.

Through the long term, there would be an initial increased production from the soil in the agricultural water use ărea with a gradual reduction in productivity. At the reservoir site, the rehabilitated

163 acres of soil would gradually increase productivity and return close to original conditions.

9.2 Water resources

The effect during the short term would be an increase in suspended sediments as the result of construction and road relocation activities.

Through the long term, the reservoir would act as a sediment trap, and water released would have a lower concentration of suspended sediment than water under natural flow conditions. The timing and volume control of stream flow would allow the water to be used to increase production in the agricultural water use area. Flooding around Kaycee and the agricultural water use area would be reduced. The peak flow associated with the maximum probable flood would be reduced by 15 percent. Floods of higher frequency would have greater reductions in flood peaks because the reservoir would seldom be completely full.

9.3 Vegetation

The short-term effect would be the loss of 1,160 acres of vegetation in the inundated area, 163 acres in the dam and embankment areas, and 40 acres along road relocation.

In the long term, 163 acres in the dam and embankment areas and 20 acres along road relocation could be rehabilitated to restore a vegetative cover. Complete return to the original composition, especially in the badlands-hillsides, would require many decades. The agricultural water use area is expected to sustain increases in vegetation growth with a peak soon after increased water is available and then a gradual decline. Exceptions would be areas where drainage problems develop, or in dry years when the removal of 28,000 acre-feet (25,000 acre-feet in the original proposal plus 3,000 acre-feet proposed by Fisk, 1974) completely from the system for industrial use could counteract expected results.

Quantification of relative amounts is not possible due to the uncertainties in the project plans. It cannot be said that gain would offset the loss because different geographic areas are involved.

9.4 Wildlife and fish

Over the short term, the wildlife habitat would be disturbed and the wildlife would be displaced into the surrounding terrain.

Through the long term, the displaced wildlife could cause overuse of the surrounding habitat until population level balances with forage. In the long term, 130 deer and 30 turkeys would be lost with unknown numbers of other species. Lake habitat would replace 8.5 miles of stream habitat. The fluctuating water level would limit the quality of the lake habitat. In the agricultural water use area, depending on types of crops grown and their proximity to cover, some benefit may accrue to pheasants, doves, Hungarian partridges, and non-game birds through increased habitat. There could be possible increases in antelope populations. There is a potential for loss to deer and turkey habitat if cover thickets are destroyed in the process of cultivation.

9.5 Cultural resources

If mitigating measures are followed, there could be a short-term gain of scientific information which would not be collected through other research projects at this time. However, an important element of archeological studies are the storehouses of scientific information in its natural, undisturbed form. Future research methods may enable more information to be obtained from the deposits or future research problems may require a different approach to the excavation of a given site. Over the long term, there could be a loss of scientific information.

9.6 Aesthetics

Over both the short and long term, there would be a loss of the existing high-quality scenic resource, primarily the free-flowing stream. In the short term, some of the impacts caused by increased visual contrast due to the project would be mitigated by rehabilitation as discussed under vegetation (9.3) in this section.

Over the long term, scenic quality would vary annually as the water level fluctuated under the proposed operation plan. In the spring of the year when the reservoir was full, scenic quality would be relatively high. As water was withdrawn through the summer months, this scenic quality would degrade due to the greater visual contrast created by increasing mudflat areas at the reservoir edges.

9.7 Recreation

On the short term, there would be adverse impacts or loss of recreational resources and opportunities. On a long-term basis, if and when recreational facilities are developed at and adjacent to the reservoir, beneficial impacts could accrue through the provision of expanded recreation opportunities which would replace those existing opportunities lost on the reservoir site.

As siltation of the reservoir basin occurs (at a rate of 4,000 acre-feet every 100 years), there would be a gradual decrease in quality and quantity of recreation opportunities available over the long term. Fishing opportunities would be affected most significantly.

Assuming constant annual water withdrawals as the reservoir bottom raised, capacity of the reservoir would be reduced, thus reducing the annual average minimum pool. This situation would result eventually (approximately 1,000 years which, may be beyond the life of the reservoir) in a minimum capacity too small to sustain fish life (approximately 10,000 acre-feet). The same situation would eventually occur, probably at a later date, for boat-oriented recreation opportunities as water depth becomes gradually shallower.

Due to the nature of the recreation resources provided by the reservoir, a change from the existing extensive recreation use of the site to intensive recreation use patterns would occur. This pattern could be expected to continue, at least in part, over the long term.

9.8 Agriculture

In the long term, due to the impact of the reservoir, it is estimated that the eight ranch units involved would sustain reduction in carrying capacity of from 900 to 1,000 animal units. However, an added 8,000 acre-feet per year of irrigation water on a permanent basis to 5,479 acres in another area can be expected to increase agricultural production substantially, but to an unknown amount due to uncertainties in the project plans. It is anticipated that a net increase in agricultural production over the long term will result from the project.

9.9 Socio-economic conditions

Evaluation of social and economic effects, both short and long term, is extremely difficult because it depends primarily upon the personal values of the observer. For that same reason, distinguishing local from regional effects is difficult, as is separating effects related to a given project from cumulative effects anticipated for a region. It seems reasonable to expect local effects of construction and operation of the reservoir to be similar to the effects anticipated in the region. These include, in the short term: additional employment; higher incomes; increased use of all public facilities, with some crowding; some evidence of a transient attitude on the part of new arrivals; some conflict between old and new attitudes and life styles. In the long term, conditions should stabilize and additional population may provide the basis for expanded and more varied services, such as broader education programs and specialized medical facilities and staffs. It should be noted, however, that the order of magnitude and the timing of anticipated effects related to the reservoir will in all probability be quite different and all social systems will not be equally impacted in the short term or "benefit" equally in the long term.

9A. The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity - Assumed industrial use of water

The construction and operation of the two gasification plants in the study area will likely be a part of a larger industrial growth occurring throughout the Eastern Powder River Basin, producing a region completely different from that existing at present. Industrial history suggests that changes will develop over time and will be very long term--for practical purposes, permanent. Production volume, technology development, and economies to be realised from large-scale and long-term operations all support this conclusion. At present, the basin is typical of the rural west. Livestock ranching is both the predominant industry and way of life. Limited oil and coal development have not yet changed that. Population is low, and outside Gillette and Douglas, it is sparsely distributed. The land is essentially wild with man's presence apparent only through a few primitive roads, grazing livestock, and fences to control the stock.

Both short-term and long-term development and use of regional resources will change long-term productivity of the basin. From a typical western ranching area, it will be transformed into an industrialized region with mining of coal and its utilization becoming the dominant industry and financial foundation. Man's presence will be abundantly evident. From development of the two gasification plants alone, some 810,000,000 tons of coal and 850,000 acre-feet of water will be consumed over the thirty-year life of the plants. Some 18,750 people will move into the area in association with the gasification development, yielding a higher average income and tax base and bringing new values and ideas into the area.

The short-term uses of the environment versus the maintenance or enhancement of long-term productivity is discussed by resource in this section. The short-term period--five years--is the period of construction and establishment of the plants, access, and increased population. The long-term time span--thirty plus years--will be the full operational life of the plants to the point where plants are shutdown and rehabilitation efforts--mitigation--are complete.

9A.1 Climate

Over the short term, climate will be subjected to high levels of dust and vehicular emissions, but these will tend to be only in small, localized areas. In the long term, and in conjuction with simultaneous development in the area, the climate will be exposed to increased loads of dust, noxious gases, water vapor, and local heating. Studies have inferred that large-scale alteration of dust loading and earth-atmospheric energy balance may contribute to creation of drought conditions in semi-arid climates (Charlson and Pilat, 1969; Bryson, 1972; Mitchell, 1971; Hugg and Changon, 1973). Precipitation could well decrease in the study area, decreasing productivity in resources where rainfall is critical.

9A.2 Air quality

In the short term, quality of the air will be decreased locally due to heavy dust and vehicle emissions in construction and population growth areas. Over the operational life of the plants, emissions of particulate matter, noxious gases, and hydrocarbons--in addition to possible unspecifiable trace emissions from the two gasification plants and other industrial operations in the area--will decrease the quality of the ambient air. Much of the emissions will be dispersed to the south and east, possibly causing the worst deterioration in this area. Lowered air quality may decrease productivity of vegetation and animal life, thereby decreasing agricultural and recreation activity. Decreased air quality may lower the aesthetic value of the region and may even change land uses.

9A.3 Topography

Two thousand acres for plant sites, two thousand more to support population growth, and five acres/mile for access systems will undergo considerable alteration of topography during the short term. Altered topography and loose materials will be conducive to erosion, yielding a higher sediment loading in adjacent drainages. However, as mitigation is employed and a somewhat natural topography and ground cover is reasserted, erosion will subside. Some drainages may be diverted from their original courses but will also reestablish as the topographical damage is mitigated. By the end of the long-term period, the industrial development will move out and the sites and rights-of-way will be established in some form of natural topography, though not necessarily the topography there originally.

9A.4 Soils

All the acreage disturbed by construction activities--plant sites, population increase and access systems--will have the topsoil altered. Soils will be stripped from the ground and stockpiled to be used in rehabilitation efforts. With the soil protection removed, erosion potential is increased, yielding a likely higher sediment load in adjacent drainages. Soils will be reestablished as the disturbed areas are rehabilitated. However, in semiarid climates, the development of soil is a slow process. The development may be further slowed by the possible change in climate, yielding less precipitation. A long-term loss in soil productivity will occur where soil has been disturbed, causing the land to be less productive for vegetation and animal life, and hence less useful for agriculture or recreation.

9A.5 Minerals

Over the short term, most of the mineral usage will be construction materials--sand, gravel, limestone, etc. As construction is carried out, conflicts with other mineral operations--oil and gas, uranium, etc.--may arise. But in the long term, mineral productivity should increase. Coal reserves will be developed and exploited to provide feed for the gasification plants. Mineral conflicts should be resolved. Generally, as the entire area undergoes the projected development, mineral productivity will be pushed as an incentive to industrial growth.

9A.6 Water

The short term period will have some effect on surface water, although likely only in localized areas. There would be increased erosion from disturbed acreage, with a possible diversion or blockage of drainages. Water use would not be as high as later, only construction and population increase supplies are required in the short term. After the plants have operated 30 years, they will have consumed 750,000 acre-feet of water. Population increase will account for an additional 90,000 acre-feet in that period. Water quality will likely be reduced and water which might have been used for other water requiring production--vegetation, fish and wildlife, recreation, and agriculture--will instead be consumed by industrial development. Productivity of at least some of these other resources will drop, a productivity drop which could be deepened further by a decline in area precipitation.

9A.7 Vegetation

Two thousand acres for plant sites, two thousand for community development, and approximately five acres per mile of access system will be disturbed during construction. Much of the vegetation on this acreage will be destroyed, increasing erosion potential and raising sediment loads in adjacent drainages. Over the long term, vegetation will be reestablished, but it will take fifty or more years for a natural plant succession to be reinstated. This reestablish could be further slowed by a decrease in precipitation due to climate change and decrease in air quality due to industrial development. Some "off-site" vegetation may be destroyed or impaired by salt drift, coating or other emissions from the industrial areas. Other vegetation may be destroyed by increased recreational use of area lands. Vegetative productivity will be reduced in the long term, causing decreased wildlife, and agricultural productivity, and making soils more susceptible to erosion. Vegetative productivity loss may impair aesthetic and recreational values.

9A.8 Fish and Wildlife

During construction, over 4,000 acres of wildlife habitat will be taken out of availability. Some animals may be directly destroyed, others will be forced to compete to survive in neighboring habitats. Not only will some acreage be removed as habitat, but neighboring areas may become undesirable as habitat owing to increased human activities, noise, and dust. As some of the lands are rehabilitated, more habitat may again become available, and wildlife populations can increase to fill this new habitat. In the long term, the population of the area will increase, requiring increased recreation and transportation facilities. More fences will be built and access systems will also hinder natural animal movement. Less water will be available to fish and wildlife, owing to increased industrial use. Likely there will be decreased productivity of vegetation, leaving less forage for wildlife. Fish and wildlife productivity will decrease, possibly reducing aesthetic and recreation values in the area.

9A.9 Cultural resources

If proper mitigation is employed, construction sites will be properly surveyed for historic and prehistoric values. These will be removed and preserved, thus construction will promote cultural resource evaluations in the area. In some cases, however, it may be undesirable to move cultural values from their site of origin, but this may be required to avoid destruction during construction. In the long term, historical areas in the region may be impaired by the proximity of industrial development, the scenic and interest value of the site being reduced. With increased population in the area, damage to historic and prehistoric artifacts could result from recreation use. Amateur archeologists and souvenir hunters may disturb valuable sites. Over the life of the project, cultural resource "productivity" in the area could well decline.

9A.10 Aesthetics

Locally within the area, the aesthetic values will be decreased by construction activity--noise and dust, traffic congestion, and large influxes of construction labor. As the plants operate, along with the other industrial development in the area, aesthetic values in the area will decline. The visual presence of plants, communities, and access systems will contrast with the "wide open spaces" now prevalent. Air and water quality will be reduced; vegetation and wildlife productivity will be reduced; traditional recreation activities may be unavailable. As far as the tourist industry is concerned, the area may become more of a place to get away from than a place to get away to.

9A.11 Recreation resources

In the short term, the recreation resources on over 4,000 acres will be taken out of production. Also, recreation sites near the construction may become undesirable due to limited access, traffic congestion, noise, and dust. As time goes by, some of the construction area will be rehabilitated, perhaps making more recreation areas available. However, more recreation will be required for the increased population. Less water will be available for recreation purposes, owing to increased industrial development need. Private land once open to some of the public may be closed. The scenic values in the area will be impaired. Depending on company and community actions to mitigate recreation area loss and increased demand, recreation resource productivity may either increase or decrease. Much can be done to increase recreation potential, but if no effort is made, recreation resource productivity will suffer.

9A.12 Agriculture

During construction, agricultural production on over 4,000 acres will be disrupted. Also, neighboring agricultural operations may be impaired by dust on crops and danger to animals from increased traffic and construction activities. As the construction areas are rehabilitated, some areas may be returned to agricultural use. However, it is likely agricultural production will be decreased in the long term. Less water will be available, owing to both alternate industrial uses of existing water and a possible decrease in precipitation from climatic changes. Increased population may cause agricultural loss due to hunters and hikers, vandals, off-road vehicle use, and other possible harassment of stock or damage to crops. Fences, built around industrial, community, and access route sites may cause increased stock losses in severe weather.

Agricultural productivity could also be aided in the long term. With increased population and industry, agricultural product processors may move into the area, thereby bringing farmers and ranchers closer to markets, cutting transportation costs and raising unit returns on products.

9A.13 Transportation

In the short term, existing transportation systems will be adversely effected by construction activities. As access systems are built, they will cross existing transportation arteries, yielding traffic congestion and safety hazards. More traffic will be encountered on the transportation networks due to influxes of construction workers. However, as industrial development steadies in the operational phase, new transportation networks will be built or existing facilities will be upgraded. There will be increased traffic throughout the area, but improved networks should alleviate this somewhat. Transportation systems will improve, thus increasing "productivity," but the increased traffic will be a danger to wildlife, livestock, and human beings, in addition to reducing air quality, decreasing aesthetic values, and adding noise. Better transportation will make cultural and recreational resource areas more accessable and possibly open land to uses not previously possible due to its inaccessable nature.

9A.14 Land use

As the gasification plants and associated facilities are built, land use planning and zoning contingencies in the area will be placed under intensive pressure. Development will proceed quickly, and planning efforts may not be able to keep pace. Land use conflicts may arise between developers and residents. With implementation of long-term planning systems and better coordination between different planning groups and the public, good land use decisions can be made, thereby resolving land use conflicts as they arise. Land use productivity can be enhanced through the need and establishment of better planning, and land use decisions can be made in the best interests of all people involved.

9A.15 Socio-economic conditions

In the short term, all public facilities will be overcrowded or overloaded and the population, particularly previous residents, will suffer. Schools face overcrowded conditions and possibly double sessions. Bussing to less crowded areas may be necessary, and there may be difficulty in recruiting teachers. Health facilities and personnel probably will also be overtaxed in the short term. Water and sewer systems and police and fire departments of both Gillette and Douglas must be expanded to serve expected populations. In the short term, all these constitute a hardship on the persons involved in growth. However, as facilities catch up to the population, more and better services should be available to all. The larger population will be able to support a larger educational system that can offer a greater variety of instruction more nearly meeting needs of more pupils. Similarly, a large population can support hospitals with more complete facilities and a more varied and specialized medical staff. Not so easily assessed is the change in life styles that will accompany development. In the short term, a conflict between old and new can be expected. A transient attitude can be expected of much of the population, particularly during construction. Accompanying this will be much that goes with a "boom town" attitude. In the long term, these factors will develop into a mixing and integration of life styles. New types of people will contribute to a "cultural diffusion" within the community group and a new "community" will result. As stated earlier, evaluation of many social and economic effects, both short term and long, depends a great deal on the personal value systems of the observer. Development of two gasification plants and associated systems will provide some 8,500 new jobs in the region. In addition to more jobs, average income is expected to rise substantially. Coupled with local expenditures by industry, the net result will be a major increase in regional income, yielding a larger tax base and, therefore, a foundation for community growth.

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10. Irreversible and irretrievable commitments of resources - Agricultural use of water

For the purposes of the statement, an irreversible commitment means that once initiated, use of the resource would continue. An irretrievable commitment means that once used, the resource is not replaceable.

10.1 Soils

One thousand two hundred acres of soil suitable for vegetative production would be lost - 1,160 by inundation, 20 covered by blacktop surfacing on proposed road relocation, and another 20 disturbed along road relocation.

10.2 Water resources

An estimated average of 2,350 acre-feet, which would be available under natural flow conditions, would be lost through reservoir evaporation. Although reservoir evaporation is theoretically controllable with evaporation retardants, their use has been limited by practical considerations (such as wind effects and interruption of air-water gas exchange and cost).

10.3 Vegetation

One thousand three hundred sixty three acres of vegetation would be lost - 1,160 acres in the area of inundation, 163 acres in the dam and embankment areas, and 40 acres along road relocation. Portions of 203 acres could be rehabilitated. However, it is felt that it may be impossible to achieve the original situation in rehabilitated areas and thus the commitment is irretrievable to a certain extent.

10.4 Wildlife and fish

One thousand one hundred sixty acres of excellent habitat, 130-head herd of deer, 30 turkeys, unknown numbers of fur bearers, rabbits, non-game mammals, amphibians, and reptiles; conversion of terrestrial habitat to an aquatic environment; and 6.5 miles and 2 miles of free-flowing stream on the Middle Fork and Beaver Creek, respectively, and the stream-type fishery they provide would be lost.

10.5 Cultural resources

All cultural resources are non-renewable portions of the human environment; any disturbance or destruction of these values are irreversible commitments of the resource. Scientific excavations can attempt to mitigate the loss involved in the destruction of any cultural resource; however, excavation is also an irreversible commitment.

Since any cultural resource cannot be duplicated, proper archeological technique requires at least half a site be left in place as a storehouse of basic scientific data in an undisturbed form. Future research methods may enable more information to be obtained from the deposits or future research problems may require a different approach to the excavation of a given site.

10.6 Aesthetics

The basic scenic character of the reservoir would be totally altered through changes in naturally existing scenic components: line, form, texture, color, and scale of scenic features.

Aesthetic resource losses of a permanent nature involve loss of the existing free-flowing stream and the associated scenic and aesthetic qualities of that stream. The impoundment of a stream or river is felt by many to be one of the most serious irreversible interventions that man can make on an ecosystem. No list of environmental impacts can capture the full loss when a previously undeveloped stream is dammed.

It must also be considered that this stream is one of a diminishing number which are free-flowing.

10.7 Recreation

There would be losses for the life of the reservoir of certain of the existing recreation resources in the reservoir area, including the loss of hunting and observation opportunities associated with white tail deer and turkeys; cultural resources, particularly prehistoric, some of which possess good interpretive potential for recreation and education; and both fishing and sightseeing opportunity.

10.8 Agriculture

An estimated 900 to 1,000 animal units would be lost from the carrying capacity of the ranches involved at the reservoir site. This might not be felt completely by the ranchers themselves, because the compensation would presumably enable them to replace the carrying capacity from elsewhere; however, the commitment of the resource on the land involved would still be present.

10A. Irreversible and irretrievable commitment of resources - Assumed industrial use of water

The assumed industrial development (two coal gasification plants and related developments) would result in irreversible and irretrievable commitments of certain resources.

10A.1 Air

The two gasification plants would consume approximately 7.5 million tons of oxygen (O_2) per year from the air.

The quality of the ambient air would be subjected to emissions of 16,000 tons/year of sulfur dioxide (SO_2), 24,000 tons/year of nitrogen oxides (NO_x), and 3,600 tons/year of particulates.

10A.2 Land

There would be an irreversible commitment of approximately 2,000 acres of land for the two plant sites. This would be true at least for the life of the projects which is assumed to be 30 years.

Approximately 2,000 acres would be committed to supporting the needs of the increased population for housing and service facilities.

Other major commitments of land use would be the land area required for the related transportation facilities. As the lineal distance of these systems is unknown an acreage cannot be determined.

10A.3 Water

Water consumed by the two gasification plants would represent, at least for the assumed 30-year life of the project, an irretrievable committtment of approximately 25,000 acre-feet per year.

Water required by the increased population would represent an irretrievable commitment of approximately 3,000 acre-feet per year.

10A.4 Other resource committments

10A.4.1 Mineral resources

The major irretrievable commitment of mineral resources would be the consumption of 27 million tons of coal per year by the two coal gasification plants.

Large amounts of aggregate, fill material, cement, and other materials will be irretrievably committed to construction of facilities.

Undetermined amounts of energy and energy fuels will be consumed by construction and operation equipment.

In addition, there is a possibility of some mineral resource commitment if permanent facilities are built on the mineral deposits.

10A.4.2 Cultural resources

All cultural resources are nonrenewable portions of the human environment; any disturbance or destruction of these values are irreversible and irretrievable commitments of the resource. Scientific excavations can attempt to mitigate the loss involved in the destruction of any cultural resource; however, excavation is also an irreversible commitment since the finds are removed from their natural setting.

The extent to which destruction of the cultural resource will occur is not known. However, any destruction of cultural resources will represent irreversible and irretrievable commitments of that resource.

10A.4.3 Loss of production

As described earlier, a total of approximately 4,000 acres would be taken out of present production to accommodate the two plant sites and the population growth. In addition, an undetermined acreage would be taken out of present production for transportation facilities. Loss of the present production would represent an irreversible commitment.

Productivity most likely to be affected would be soil productivity on disturbed areas and areas for permanent facilities. Wildlife habitat and grazing lands would be lost on the above acreages.

10A.4.4 Loss of life

Fatal accidents will occur which are related directly to the physical activity of industrial development and are considered on-the-job accidents. Secondary, however, will be a variety of occurrences which will be fatal to human life which occur not because of direct industrial activity, but as a result of increased human interaction from population increases. Historical trends for all types of on-the-job fatalities could be cited as they could for a multitude of other fatal occurrences. The point is not so much how many will occur, because projected future fatality rates are at best speculative, but that they historically do occur and they will contine to occur as a result of industrial development. An unquestionably irreversible and irretrievable commitment of human resources will be lost due to construction accidents, traffic accidents, murders, and suicides. Regardless of the impetus or fault of any of these, they are all irreplaceable losses and there will be more of them than previously occurred.

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11. Consultation and coordination

Numerous federal, state, local entities and agencies, and others have assisted the Bureau of Land Management in various ways in preparation of this draft Environmental Impact Statement. This assistance has ranged from active participation in study and consultation through review of reports. Basic data, information, services, and suggestions were provided by many sources. Individuals, agencies, and other entities directly and indirectly involved in development of this document are listed below, with particular involvement noted.

11.1 Within BLM

The Casper, Wyoming, District Office of the Bureau of Land Management had lead responsibility in the preparation of the Middle Fork Reservoir Environmental Impact Statement. The EIS team consisted of specialists in the fields of hydrology, soils, recreation, wildlife biology, archeology, range, economics and planning, and geology.

One hydrologist and the soils specialist were detailed to the District temporarily from the BLM State Office in Cheyenne. Other BLM State Office personnel consulted were specialists in recreation, planning, archeology, and cartography. Personnel from the Denver Service Center of the BLM were also consulted.

11.2 Other federal agencies consulted

Soil Conservation Service was consulted about soil types on both the reservoir site and the agricultural use area. They assisted on-the-ground investigations on irrigated land involved.

U.S. Bureau of Reclamation's reports on this proposed reservoir were extensively used and they were consulted about the interpretation of these reports.

U.S. Geological Survey provided information of the geology of the reservoir site and the agricultural water use area.

The U.S. Fish and Wildlife Service is updating their report pursuant to the Fish and Wildlife Coordination Act and their recommendations should be available for inclusion in the final environmental impact statement.

Office of Coal Research was consulted concerning the probability of coal conversion processes and detailing these methods.

Residents Advisory Council on Historic Preservation has been requested to review and comment on the preliminary case report on the reservoir project according to the National Historic Preservation Act.

11.2 Other federal agencies consulted (continued)

Northern Great Plains Resource Program were consulted about probabilities of developments using quantities of industrial water. Data interpretations were requested on their published reports.

Environmental Protection Agency assistance was requested on the applicability of laws they administer that concern air and water quality. They were also asked for data on emissions of heavy equipment.

Energy Research and Development Administration provided frameworks for determining industrial energy alternatives.

11.3 State and local

State of Wyoming, Department of Economic Planning and Development were consulted on industrial development projections, support services and resultant population increases in the project area.

University of Wyoming provided assistance in various departments on data needs and interpretations of information they have published.

Wyoming Game and Fish Commission participated on two separate inputs for the proposed reservoir project. They first assisted us in gathering and interpreting wildlife data for the project and, second, assisted the U.S. Fish and Wildlife in accordance with the Fish and Wildlife Coordination Act.

Denver University, Denver Research Institute were consulted on the interpretation of their reports and work on the Powder River Basin on roads which will be involved in the project.

Wyoming State Highway Department provided standards for secondary roads which will be involved in the project.

Wyoming State Engineer's Office was consulted on status of water rights involved in the proposed project and interpretation of Wyoming Water Law.

Wyoming Recreation Commission, Historic Preservation Office and State Archeologist assisted in three areas. The Recreation Commission assisted on visitor use projections. The Historic Preservation Office reviewed the planning case report as part of the statement for the National Historic and Preservation Act which is included in this statement. The State Archeologist assisted with on-the-ground investigation, reviews and interpretation of data. Inventories for cultural resources were provided for review by these agencies.

11.4 Private

J. T. Banner & Associates of Laramie, Wyoming were the prime engineering contractor for the reservoir. They were frequently consulted on all engineering phases of the project.

Powder River Reservoir Corporation of Kaycee, Wyoming provided specific information on the agricultural water use area and a broad range of information on the entire project.

Energy Transportation Systems, Inc. of Casper, Wyoming provided information of industrial probabilities of coal conversion.

Kirven & Hill, Attorneys-at-Law, of Buffalo, Wyoming were consulted on a broad range of questions on the project.

C. Fisk, Consulting Engineer, Denver, Colorado assisted on water law and proposed transfers of water rights affecting the project.

Paul A. Richard, Consulting Engineer, provided detail on the operational plan for the reservoir.

Sterns-Roger, Inc., Rapid City, Dakota were consulted on coal gasification process.

Consolidation Coal Company, Rapid City, South Dakota were consulted on coal gasification process.

11.5 Distribution

Copies have been sent to the following for review:

Environmental Protection Agency
U.S. Fish & Wildlife Service
Bureau of Outdoor Recreation
Department of Agriculture
Department of the Interior
Soil Conservation Service
Army Corps of Engineers
Water Resources Council
River Basin Commissions
National Park Service
Federal Power Commission
Bureau of Mines
Department of Transportation
Interstate Commerce Commission
Department of Labor
Department of Housing and Urban Development
Agricultural Stabilization and Conservation Service
Bureau of Outdoor Recreation
Department of Health, Education, and Welfare
Water Resources Council
Advisory Council on Historical Preservation
Energy Research and Development Administration

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APPENDIX 13.1

Soil Series Descriptions

Barnum series. The Barnum series consists of nearly level, well-drained soils. These soils formed in reddish-colored alluvium on flood plains. They are mainly along the Red Fork of Powder River, Beaver Creek, and Buffalo Creek in the Barnum area; along the North Fork of Powder River and along the Middle Fork of Powder River above Kaycee. Slopes range from 0 to 3 percent. Elevations range from 5,000 to 5,500 feet. The average annual precipitation is 12 to 13 inches, the average annual soil temperature is about 50¼ F., and the frost-free season is 100 to 105 days. The vegetation is basin wildrye and western wheatgrass.

In a representative profile, the surface layer is reddish-brown, moderately alkaline, very fine sandy loam about 4 inches thick. The underlying material is reddish-brown, moderately alkaline loam that is stratified with thin lenses of fine sandy loam or clay loam. This material reaches to a depth of 60 inches or more.

Permeability is moderate, and the available water capacity is high. The effective rooting depth is 60 inches or more. The seasonal high water table is below a depth of 40 inches.

These soils are used for range; for irrigated hay, pasture, and small grain; and as wildlife habitat.

Representative profile of Barnum very fine sandy loam, in an area of Barnum-Redbank association, in the NW 1/4 NE 1/4, Section 6, T. 41 N., R. 83 W.

A1. 0 to 5 inches, light brownish-gray (2.5Y 6/2) loam, light olive brown (2.5Y 5/4) moist; weak, medium crumb structure; slightly hard, friable; many roots; strong effervescence; moderately alkaline; clear, smooth boundary.

Ac. 5 to 18 inches, pale-yellow (2.5Y 5/4) silt loam, light olive brown (2.5Y 5/4) moist; weak, coarse, angular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few roots; strong effervescence; moderately alkaline; clear, smooth boundary.

Cca. 18 to 60 inches, pale-yellow (2.5Y 7/4) silt loam, light olive brown (2.5Y 5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; many nodules of precipitated carbonates on ped faces and in pores; strong effervescence; moderately alkaline.

These soils generally are calcareous to the surface, but in places they are noncalcareous in the uppermost 2 to 4 inches. Content of coarse fragments ranges from 0 to 15 percent but typically is less than 10 percent. The C horizon generally has some visible secondary calcium carbonate, but it does not consistently have secondary carbonate accumulation.

The A horizon ranges from 10YR to 5Y in hue, is 5 or 6 in value when dry and 4 or 5 when moist, and ranges from 2 to 4 in chroma when dry or moist. It is mildly alkaline or moderately alkaline.

The C horizon ranges from 10YR to 5Y in hue, ranges from 5 to 7 in value when dry and from 4 to 6 when moist, and ranges from 3 to 5 in chroma when dry or moist. It is moderately alkaline or strongly silt loam, loam, or clay loam.

Limon series. The Limon series consists of nearly level to moderately steep, well-drained soils. These soils formed in fine-textured alluvium on alluvial fans and foot slopes. Slopes range from 0 to 20 percent. Elevations range from 4,500 to 5,200 feet. The average annual precipitation is 11 to 12 inches, the average annual soil temperature is about 53¼ F., and the frost-free season is 100 to 105 days. The vegetation is western wheatgrass and big sagebrush.

In a representative profile the surface layer is light-gray, moderately alkaline silty clay about 4 inches thick. The underlying layer is light yellowish-brown or pale-yellow, strongly alkaline silty clay that reaches to a depth of 60 inches or more.

Permeability is slow, and the available water capacity is high. The effective rooting depth is 60 inches or more.

These soils are used for range; for irrigated hay, pasture, and small grain; and for limited dry farming.

Representative profile of Limon silty clay, in an area of Limin-Cadoma association, in the NE 1/4 SW 1/4, Section 17, T. 45 N., R. 80 W.

A1. 0 to 4 inches, light-gray (2.5Y 7/2) silty clay, light olive brown (2.5Y 5/4) moist; strong, fine, granular structure; hard, firm, sticky and plastic; many roots; moderately alkaline; abrupt, smooth boundary.

C1. 4 to 17 inches, light yellowish-brown (2.5Y 6/4) silty clay, light olive brown (2.5Y 5/4) moist; weak, medium, subangular blocky structure; hard, firm, and plastic; many roots in upper 4 inches, few roots below; strong effervescence; strongly alkaline; clear, smooth boundary.

C2. 17 to 28 inches, light yellowish-brown (2.5Y 6/4) silty clay, light olive brown (2.5Y 5/4) moist; weak, medium subangular blocky structure; hard, firm, sticky and plastic; strong effervescence; strongly alkaline; clear, smooth boundary.

C3ca. 28 to 60 inches, pale-yellow (2.5Y 7/4) silty clay, light yellowish brown (2.5Y 6/4) moist; massive; hard, friable, slightly sticky and slightly plastic; many splotches of carbonates; violent effervescence; strongly alkaline.

Content of coarse fragments ranges from 0 to 15 percent but typically is less than 5 percent. The A and C horizons are moderately alkaline or strongly alkaline.

The A1 horizon ranges from 5Y to 10YR in hue, is 5 to 7 in value when dry and 4 or 5 when moist, and ranges from 2 to 4 in chroma when dry or moist.

The C horizon ranges from 10YR to 5Y in hue, ranges from 5 to 7 in value when dry and is 5 or 6 when moist, and ranges from 2 to 4 in chroma when dry or moist. It is mainly silty clay loam or silty clay and has a clay content of 35 to 50 percent. In some profiles the lower part of the C horizon is clay loam that is 30 to 34 percent clay.

APPENDIX 13.2

Summary of Regulations

Affecting Cultural Resources

The legislature and administrative authorities and obligations for cultural resources on any federally approved right-of-way and resulting project are stated in the Antiquities Act of 1906 (34 Stat. 225), Historic Sites Act, 1935 (49 Stat. 666), Wyoming Antiquities Act, 1957 (Sections 36-11 to 56-13 and 18-330, 7 W.S. 1957), Reservoir Salvage Act, 1960 (74 Stat. 220), National Historic Preservation Act, 1966 (80 Stat. 915), National Environmental Policy Act, 1969 (83 Stat. 852), Executive Order 11593, May 13, 1971 (36 FR 8921), and the Amendment to Reservoir Salvage Act. (Archeological and Historic Preservation Act of 1974) (88 Stat. 174).

The Antiquities Act of 1906 has provisions for fines and/or imprisonment of 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. Provisions are made for the issuance of a permit (Antiquities Act Permit) to reputable museums, universities, colleges, or other recognized scientific or educational institution, but not to any individual, for the excavation of sites or the gathering of objects of antiquity. The permit is made with the view to increasing the knowledge of such objects and preserving such objects in public museums.

Historic Sites Act, 1935 states 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.

The Wyoming Antiquities Act, 1957 requires a permit from the State Board of Land Commissioners be obtained before any excavation on any prehistoric ruin, pictographs, hieroglyphics, or any other ancient markings or writings, or archaeological and paleontological deposits in the State of Wyoming on any State lands. The State Board of Land Commissioners is authorized to promulgate and enforce such regulations as it may deem needful to protect from vandalism or injury the prehistoric ruins, relics, archeological and paleontological deposits of the State. Violators of this act would be punished by fine and/or imprisonment.

The Reservoir Salvage Act, 1960, as amended by the 1974 Act provides for the preservation of historical and archeological data (including relics and specimens) which might otherwise be irreparably lost or destroyed as the result of flooding, building access roads, erection of workmen's communities, relocation of railroads and highways, and other alteration of the terrain caused by the construction of a dam by any agency of the Federal Government or by any private person or corporation holding a license issued by any such agency. Under this act the Secretary of Interior is to be given written notice of the proposed reservoir. When construction of a reservoir may cause irrevocable loss or destruction of significant scientific, prehistorical, historical, or archeological data, the licensing agency shall notify the Secretary of Interior of such values. After notification the Secretary of Interior may conduct, or cause to be conducted, investigation of the areas which are or may be affected by the project when in his opinion the investigations are not being conducted. The goal of these investigations is to recover and preserve cultural resources in the public interest.

In order to accomplish the national goal of historic preservation the National Historic Preservation Act provided for three significant innovations: an expanded National Register of Historic Places, a program of grants-in-aid for historic preservation, and in Section 106 an Advisory Council on Historic Preservation empowered to comment upon all undertakings licensed, assisted, or carried out by the Federal Government that have an effect upon properties in the National Register. The expanded National Register allows sites of national, state, and local significance to be nominated for placement in the National Register. Procedures established in accordance with Section 106 require a written submission to the Advisory Council on Historic Preservation for review and comment of all plans which would affect National Register sites.

One goal of the National Environmental Policy Act is to preserve important historic, cultural, and natural aspects of our national heritage. Section 102 requires an Environmental Impact Statement for federal actions which would significantly affect the quality of the human environment. Each environmental impact statement includes a discussion of cultural resources.

Executive Order 11593 was signed May 13, 1971 with the purpose of implementing and furthering the policies of the National Environmental Policy Act, National Historic Preservation Act, Historic Sites Act, and the Antiquities Act. This order instituted procedures to assure that federal plans and programs contribute to the preservation and enhancement of non-federally and federally owned sites, structures, and objects of historic, architectural, or archeological significance.

APPENDIX 13.3

Aesthetic Impacts of Reservoir Fluctuation

In the spring, a large body of water would provide a pleasing contrast against the lush green of spring vegetation and the vivid reds of rock escarpments. As summer progressed, greater amounts of water would be drawn off the reservoir to meet increasing irrigation needs as well as a fairly constant industrial commitment. There is the possibility however, that there could be a time lag of several years before the industrial water allocation is utilized. In this situation, the reservoir water levels would be higher than indicated in the following discussion, unless that allocation is sold by industry for some other purpose.

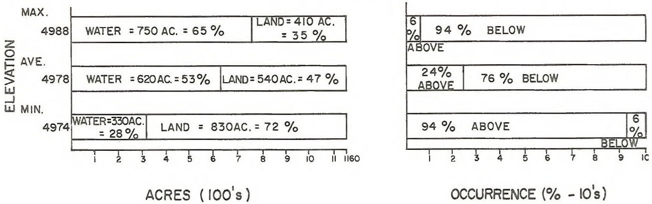
Under normal operating conditions based on the eighteen year historical record (1951-1968) the reservoir level would be drawn down to an end-of-August average elevation of 4,979', a vertical drop of thirty-four feet below normal high water line (5,013'). This would result in 520 acres or 45% of the reservoir site being exposed above the water level. Drawdowns of this magnitude would result in extensive areas of barren ground, creating extreme visual contrast and thus constituting a negative scenic impact. The worst situation which could occur would be that experienced in an extremely dry year if the reservoir pool is drawn down to the dead storage level at the outlet works (4,930'). Although it is unlikely that this would happen (the lowest elevation reached under the proposed operation based on historic flows would be 4,950'), such a condition would result in a water surface of only 140 acres, leaving 1,020 acres of dry land exposed; 88% of the total pool area. The lowest annual levels would be reached between January and April, the period of lowest flows. Based on the historic record, the lowest average level would be 4,978' resulting in a pool of 620 acres or 53% of total surface area.

Figure 13.3-A is provided to graphically depict the relationship between water level elevations, water surface, land surface exposed, and the relative frequency with which the reservoir pool can be expected to be above and below the given elevations under the proposed operation. This information is based on the historic flow data and other information provided by J. T. Banner & Associates. The data in these graphs are presented on a monthly basis with the dates January 31, May 31, August 31, and October 31 selected for illustration purposes. For each date the actual maximum, average, and minimum elevations are given for the 18-year period of record. The left hand graphs depict the acreage of the reservoir pool and the acreage of exposed land from water's edge to the normal high water line for each of the maximum, average, and minimum elevations on the selected dates. The right hand graphs depict the frequency with which these elevations can be expected to be reached over an extended period of years. For example, at the end of any given January, on the average, the reservoir pool would be at elevation 4,978', resulting in a pool surface area of 620 acres (53% of the total pool at normal high water line) and 540 acres of land exposed to view which was previously under water. The probability that the pool would be at that elevation at the end of any January is given in percentages of occurrence frequency. The pool would be above this level 24% of the time on this date (1 our of 4 years), and below this level 76% of the time (3 out of 4 years). Maximum and minimum elevations are given to

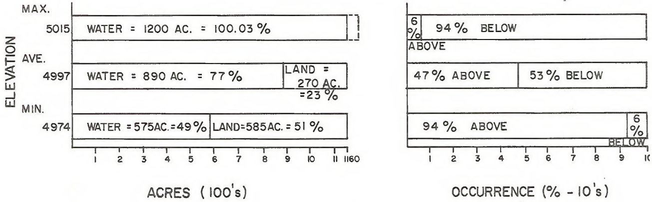
Figure 13.3 - A

RESERVOIR AREA AND FEQUENCY OF OCCURENCE

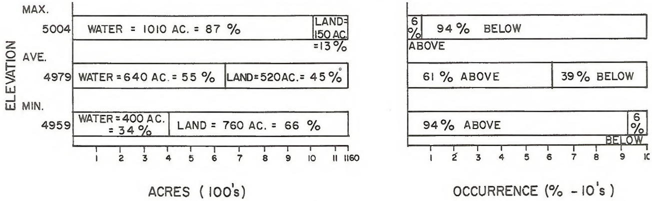
JANUARY 31



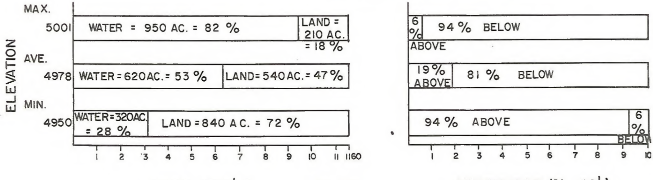
MAY 31



AUGUST 31



OCTOBER 31



illustrate the historic range of pool levels for the given dates and their frequency of occurrence.

APPENDIX 13.4

Land Status Map

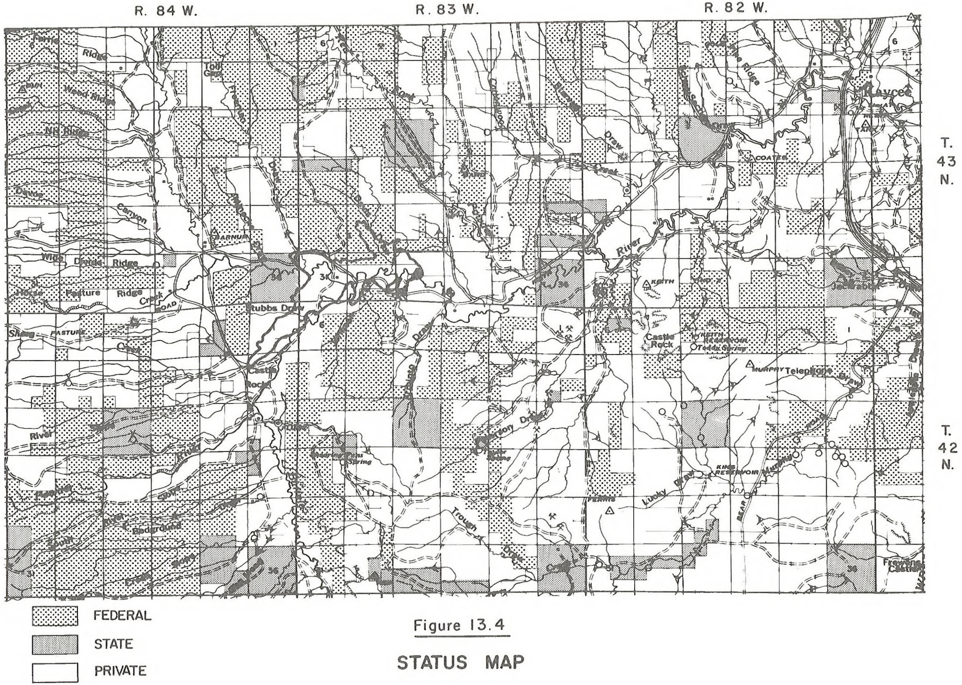


Figure 13.4

STATUS MAP

APPENDIX 13.5

Correspondence from

Carter Oil Company and Atlantic Richfield

THE CARTER OIL COMPANY

HOUSTON, TEXAS 77001

RUSSELL C. CURTIS
SENIOR VICE PRESIDENT
SYNTHETICS

POST OFFICE BOX 2180

June 19, 1975

Middle Fork Dam Water Use

Mr. Daniel P. Baker
State Director
Bureau of Land Management
P. O. Box 1828
Cheyenne, WY 82001

Dear Mr. Baker:

We have received a copy of your letter to the Powder River Reservoir Corporation of June 5, 1975, in which you requested information about the planned end use of the water in the proposed reservoir. As you know the water from the dam and our coal reserves in Wyoming assure the raw material supply for a coal conversion plant in that area.

In our letter to you on July 29, 1974, we explained that a task force was studying the feasibility of a coal conversion plant in the Powder River Basin. This task force is in being and has been actively studying the problems associated with determining the technical and economic feasibility and financial attractiveness of such a facility. As stated in our original letter, we had hoped to be able to reach a definitive decision in the first half of 1975. Unfortunately, we have not been able to do so.

As you know the conditions for establishing a synthetics coal plant are in a state of constant change. The U.S. Government has so far not established a definite plan for implementing Project Independence and as we understand it will not settle on such a plan until late this year. At the same time, we are presently restrained from proceeding with development of our Rawhide mine by a court injunction; and the conditions under which mining can be done in the area are not obvious at this time. In addition, the state of Wyoming has enacted rigorous regulations relating to emissions and to plant siting which require reevaluation of our plans.

The events mentioned above, along with others, have seriously delayed the preparation of any definitive plan for use of the water. At present we feel that it is unlikely that we will have commercial facilities available to use our portion of the water before 1980-1985. However, we must have positive assurance that a water supply is available before we can undertake more definitive studies of a specific plant. For this reason we are interested in having work on Middle Fork Dam proceed as soon as possible. It is our understanding that the ranchers in the area can put the water to beneficial use as soon as the dam is complete. Therefore, it would seem to be in everyone's interest to have the work go forward.

We regret that we cannot be more definite about our plans at this time. About all that we can say is that we plan to use our share of the water for coal synthetic plants. As soon as our plans are definite, we will inform you. We assume that construction of the plant and mine will necessitate an environmental assessment of the proposed work at the time of construction and that Federal approval of the proposed Middle Fork reservoir does not constitute or imply eventual approval of possible future industrial activities.

Yours very truly,

R C Curtis

R. C. Curtis

REL:sc

cc - Kirven and Hill
Powder River Reservoir Corporation
104 Fort Street
Buffalo, WY 82834

icRichfieldCompany
Synthetic Crude and Minerals Division
Resource Development Group - U.S.
1500 Security Life Building
Denver, Colorado 80202
Telephone 303 266 3741

F. C. Witmer
Manager

July 1, 1975

Mr. Daniel P. Baker
State Director
U. S. Department of the Interior
Bureau of Land Management
State Office
P. O. Box 1828
Cheyenne, Wyoming 82001

Dear Mr. Baker:

In response to your letter of June 5th, requesting information relating to the end use of the total capacity of Middle Fork Reservoir, I must advise again that the Atlantic Richfield Company has no present plans as to the use of this potential water source. We anticipate that our part of this water resource will eventually be utilized in the development of our coal reserves in the Powder River Basin of northeastern Wyoming. However, no firmer plans have developed since our last conversation.

We have attempted to assist Mr. Winter in developing a model for potential uses of Middle Fork water. We hope this information will be helpful in allowing you to draft assumptions of possible industrial uses.

Very truly yours,

F. C. Witmer

FCW/bb

APPENDIX 13.6

Determination of Eligibility of Cultural Resources for Nomination to the National Register of Historic Places

IN REPLY REFER TO:

United States Department of the Interior 6233 (370)

BUREAU OF LAND MANAGEMENT
WASHINGTON, D.C. 20240

Memorandum

To: State Director, Wyoming

From: Chief, Division of Recreation

Subject: Eligibility Determinations, Casper District Sites

You requested determinations of eligibility for placement on the National Register of Historic Places of six sites related to the Middle Fork Reservoir area.

The National Register staff has determined that five sites are eligible: Cantonment Reno, Dull Knife Battlefield, Castle Rock Archeological Site, Middle Fork Pictograph-Petroglyph Panels, and Portuguese Houses.

The sixth site, Hole-in-the-Wall Country, was determined to be ineligible because insufficient data was presented. However, the National Register staff considered that some individual cultural resources within Hole-in-the-Wall Country might be eligible for nomination.

The eligibility determination process for this group of cultural resources was rather confused and time-consuming. The confusion and time requirements were caused mainly by BLM providing insufficient data to undertake determinations including the lack of maps, ill-defined boundaries, and the lack of site information and significance statements. The transmittal of the original request to the National Register was also delayed in transit for some unknown reason. The National Register staff was fully cooperative in making these determinations.

A copy of a memorandum to the Wyoming SHPO is enclosed; we have not yet received the memorandum from the National Register to BLM.

Enclosure

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United States Department of the Interior

BUREAU OF LAND MANAGEMENT

State Office
P. O. Box 1828
Cheyenne, Wyoming 82001

IN REPLY REFER TO

6230 (931)

AUG 18 1975

Mr. Paul H. Westedt, Director
and State Historic Preservation Officer
Wyoming Recreation Commission
604 East 25th Street
Cheyenne, Wyoming 82002

Dear Paul:

In compliance with section 106/2(b) of the Historic Preservation Act of 1966, and section 2(b) of Executive Order 11593 as implemented by the procedures of the Advisory Council on Historic Preservation (36 CFR 800), we have requested and received a Secretarial determination of eligibility concerning six sites related to the Middle Fork Reservoir area for placement on the National Register of Historic Places.

The National Register staff has determined that five sites are eligible: Catonment Reno, Dull Knife Battlefield, Castle Rock Archeological Site, Middle Fork Pictograph-Petroglyph Panels, and Portuguese House. The sixth site, Hole-in-the-Wall Country, was determined to be ineligible because insufficient data was presented.

Because eligibility for the above sites has been determined, we would like to solicit the following comments and views from you:

a. Statement regarding the nature of effect of the proposed action on the eligible properties.

b. Statement expressing your views regarding the proposed mitigation or avoidance of adverse effect.

c. Alternative suggestions to avoid or mitigate adverse effects on the proposed action.

d. Statement of your concurrence with proposals to mitigate or avoid action's adverse effects (as appropriate).

We will include your comments in section VII of the enclosed Preliminary Case Report for Advisory Council review. The document, when returned with your comments, will remain unchanged with one exception -- the section on Hole-in-the-Wall Country will be deleted.

Your prompt attention to this most important matter will be appreciated.

Sincerely yours,

Daniel P. Baker
State Director

Enclosure 1

cc:
DM, Casper
Director (370)

United States Department of the Interior

NATIONAL PARK SERVICE
WASHINGTON, D.C. 20240

IN REPLY REFER TO:

JUL 2[illegible]

H34-PR

Mr. Paul H. Westedt
Director, Wyoming Recreation Commission
604 East 25th Street, P.O. Box 309
Cheyenne, Wyoming 82001

Dear Mr. Westedt:

Thank you for your recent letter concerning the eligibility of sites in the Bureau of Land Management's Casper District, Wyoming, for inclusion in the National Register pursuant to Section 2(b) of Executive Order 11593.

After evaluation of the documentation which we have on these properties, including your opinion on their eligibility, we have determined that the following sites are eligible for inclusion in the National Register under (A) and (D) of the National Register Criteria for Evaluation:

Cantonment Reno
Dull Knife Battlefield
Castle Rock Archeological Site
Middle Fork Pictograph-Petroglyph Panels
Portuguese Houses

We have informed the Bureau of Land Management that we do not believe that there is sufficient information about "Hole in the Wall" for us to make a determination on its eligibility for inclusion in the National Register as a district. We recommended, however, that the Bureau of Land Management consider preparing National Register nominations for individual resources in this area.

We appreciate your assistance in the implementation of Executive Order 11593.

Sincerely yours,

William J. Murtagh

Director, Office of Archeology
and Historic Preservation

United States Department of the Interior

NATIONAL PARK SERVICE
WASHINGTON, D.C. 20240

IN REPLY REFER TO:
H34-PR

JUL 30 1975

Memorandum

To: Director, Bureau of Land Management
Attention: Chief, Division of Recreation

Through: Assistant Secretary for Fish and Wildlife and Parks

From: Associate Director, Professional Services

Subject: Request for determinations of eligibility for inclusion in the National Register on sites in the Casper District, Wyoming, of the Bureau of Land Management

Thank you for your request for a determination of eligibility for inclusion in the National Register on sites in the Casper District of the Bureau of Land Management, Wyoming, pursuant to Section 2(b) of Executive Order 11593 as implemented by the procedures of the Advisory Council on Historic Preservation (36 CFR 800).

After evaluation of the documentation which we have on these properties, and in consultation with the Wyoming State Historic Preservation Officer, we have determined that the following sites are eligible for inclusion in the National Register under criteria (A) and (D) of the National Register Criteria for Evaluation:

The Portuguese Houses (Fort Antonio)
Cantonment Reno
Dull Knife Battlefield
Castle Rock Archeological Site
Middle Fork Pictograph-Petroglyph Panels

We do not believe that there is sufficient information about "Hole in the Wall" or "Red Wall Country" for us to make a determination on its eligibility for inclusion in the National Register as a district. However, the Bureau of Land Management may wish to consider preparing National Register nominations for individual resources in this area.

As you understand, a request for our professional judgment pursuant to the Advisory Council's procedures in this regard, developed in consultation, inter alia, with the Department of the Interior, constitutes a part of the Federal planning process. We urge that this information be integrated into the National Environmental Policy

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Act analysis to permit the Bureau of Land Management to reach the most effective program decisions. This determination of eligibility for inclusion in the National Register does not serve in any manner as a veto to uses of such property, with or without Federal participation or assistance. Any decision on the property in question and the responsibility for program planning concerning such properties lies with the Bureau of Land Management after the Advisory Council on Historic Preservation has had an opportunity to comment.

We appreciate your assistance and cooperation in the implementation of Executive Order 11593.

Ernest Allen

APPENDIX 13.7

Right-of-Way Application from

Powder River Reservoir Corporation, as Amended

July 16, 1973

Re: W-40720

Director, Land Office
Bureau of Land Management
P.O. Box 1828
Cheyenne, WY 82001

Dear Sir:

Powder River Reservoir Corporation, a Wyoming corporation, hereby applies for a right-of-way to construct a reservoir and appurtenant distribution system on and over 2,373.45 acres of land owned by the United States and generally described as follows:

<u>Township 42 North, Range 83 West:</u>

Sections 5 and 6: 441.0 acres

<u>Township 43 North, Range 83 West:</u>

Sections 28, 29, 30, 31, 32, 33: 1440.34 acres

<u>Township 42 North, Range 84 West:</u>

Sections 2, 12, 13 and 24: 457.94 acres

<u>Township 43 North, Range 84 West:</u>

Section 35 34.17 acres

all situated in Johnson County, Wyoming.

The exact location of the lands for which this right of way is requested is shown on the map accompanying this application.

Also accompanying this application are:

(1) A copy of Application for a Permit for the Middle Fork of Powder River Reservoir, Temp. Filing No. 14 2/238, and copy of Application for Enlargement of Middle Fork Powder River Reservoir, Temp. Filing No. 20 1/378, filed with the State Engineer, State of Wyoming. These applications are in the process of being converted to permit status by the State Engineer.

(2) A copy of the Articles of Incorporation of Powder River Reservoir Corporation, duly certified by the Secretary of State, State of Wyoming.

(3) A copy of the resolution of the Board of Directors of said corporation authorizing the filing of this application.

(4) $10.00 service fee.

The applicant is a non-profit corporation and seeks water storage capacity and distribution system for irrigation and industrial purposes, and for such other purposes as are shown on the copies of the Applications for a Permit, Temp. Filing No. 14 2/238 and Temp. Filing No. 20 1/378 accompanying this application.

This application is made under the provisions of the Act of February 15, 1901 (43 U.S.C. 959), and pursuant to the regulations of 43 CFR-2800, 2870, and if approved, said right of way will be subject to the terms and conditions of said regulations.

POWDER RIVER RESERVOIR CORPORATION

By [signature]
President
Sussex Route
Kaycee, WY 82639

ATTEST:

[signature]
Secretary

Alma Lundberg
Chief, Lands and Mining Section
Bureau of Land Management
P. O. Box 1828
Cheyenne, WY 82001

Re: W-40720

To Alma Lundberg:

Powder River Reservoir Corporation, a Wyoming corporation, hereby amends the first paragraph of its application for a right-of-way across lands owned by the United States, dated July 16, 1973, to read as follows:

Powder River Reservoir Corporation, a Wyoming corporation, hereby applies for a right-of-way on and over approximately 141.63 acres of land owned by the United States and generally described as follows:

See Exhibits A, B, C, D, E, F and G attached hereto.

Dated this 7th day of March, 1974.

POWDER RIVER RESERVOIR CORPORATION

By [signature: Stanley Mayor]
President
Sussex Route
Kaycee, WY 82639

ATTEST:

[signature: George H. Gibbs]
Secretary

NOTE: Legal description for application
is on file in Casper District Office

APPENDIX 13.8

Contract between

Powder River Reservoir Corporation and Carter Oil Company

CONTRACT BETWEEN
POWDER RIVER RESERVOIR CORPORATION AND
THE CARTER OIL COMPANY
FOR THE FURNISHING OF WATER FOR INDUSTRIAL,
MUNICIPAL AND OTHER BENEFICIAL USES

THIS CONTRACT, dated the 22nd day of May, 1973, by and between POWDER RIVER RESERVOIR CORPORATION, a Wyoming corporation of Kaycee, Wyoming, hereinafter called "POWDER RIVER," and THE CARTER OIL COMPANY, a corporation having its principal office in Houston, Texas, hereinafter called "CARTER";

WITNESSETH THAT:

Article 1
Recitals

1.1 Sussex Irrigation Company, the predecessor of POWDER RIVER, and John H. Tippit of Denver, Colorado, acting as trustee for the predecessor of CARTER, entered into their Option Contract in writing dated July 27, 1967, by the terms of which Tippit as such trustee was granted option rights upon an application filed with the Wyoming State Engineer for permission to construct a reservoir with a contemplated capacity of 49,583 acre feet on the Middle Fork of the Powder River, said original application bearing temporary filing No. 14 2/238 and a priority date of March 7, 1940, and with an enlargement having temporary filing No. 20 1/378 and a priority date of December 29, 1970, said option rights extending to the contemplated reservoir, the yield of water therefrom, and the water and water rights accruing thereto, as well as to said filing.

1.2 The parties hereto have reached the agreement set forth in this instrument, which shall supersede said Option

Contract of July 27, 1967, under which said reservoir shall be constructed by an assignee of POWDER RIVER and a portion of the waters lawfully appropriated and stored therein shall be sold to CARTER, all subject to the contingencies hereinafter set forth and in accordance with the terms, conditions and provisions hereof.

1.3 The considerations for this contract are the mutual agreements of the parties herein set forth and the mutual benefit and advantage which will accrue to each of the parties by reason of this agreement.

Article 2
Preliminary Actions and Contingencies

2.1 As promptly and expeditiously as possible, POWDER RIVER shall file with the State Engineer of the State of Wyoming an amended application for a permit to construct the reservoir above mentioned and thereby convert its temporary filing to a permit. POWDER RIVER, at the same time, shall diligently seek to have added to the list of purposes for which the water is appropriated and stored a recreational purpose as well as other uses and purposes heretofore shown. CARTER shall, when and as reasonably requested, make available its employees, its retained consultants and its attorneys for consultation with and assistance to POWDER RIVER in obtaining said permit status and added beneficial use. In addition to the other contingencies hereinafter set forth, CARTER'S obligations under this contract are expressly subject to and contingent upon a duly issued and valid permit which establishes a priority date of March 7, 1940 for the full quantity claimed in the original filing, and which specifies the authorized uses to be for irrigation, stock, domestic, power, municipal and industrial uses.

2.2 POWDER RIVER shall organize an irrigation district or in lieu thereof with the consent of CARTER, a conservancy district, and cause the same to be formulated and approved by a court of competent jurisdiction in accordance with the statutes of the State of Wyoming and shall assign unto said newly created District its permit to construct said reservoir and all waters to be appropriated under said permit and stored therein and all water rights granted by said permit, and shall assign to said new District all of its rights under this contract and shall obtain from said newly created District an express written assumption of all of POWDER RIVER'S obligations under this contract with the result and legal effect that said newly created District (herein called "DISTRICT") shall be thereupon substituted in this contract in the place and stead of POWDER RIVER. POWDER RIVER shall submit to CARTER true copies of all proceedings relating to the formation of the DISTRICT and the approval thereof. The DISTRICT shall also submit to CARTER true copies of all instruments of assignment to and assumptions by the DISTRICT showing that the DISTRICT is the lawful owner and holder of the water rights and privileges assigned to it and that it has been validly and properly substituted in place of POWDER RIVER as one of the parties to this contract.

2.3 POWDER RIVER represents that the DISTRICT, subject to the approval of the District Court for Johnson County, Wyoming, can secure and will make application to the Farm Loan Board of the State of Wyoming and to the other appropriate state officials for a loan repayable over a forty-year period with interest at the statutory rate in a principal amount sufficient to defray the entire cost of said reservoir, including costs of acquisition of the lands to be inundated, as well as the other costs incident to and incurred in the construction of said reservoir.

2.4 The DISTRICT shall propose as security for said loan pro rata assessments for construction against the lands of each landholder included within the DISTRICT, which assessments have been finally confirmed by the District Court of Johnson County, Wyoming, and the time limited for appeal of such order of confirmation shall have expired, which order shall make provision for repayment of the principal and interest due on said loan over a period of forty (40) years, together with a deed of trust or mortgage to cover said reservoir, including all of the DISTRICT'S real and personal property located at the reservoir site which is part of or used in connection with the same and also, if required by the lending authority, as additional security, an assignment of water rights and the payments to be received from CARTER for purchase of waters under the terms of this contract.

2.5 Prior to the disbursement by the lending authority of any of the proceeds of said loan, CARTER shall execute and deliver to the Farm Loan Board of the State of Wyoming a written representation in a form acceptable to the Attorney General of said state expressly representing and agreeing that the conditions specified in the following Section 3.1 have been met and performed and that this agreement has become final and complete. And concurrently therewith, CARTER shall acknowledge in writing notice of the DISTRICT'S assignment of the payments to be made for the waters to be purchased under this contract and shall agree to make those payments to the assignee until the amount of said loan, both principal and interest, shall have been paid in full. But if said conditions are not met and performed and this contract terminates under the provisions of the following Section 3.2, then CARTER shall so notify the lending authority in writing and the loan application shall thereupon be deemed withdrawn.

Article 3
Sale and Purchase of Waters

3.1 CARTER'S obligation to purchase waters under the terms of this agreement and the DISTRICT'S obligation to sell those waters are each and both expressly subject to and contingent upon the fulfillment of the following described conditions:

3.1.1 The formation with court approval of the DISTRICT in a valid and lawful manner and the assignment to the DISTRICT of this contract and of the water rights and water filings which are the subject of this contract, and the assumption by the DISTRICT of the obligations under this contract, so that the DISTRICT may lawfully construct the reservoir, appropriate and store waters therein, and sell the waters hereinafter prescribed to CARTER under the terms hereof.

3.1.2 The securing by the DISTRICT of a loan from the Farm Loan Board of the State of Wyoming in an amount sufficient to defray the entire costs of the reservoir, in an amount not to exceed Eight Million Dollars ($8,000,000.00), repayable under the terms and conditions and with the interest set forth in the foregoing Section 2.4, with a covenant by the DISTRICT to the lender that the proceeds of the loan will be used for the acquisition of lands to be inundated by the reservoir and for the construction of the reservoir and for no other purpose.

3.1.3 Total estimated costs for the said reservoir and all costs incident to or incurred in connection with the same, as approved by the court having jurisdiction of the DISTRICT, to be in an amount not to exceed Eight Million Dollars ($8,000,000.00) or in such amount as is acceptable to CARTER, with the acquisition cost of the land to be inundated by or used in the construction of the reservoir included in said total sum to be not more than fifteen percent (15%) more than the independently appraised value of said lands, unless such higher land cost is acceptable to CARTER.

3.1.4 Engineering design and specifications for the dam for said reservoir (including the optimizing of the size and storage capacity in view of the expected water yield) to be acceptable to CARTER.

3.2 In the event that either party to this agreement should form a good-faith judgment that any one or more of the conditions set forth in the foregoing Section 3.1 will not occur and cannot be met or performed, then it shall notify the other party of that judgment. The party receiving such a notice shall reply within thirty (30) days, stating whether that party is in agreement that the condition will not occur and cannot be met or performed. If the party receiving said notice is of the opinion that the condition will occur or can be met or performed, then in addition to stating that opinion it shall prescribe a period of time up to two (2) years within which it expects said condition will occur or be met or performed. In the event both parties give notice that they are in agreement that any one or more of said conditions will not occur and cannot be met or performed, or in the event the period of time prescribed as aforesaid by one of the parties and anv extension thereof mutually agreed to should expire without said occurrence, then this agreement shall thereupon terminate. Upon such termination of this agreement, said prior Option Contract of July 27, 1967 shall thereupon be reinstated and shall continue in force and effect to the same extent as if this contract had not been executed except that the term thereof shall be extended for the same period of time this agreement was in effect and no payments shall be due thereunder for the time periods this agreement was in effect.

3.3 The DISTRICT shall sell to CARTER, and CARTER shall purchase from the DISTRICT, the waters lawfully appropriated and stored in said reservoir according to the following provisions. The waters sold to CARTER shall be released, so far as is possible, in accordance with annual or quarter-annual schedules furnished by CARTER to the DISTRICT and shall be delivered to CARTER at the outlet works of the dam. The reservoir shall be operated, portions of the waters yielded therefrom shall be sold to CARTER, and portions shall be retained for use by the DISTRICT and for carryover storage, all in accordance with the following provisions:

3.3.1 For the purposes of this contract, the water year shall begin each October 1st and end the following September 30th. During each water year, to the full extent that such sale is legally possible and the water is physically available, there shall be sold to CARTER 25,000 acre feet, said quantity to be delivered at approximately a uniform rate during the water year. In the event CARTER elects not to take or use all or part of said quantity during any water year, or in the event said quantity is not legally or physically available in whole or part, CARTER shall nonetheless be obligated to pay for the full quantity of 25,000 acre feet per year.

3.3.2 The DISTRICT may use or sell for irrigation up to 24,000 acre feet in any consecutive three-year period, but not to exceed 10,000 acre feet in any one year, after the quantities prescribed for the foregoing subsection 3.3.1 have been provided to CARTER, further restricted, however, by the following limitations:

(a) The reservoir will be operated, subject to administration and regulation by the State Engineer of the State of Wyoming, in a manner which will maximize the certainty of delivering 25,000 acre feet per year of industrial water supply.

(b) Deliveries of irrigation water from the reservoir during months May through September of each year will be limited to the extent necessary to prevent the active storage content of the reservoir from being lowered at the end of the said months below the following respective amounts:

May 31 ------------	15,000 acre ft.
June 30 -----------	12,500 acre ft.
July 31 -----------	10,000 acre ft.
August 31 ---------	7,500 acre ft.
September 30 ------	5,000 acre ft.

These provisions for minimum monthly carryover storage are subject to revision each five (5) years following the initial sale of water by the DISTRICT to CARTER. Revision shall be effective during the next ensuing five-year period and shall be made only in the event and to the extent that, in the unanimous opinion of three selected hydrologists, revisions are necessary in order to accomplish the purpose and intent of this agreement. CARTER and the DISTRICT shall each select one of the hydrologists and the Wyoming State Engineer shall designate the third.

(c) There shall be no deliveries of water to the DISTRICT for irrigation or resale for irrigation during the period from October 1st to April 30th of any water year.

3.3.3 CARTER may also purchase, if it so elects and gives the DISTRICT two years' prior written notice of its intent to do so, 25/32nds of the Excess Waters which are lawfully appropriated and stored in said reservoir. For the purpose of this contract, Excess Waters are defined as the lawfully appropriated and stored waters, if any, in excess of the waters provided to CARTER by subsection 3.3.1 and in excess of the waters available to the DISTRICT by the provisions of subsection 3.3.2, and which, in the unanimous opinion of the three hydrologists designated in paragraph 3.3.2(b) above, can safely be withdrawn from the reservoir without impairing the availability of water designated for delivery to CARTER in subsection 3.3.1, and for delivery to the DISTRICT in subsection 3.3.2.

3.3.4 CARTER shall have a preferential right of purchase as to that portion or portions of the waters developed in the reservoir and available to the DISTRICT which the DISTRICT proposes to sell to a third party. CARTER'S said preferential right of purchase shall be upon the same terms and conditions as are offered by the third party and accepted by the DISTRICT and shall extend for a period of sixty (60) days after CARTER has received written notice giving all of the terms and conditions of the proposed sale; provided that sales by the DISTRICT of quantities of water for agricultural purposes only up to an aggregate of 500 acre feet in any one water year are exempt from CARTER'S preferential right of purchase.

3.4 The purchase price for the waters sold to CARTER under the provisions of this agreement shall be:

3.4.1 For the waters sold pursuant to the foregoing subsection 3.3.1, an amount per acre foot equal to 1/25,000 of the annual payment, both principal and interest, required to repay the Farm Board loan above mentioned. In addition, CARTER shall pay the DISTRICT 25,000/49,000 of all actual costs of operating and maintaining the reservoir.

3.4.2 For the Excess Waters, if any, available to CARTER and elected to be purchased by CARTER under the provisions of the foregoing subsection 3.3.3, an amount per acre foot equal to seventy-five percent (75%) of the per acre foot cost of the waters purchased under subsection 3.3.1. The portion of the cost of operating and maintaining the reservoir to be paid by CARTER shall not be increased by reason of CARTER'S purchase of Excess Waters.

3.4.3 For the waters, if any, purchased by CARTER pursuant to its preferential right of purchase provided by subsection 3.3.4, the same purchase price as was offered by the third party and which the DISTRICT desired to accept. The portion of the cost of operating and maintaining the reservoir to be paid by CARTER shall not be increased by reason of exercise of CARTER'S preferential right of purchase unless the purchase offer which it preempted included an obligation to pay a portion of said cost.

3.5 The term for the water sales and purchases hereby provided shall be a period of forty (40) years commencing at the date of the first availability of water or January 1, 1985, whichever is the earlier, with the right in CARTER at its own sole election to extend this contract for an additional period of forty (40) years under the same terms and conditions, except that the purchase prices for the first 25,000 acre feet taken each year and for the Excess Waters, if any, shall be, respectively, fifty percent (50%) of the purchase price per acre foot during the first forty-year term as determined under subsections 3.4.1 and 3.4.2 above, said prices to be adjusted to reflect the then prevailing purchasing power of the dollars as compared to said purchasing power in the year in which water is first available under this contract, using the Consumer Price Index (all items) of the United States Department of Labor, Bureau of Labor Statistics or other mutually acceptable criteria.

3.6 If CARTER and the DISTRICT should determine by their mutual agreement that maintenance work involving a cost of more than Twenty-Five Thousand Dollars ($25,000.00) is reasonably required in order that operation of said dam and reservoir may continue in a safe and proper manner and if CARTER and the DISTRICT further agree as to the engineering details of said maintenance work and the reasonableness of the cost thereof, then the DISTRICT shall seek a renewal loan from the Wyoming Farm Loan Board in an amount sufficient to retire the existing loan and to pay the cost of such maintenance work. Said renewal loan, if granted, shall be repaid in the following manner:

(a) In the event said renewal loan is granted during the initial forty-year term of this contract, then CARTER'S obligation herein provided to purchase a quantity of 25,000 acre feet of water annually and all other terms and provisions of this contract shall be extended beyond the specified forty-year term for a sufficient number of years in order that the annual payments (continuing the amount as prescribed by this contract before the renewal loan) shall retire said renewal loan, both principal and interest; and

(b) In the event said renewal loan is granted at the end of the initial term of this agreement and a renewal term has been elected by CARTER, then from the purchase prices prescribed by the foregoing Section 3.5. But in the event the purchase prices prescribed in the foregoing Section 3.5 are insufficient to retire said renewal loan amortized over a forty-year period, then said purchase prices during the renewal term shall be increased beyond the prices so specified to an amount sufficient to retire said loan amortized over a forty-year period. It is the intent and purpose of the foregoing provision to provide that the purchase prices during the renewal term, if renewal is elected by CARTER, shall be fifty percent (50%) of the price during the first term, as specified in Section 3.5, or an amount sufficient to repay the renewal loan obtained under the provisions of this section, whichever are the greater purchase prices.

Provided, however, that no provision of this contract and no approval or assignment for security hereof shall ever be construed as implying any representation, commitment or understanding that a renewal loan will be granted by the Farm Loan Board of the State of Wyoming or its successors.

3.7 The beneficial purposes to which CARTER may place the waters purchased by it are not restricted by this agreement and such uses may be industrial, municipal or other uses and purposes, specified in the permit or permitted by state law, and this contract places no restriction upon the right of CARTER to resell the waters so purchased as and when CARTER so desires; provided, however, that the DISTRICT shall have a preferential right to purchase upon the same terms and conditions any water which CARTER proposes to sell to direct irrigation users; and provided furthe that no resale of the waters shall affect, impair or relieve CARTER'S obligations to make the payments for the waters purchased under the terms and conditions of this contract.

3.8 The payments prescribed by this article for the waters purchased by CARTER hereunder shall be made annually to the DISTRICT at its principal office in Kaycee, Wyoming and shall be made fifteen (15) days or more prior to due date of the annual installments for repayment of the loan for the reservoir.

Article 4
Miscellaneous Provisions

4.1 The relationship of the parties to this agreement shall be solely that of water seller and water purchaser. This agreement is not intended to create, and shall not be construed as creating, a partnership or joint venture between the parties. Each party shall be liable only for its own obligations as specifically assumed by the terms hereof. Without limiting the generality of the foregoing, it is specifically agreed that the DISTRICT will not be responsible for the control, carriage, handling, use, disposal or distribution of the water sold to CARTER hereunder, nor will it be liable in any manner for any damages, claims, demands, suits or judgments arising from or in connection with such handling, use, disposal or distribution by CARTER; and that CARTER will not be responsible for the construction, operation, maintenance or control of the dam, or storage of reservoir waters prior to delivery of the waters to it hereunder, nor will it be liable in any manner for any damages, claims, demands, suits or judgments arising from or in connection with the construction, operation or maintenance of the dam, or storage of the waters, or breaks in the dam.

4.2 Any notice required or permitted by the terms of this agreement shall be deemed sufficiently given when duly deposited in the United States mail, certified or registered, with sufficient postage prepaid, addressed to the parties at their following address:

The Carter Oil Company
Post Office Box 2180
Houston, Texas 77001

Powder River Reservoir Corporation
Kaycee, Wyoming 82639

District
Kaycee, Wyoming 82639

4.3 This contract may be assigned by CARTER in whole or in part to any corporation which is a wholly-owned subsidiary of itself or of CARTER'S parent corporation, or which is a subsidiary of any corporation with which its parent company may be merged, but no other assignment of this contract by CARTER shall be effective as to the DISTRICT without prior written consent of the DISTRICT, which consent shall not be unreasonably withheld; provided that the foregoing requirement shall in no wise limit CARTER'S rights stated in Section 3.7 above. And this contract may be assigned by the DISTRICT to a reorganized or successor water or irrigation district formed in accordance with applicable Wyoming law or to a duly organized and existing private corporation, provided that DISTRICT'S assignee becomes the lawful owner and holder of the water filing mentioned in the foregoing

Section 1.1, the reservoir permit issued pursuant thereto, and said reservoir and the waters appropriated and stored therein and the water rights accruing thereto, and further provided that said assignee expressly assume, in writing, the DISTRICT'S obligations hereunder. Subject to the requirements aforesaid, this agreement shall be binding upon and inure to the benefit of the respective successors and assigns of the parties hereto.

4.4 The provisions of this contract constitute the complete and entire agreement between the parties and there are no additional agreements, written or oral, which will control the actions of either party with respect to the matters herein provided.

IN WITNESS WHEREOF, this contract has been duly executed by the parties hereto as of the day and year first above stated.

ATTEST:

W. B. Oliver
~~Secretary~~
Manager, Resource Acquisitions

THE CARTER OIL COMPANY

By G. H. Shipley
President
"CARTER"

WBO

ATTEST:

~~Secretary~~
Vice President

POWDER RIVER RESERVOIR CORPORATION

By
President
"POWDER RIVER"

STATE OF WYOMING)
) SS.
COUNTY OF LARAMIE)

On this 30TH day of MAY, 1973, A.D., before me personally appeared CHARLEY MAYOR to me personally known, who, having been by me first duly sworn, did say: That he is the PRESIDENT of POWDER RIVER RESERVOIR CORPORATION, the corporation described in and which executed the foregoing instrument; that the seal affixed to said instrument is the corporate seal of said Corporation; and that said instrument was signed and sealed in behalf of said corporation by authority of its Board of Directors; and said CHARLEY MAYOR acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my notarial seal on the day and year in this certificate first above written.

William J. Kirven
Notary Public

My commission Expires:

Sept. 19, 1976

STATE OF WYOMING)
) SS.
COUNTY OF LARAMIE)

On this 30TH day of MAY, 1973, A.D., before me personally appeared G. H. SHIPLEY, to me personally known, the President of THE CARTER OIL COMPANY, the corporation described in and which executed the foregoing instrument; ~~that the seal affixed to said instrument is the corporate seal of said corporation~~, and that said instrument was signed ~~and sealed~~ in behalf of said corporation by authority of its Board of Directors; and said G. H. SHIPLEY acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my notarial seal on the day and year in this certificate first above written.

William J. Kirven
Notary Public

My commission expires:

Sept. 19, 1976

☆ U. S. GOVERNMENT PRINTING OFFICE 1975 - 679-022/228 Reg. 8

8A.3.1.3 The coal slurry pipeline system

The slurry pipeline system is spread over a large distance, much of which will not likely be built in the area of study. However, to get an adequate idea of what the system involves, the entire system will be described. In discussing construction and later, in discussing impacts, it is assumed that only the preparation plant, one or two pumping stations, and possibly one or two hundred miles of pipeline will be established in the area of study. The pipeline system can be thought of as consisting of three sets of components--preparation components, mainline components, and dewatering components.

Preparation components

Coal supply - This is the component where the coal is supplied to the preparation plant. Run of mine coal, coal as it comes from the mine, is crushed to pieces generally no larger than two inches and transported by either large truck or train to the coal washing plant.

Coal washing - In coal washing the coal is cleaned of noncoal material which may be associated with it. Sometimes shale or mineral material such as pyrites will be interbedded with the coal, and to bring the coal's value up, this material must be separated. The coal could be washed after transport, or be used unwashed, but it is generally bad economics to transport material which has little or no value and still costs the same to transport. The tailings derived from washing must be disposed of properly, especially if pyrites are present. When exposed to water, these pyrites may be altered to form aqueous acids, resulting in acid mine water.

8A.3.1.2 Plant disposition assumptions

Coal slurry transport is a commercially feasible process, and the properties necessary in the slurry to make transport efficient and economic are well understood. Typically, a slurry which is fifty weight percent coal--that is, the slurry contains one pound of coal for every one pound of water--has the necessary properties to be easily transportable by pipeline. Each company has some 12,500 acre-feet of water to use each year. This is the equivalent of seventeen million tons of water, enough water to transport seventeen million tons of coal.

The coal slurry pipeline process differs from some of the other processes previously discussed. There is really no main plant, instead there are smaller sub-plants arrayed along the pipeline route. At the beginning of the pipeline is the slurry preparation plant and first pump station, requiring about 100 acres. Then, every 100 miles along the line are other pumping stations, each requiring about 40 acres. At the end of the line is the slurry dewatering station, requiring probably another 100 acres. The pipeline itself will require approximately 3-5 acres per mile. More than likely, this entire area of study, and more realistically the preparation plant and maybe one or two pumping stations, will be built in the area, with the rest of the pipeline extending to a point where the coal is needed.

8A.3.1.1 Coal slurry transport

When a solid material is finely ground and mixed with water to form what is commonly called a slurry, that mixture acquires some of the properites of a liquid, principally, the mixture is able to flow through pipes and hence be transported for long distances. Many materials, even very heavy and dense materials, such as iron ore concentrates, have been moved in slurry lines, although most of these lines have been short lines, such as tailings pipelines in mineral concentration plants. Pipelines have been built which are almost 300 miles long, for example, the Black Mesa pipeline in Arizona transports coal over 270 miles.

To be transported as a slurry, the coal must be ground to the powdery consistency of talcum powder, then mixed with water, usually in a ratio of about one pound of coal to one pound of water. This is thoroughly mixed and agitated to keep the coal and water from separating. Then the slurry, a thick black liquid, is pumped into the pipeline. About every one hundred miles or so along the pipeline route, a pumping station is necessary to keep the slurry moving and keep it from slowing enough to begin separating into coal and water. When the slurry gets to its final destination, the water is removed by filtering and thermal drying, leaving dry coal for futher utilization.

8A.3.1 Assumptions and analysis guidelines for alternatives

Coal Slurry Transport - 2 Systems

1.	Product	17,000,000 tons/year/system
2.	Coal Use	17,000,000 tons/year/system
3.	Water Use	16,275,000 tons/year/system 12,500 acre-feet/year/system 0.16 acre-feet/year/person
4.	Water Evaporation	Uncertain
5.	Waste Ash and Dust	None
6.	Emissions:	
	sulfur dioxide	Uncertain
	nitrogen oxides	None
	particulates (with dust control)	Possible dust from coal handling
7.	Transport Systems:	
	coal	4-6 round trips/unit train/system 500 round trips/100 tons truck/system
	product	3½ foot pipeline/system
	water	3 foot pipeline/system
8.	Land Use	200 acres/system 0.16 acre/family 6 acres/pipeline mile (3-5 acres disturbed) 10 acres/transmission line mile
9.	Population:	
	construction labor	peak) 500-1,000/system average) 300-400/system
	operational labor	50-100/plant
	population multiplier factor	4-5
	construction population	2,000-5,000/system
	operational population	200-500/system
10.	Time Frame:	
	construction	1½-2 years
	operation	30 years

8A.2.3 References

1. Applicant's Environmental Assessment, Naughton Units 4 and 5, Utah Power and Light Company (Draft) September 1973.

2. Clean Energy from Coal - Pittsburgh Energy Research Center - Energy Research and Development Administration, March 1975.

3. Clean Energy from Coal Technology, Department of the Interior, Office of Coal Research.

4. Coal Development Alternatives - An Assessment of Water Use and Economic Implications, David D. Freudenthal, Peter Ricciardelli, Michael N. York, Wyoming DEPAD, December 1974.

5. Final Environmental Impact Statement - Eastern Powder River Coal Basin of Wyoming, Volume 1, October 1974.

6. Environmental Impacts of Alternative Conversion Processes for Western Coal Development, Old West Regional Commission, Dr. Steven Miller and Thomas F. Carroll and Associates, October 1974.

7. Kaiparowits Project, Draft Environmental Statement, July 1975.

8. Northern Great Plains Resource Program - Draft Report, September 1974.

9. Second Unit, Huntington Canyon Generating Station Draft Environmental Statement, May 1974.

10. Shaping Coal's Future through Technology, Office of Coal Research, Department of the Interior, 1974-75.

11. Solving the SO_2 Problem - Where We Stand with Applications and Costs, J. Jonakin, Coal Age, May 1975.

12. Yampa Project Environmental Analysis, 1973.

While the addition of 10,800 people is not necessarily adverse, the impact of population growth may generate negative secondary effects which are summarized below and described in more detail in the analysis of socio-economic conditions for the liquefaction alternative (8A.1.2.15).

Employment - 6,600 new jobs would be created.

- construction labor varies from 2,000 to a peak of 4,000 laborers for each plant.
- operational labor varies from 150-350 workers per plant.

Income - entering industrial labor wages should range from $10,000 to $15,000 per year.

Housing - an additional 3,000 to 3,200 housing units may be required to meet demands.

Public education - student enrollments would increase in the areas of development; however, since electric generating plants produce only about half as large a population increase as assumed gasification or liquefaction, the impact should not be as great. Initial crowding during construction would be as great as gasification or liquefaction, however, since construction forces for generation, gasification, and liquefaction are of similar size.

Health and social services,

Law enforcement,

Fire protection, and

Water and sewer facilities - during construction, crowding and facility shortages would be as great as those experienced for liquefaction development. The operational phase impacts would be less than for liquefaction projects because power generation permanent crews are somewhat smaller.

8A.2.2.14 Land use controls and constraints

Electric generation development may precipitate the need to revise or develop land use controls and constraints, as existing planning may not adequately guide development.

8A.2.2.15 Socio-economic conditions

Population

The following population figures are estimates of population growth that might result if coal fired steam electric generation plants are built. These figures do not reflect population and employment for coal mining.

Potential Population Growth in the Study Area

PROCESS	POWER GENERATION 1,000 MW (2 plants)
Low estimate, new permanent employment	300
Induced non-industrial employment 1/	300
Total new employment	600
Additional population 2/	1,800
Low estimate, average temporary construction employment	4,000
Induced non-construction employment 3/	2,000
Total new construction related employment	6,000
Additional population 4/	9,000
All new employment	6,600
All additional population	10,800

1/ Assumes 1 new non-industrial employee per each new industrial employee.
2/ Assumes 3 persons per each new employee.
3/ Assumes 1/2 new non-construction employee per each construction employee.
4/ Assumes 1-1/2 persons per each new construction related employee.

Construction and fencing of railroads, highways, and service roads would lead to land separation and alter present ownership patterns, thereby separating and isolating ranch properites, disrupting established use patterns, and causing access problems for watering and livestock care. Small isolated tracts could result which are too small in size to be of economic use. Livestock drifting during severe weather may be trapped by fences and lost. Physical separation of adjoining private land from federal grazing leases and division of grazing allotments by fenced rights-of-way may cause loss or realignment of leases.

Agricultural lands could be affected by increased erosion, sedimentation, and headcutting in productive drainage bottoms, resulting in additional losses of forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

8A.2.2.13 Transportation networks

Construction and operation of the plants, transport systems, and increased population would create additional use of existing transportation networks causing likely modification and/or upgrading. Increased use of the existing roads and highways requires increased maintenance expenditures, upgrading to higher road standards in some cases, and possibly relocation of sections of some routes. Construction of the new transportation networks would result in conflicts with existing systems such as disruption of an existing facility while new ones--crossing or affecting systems in operation--are under construction. Once built, though, the new transportation facilities may complement or improve the existing facilities.

Much of the sand, gravel, and clinker material may be mined from stream courses, alluvial mountain slopes, or limestone outcrops, possibly impacting scenic recreation areas.

The anticipated population growth would generate increased strain on recreation facilities. Recreation facilities near population centers would experience the greatest demand and be subjected to greatest impacts.

During inversion periods and high winds, visibility would be reduced, obscuring to some extent the scenic views of the area and reducing the visitor's enjoyment. Transmission lines would also reduce the sight-seer's enjoyment of the view. Decreased scenic value may also affect long-term economic strength for certain sectors by reducing nonresident recreation. Increased use of recreation resources outside the area could result in the lowering of recreation quality in an ever-widening circle.

8A.2.2.12 Agriculture

Agricultural land use changes which would occur to accommodate plant sites, community development, and access ssytems are estimated at over 2,000 acres.

With regard to livestock grazing, a loss of approximately six acres represents an estimated loss of one animal unit month (AUM) of grazing. Using the above acreages, which excludes the transportation systems, the annual loss of livestock forage could range from 300 to 350 AUMs.

Secondary impacts associated with population increases due to construction and related development would affect livestock grazing. Vandalism and accidental property damage may increase due to larger numbers of hunters and outdoor recreationists, and animals may be harrassed or harmed by recreation use.

8A.2.2.9 Cultural resources

There would be some 2,000 or more acres disturbed during construction of the plants, community facilities, and access systems. Cultural sites on this acreage would be damaged and/or destroyed, making the values unavailable for future study and salvage. Besides the direct impact of construction, indirect losses would result from population increase. Recreational users--arrowhead hunters, rock collectors, pot hunters, and off-road vehicle users--would disturb additional surface acreage, destroying evidence which could provide information on known as well as unknown cultural sites. However, beneficial impacts could result from inventory and recognition of cultural values.

8A.2.2.10 Aesthetics

Construction, physical presence, and operation of generation facilities, transportation systems, and residential and commercial development would have an adverse effect, although generally less than gasification or liquefaction, on the aesthetics of the area through alteration of the landscape, increased noise levels, and air contaminants such as dust and plant and vehicular emissions.

8A.2.2.11 Recreation resources

Impacts on recreation resources would primarily result from increased population due to industrial development. Another source of impact would be the loss of land base (potentially over 2,000 acres) committed to recreation use. Development of material sites, replacement agricultural lands, and increased recreational use would also decrease recreational land. Private land normally available for this type of use may be closed and posted, further reducing the recreation land base.

loading of particulates, salts from cooling water evaporation, sulfur dioxide (SO_2), and nitrogen oxides (NO_x).

Increased population would intensify recreation use, possibly destroying or decreasing vegetative cover. Secondary impacts from loss of vegetation would result--increased soil erosion (wind and water), loss of cover for wildlife, loss of livestock forage, and adverse effect on aesthetic values.

8A.2.2.8 Fish and wildlife

Electric generation development would result in impacts on the fish and wildlife; habitats would be destroyed and overall animal populations would be reduced. Increased human activity would affect wildlife and habitat.

Industrial development destroys or impairs habitat. This impact on habitat then translates itself into an impact on fish and animal residents, resulting in loss of population. Each wildlife species in the study area would be subject to the cumulative effects of several of the different categories of impacts caused by industrial development which include direct destruction of animals; permanent destruction of habitat; initial destruction of habitat followed, in time, by some degree of recovery in habitat value; impairment or reduction in value of habitat near human development or activities; increased introduction of hazards into the wildlife environment; off-site and secondary impacts caused by displaced animals, disrupted food chains, changed land and water uses, etc.; and improvement of habitat.

8A.2.2.5 Mineral resources

The primary impact on mineral resources in the area is the removal and subsequent use of 210,000,000 tons of coal during the projected thirty-year life of the generation stations. Significant amounts of sand, gravel, fill dirt, and limestone may be used for construction purposes. Energy fuels would be consumed by equipment used during construction and plant operations.

Depending upon ultimate location of plant sites and transportation facilities, there could be a conflict if construction occurs on mineralized areas, hampering development of those minerals.

8A.2.2.6 Water resources

The consumptive water use for the coal fired steam electric generation plants would be approximately 25,000 acre-feet per year.

Other impacts on water resources in the Eastern Powder River Basin would result from the approximately 1,800 acre-feet/year required for the increased population supporting plant development. Water presently being used for other purposes--agricultural use, recreation, and fish and wildlife populations--would be needed to support population growth.

8A.2.2.7 Vegetation

Vegetation would be destroyed on the two plant sites (100-500 acres per site), the land area required for the transportation systems (roads, railroads, pipelines, etc.), and the land area required for residential and commercial development (1,000 acres) to meet increased population needs.

In addition to the loss of vegetation from physical disturbance, the potential would exist for loss to occur due to increased atmospheric

8A.2.2.3 Topography

The land surface would be altered during site preparation for the two assumed plants, which would require approximately 200-1,000 acres. Another 1,000 acres would be disturbed to accommodate community growth. Construction of roads, transmission lines, and railroads would result in alterations of the land surface. The disturbance would consist of earthwork and grading for construction of facilities.

8A.2.2.4 Soils

Soil disturbance would result from construction of the generation plants, community development, and associated transportation systems. The soils on the majority of some 1,600 acres would be disturbed.

As sites are unknown, the length of rights-of-way for the transport systems is also unknown. However, construction of these facilities will result in additional soil disturbance. An average disturbance of five acres per lineal mile for the various transport facilities is estimated.

Disturbances on construction sites result in fine grained soil and parent material being exposed to wind and water actions. Soil productivity, permeability, and infiltration rates would be reduced, increasing runoff, soil erosion, and sedimentation. Wind action, which is almost constant over the entire area, would cause fine soil, silt, and clay particles to be lifted into the atmosphere, reducing air quality and adding to soil loss. Prior to revegetation of exposed soils, soil erosion resulting from high intensity storms would remove fine materials and 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, adding to soil loss and sedimentation.

8A.2.2.2 Air quality

Development of two generating plants, transportation systems, residential areas, and disturbances of relatively large areas of land would create multiple sources of air pollutants which, with prevailing upper level wind direction (northwest), could affect existing communities to the south and east of the sites.

Potentially, the most serious possible adverse impacts on humans, animals, and vegetation are from gases emitted by the generating plants. Emissions include sulfur oxides (42,000 tons/year), nitrogen oxides (56,000 tons/year), and particulates (2,200 tons/year).

The industrial development and attendant population increase (10-12,000) would increase use of internal combustion engines of all types. Engine emissions would result in the addition of carbon monoxide, hydrocarbons, particulates, nitrogen oxides, and sulfur oxides in the basin air.

Increases in airborne dust and similar particulate matter will result from development activities. Airborne particulate matter could reduce visibility, possibly cause traffic accidents during periods of inversions and periods of high winds, contribute to human allergies and similar irritations, and coat vegetation with potentially harmful chemicals.

Present ambient air quality in the area is good, but it would decline with the development of complex pollution sources.

8A.2.2 Probable impacts of coal fired steam electric generation

Impacts described below are those which can be anticipated from the construction, operation, and phase out of two 1,000 megawatt (MW) coal fired steam electric generating plants, related transportation systems, and community facilities. Again, in view of other major energy development proposals in the area, the impacts of two coal fired electric generation plants must be reviewed as part of the cumulative impact of all the potential projects in the Eastern Powder River Basin. As specific plant sites are unknown, impacts described are those which would be common to nearly any future plant site(s) within the study area.

8A.2.2.1 Climate

Generation plants would likely have the greatest effect of all the alternatives on the micro-climate of the immediate plant areas, emitting larger amounts of sulfur dioxide, nitrogen oxides, and water evaporation from cooling. Increases in air temperature and humidity could result. In conjunction with other proposed and projected development in the Eastern Powder River Basin, climate could be affected to a significant degree.

As with gasification and liquefaction processes, recent studies indicate that changes of atmospheric particulate loading and alteration of the earth-atmosphere energy balance may contribute to decreased precipitation and creation of drought conditions in semiarid climates.

8A.2.1.6 Typical steam electric power project summary

1.	Process used	Coal fired, steam electric power plant
	Capacity	1,000 megawatt
2.	Coal consumption	3-4 million tons/year
3.	Coal reserves required (assumed 30-year life)	90-120 million tons
4.	Water requirements	12,500 acre-feet/year
5.	Land needs	100-500 acres
6.	Employment (full production)	Without scrubber: 150-250 With scrubber : 200-350
7.	Construction employment (four years)	a) peak - 2,000-4,000 b) average - 2,000
8.	Total plant investment (order of magnitude, 1975 dollars)	\$400-\$600 million
9.	By-products:	
	a) waste	ash - 350,000 tons/year
	b) emissions	particulate matter - 1,000 tons/year sulfur oxide - 20,000-25,000 tons/year nitrogen oxides - 30,000 tons/year
10.	Utilization factor	80 percent - varies with demand
11.	Thermal efficiency	35-40 percent

gradually phase out operations. In the case of coal fired steam generation, product price and demand in addition to governmental policies can determine whether plant operation is economically feasible. However, this rather sudden closeout would not likely happen. This represents very poor public relations for the company involved.

Unless some sort of plant deconstruction plan is implemented, the plant may be abandoned. However, some of the equipment and structures may have salvage or second-hand value. The plant site can then be cleared of any remaining structures and the site may be returned to a natural topography. This would mean a short-term, several month period of heavy vehicular traffic somewhat similar to the construction phase. Access systems may also be removed if no longer needed for transport systems. These rights-of-way can also be returned to a somewhat natural aspect.

assembled. Many bulldozers, scrapers, trucks, draglines, cranes, and other vehicles will work at leveling the site.

This labor force may well reach over 4,000 workers. During various periods during the construction schedule, the force will include, in addition to a large number of manual workers, many equipment operators, welders, masons, iron workers, and pipe fitters. The construction schedule will likely resemble the schedule diagrammed for the previous plant descriptions.

Routine plant operation

As construction of the site draws to a close, the operating crews will be trained and the plant systems will be tested and brought into production. When the plant is operating at a steady level, the labor force will stabilize. The operational phase time frame is somewhat dependent on economics and availability of raw materials, but a thirty-year life is a reasonable approximation. For the generation plant, the operating crew will be approximately 150-350 workers. With the plant operational, a constant level of heavy duty commercial (rail and road) and light duty private traffic will persist.

Phase out and shutdown

Process plants are designed to run at full rated capacity or, occasionally, a bit higher and are often uneconomical to operate at reduced capacity. Thus, a plant will generally be run at as near full capacity as possible until the critical resource is depleted. When this happens, it is more economically sound to suddenly shutdown rather than compressors, etc.) which cannot be assembled on site. Transport systems must be supplied for raw materials--coal, water--as well as electric power by-products or waste products. If coal is to be shipped by rail, access must be provided, most probably, for one or two round trip, 100 car unit trains per day. Coal hauled by large, 100-ton, off-road trucks would require a road system capable of handling approximately 100 round trip truck hauls per day. Another alternative would be moving coal in a slurry pipeline. This would require a one and one-half foot pipeline. The pipeline carrying raw water would be about three feet in diameter. A transmission line system would be necessary to get the electrical power to consumers. Additional trains and/or trucks would need access to the plant to deliver scrubbing media materials if SO_2 control is required. Waste solids could be hauled back to the mine in the empty unit trains or in a pipeline paralleling the slurry pipeline. The right-of-way for the access systems would have to be cleared, leveled, and finally the system itself would be built. Also, before the plant becomes operational, access must be provided for employee roads, electric service lines, and telephone lines. The construction activities will resemble most nearly the construction of a typical two lane highway. Bulldozers, scrapers, trucks, and draglines, in addition to some specialized railroad or pipeline laying equipment, would generally be used. Crews would be fairly small and mobile.

During site preparation and setup, most of the 100-500 acre site will be leveled, storage and evaporation ponds dug, and finally buildings, storage structures, and steam-generation equipment will be moved in and

ARTIST's CONCEPT of 760 MW PLANT

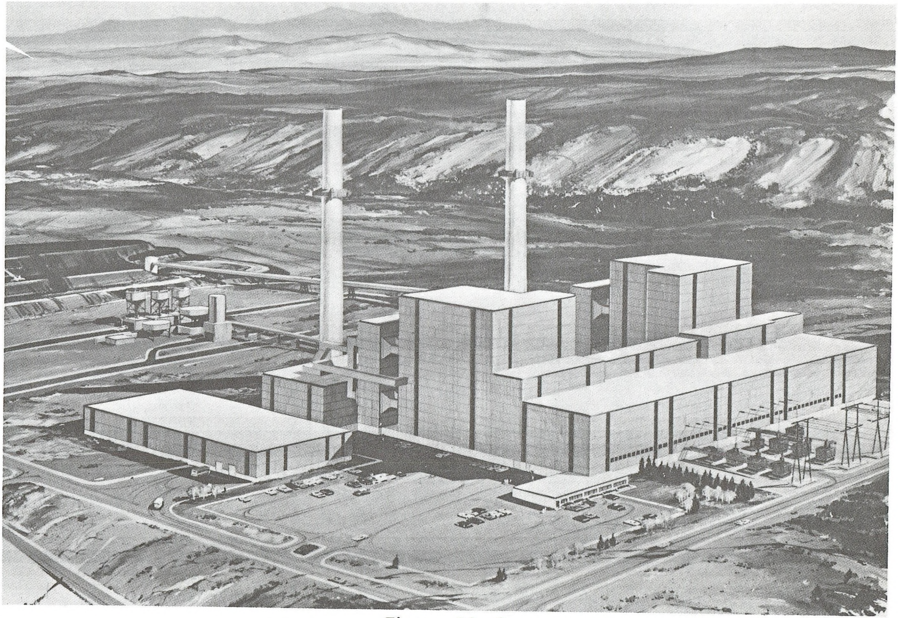


Figure 8A - G
FROM: Yampa Project Environmental Impact Statement

Energy Balance - Many of these plants have been in operation for some time, and much energy balance data has been gathered. The plants run with thermal efficiency generally between 35 and 40 percent. Since the exact energy balance and conversion efficiency depend on the final plant design, no example energy balance is presented here.

8A.2.1.5 Physical plant

The coal fired steam electric generation plant will resemble, at least to some extent, a land-locked steamship. It consists of a rather large building or buildings, the most notable features being large, tall smokestacks, which in the case of a 1,000 MW plant could be, for example, 600 feet tall. The plant site is somewhat variable but should be somewhere between 100 and 500 acres depending where the solid wastes are disposed. The electric generation plant passes through three periods in its lifetime--construction, operation, and phase out.

Plant construction

Principle construction considerations are plant access and transport systems, site preparation and setup, and labor force. The labor force will probably reach a peak of 4,000 individuals and possibly higher. Likely, most of the 100-500 acres will be disturbed or altered during construction.

Access to the plant is critical during all three phases of plant life. During construction, the site must be accessible to both equipment (caterpillars, scrapers, draglines) and labor, and provisions must be made for transport of large process components (turbines, boilers, easy to handle dry. Generally, dust is combined with the ash, then wetted to form a slurry and buried in the mine or at the plant.

Water Evaporation - A great deal of the water used in the plant is lost to evaporation during the cooling process, either in evaporat ponds or in the cooling towers.

Vent Gas - The vent gas is somewhat typical of a combustion gas resulting from coal burning. This gas has been cleaned of a significar amount (99 percent) of the dust using an electrostatic precipitator. However, the sulfur dioxide has not been controlled, but if regulations require, this could easily be accomplished.

Vent gas composition	(percent)
Carbon dioxide	20.2
Water vapor	4.1
Nitrogen	71.2
Oxygen	4.4
Sulfur dioxide	0.04
Nitrogen oxides	0.06
Particulates	0.002
Total	100

If SO_2 control is necessary:

Scrubber Sludge - This is the product of the reaction of the lime-limestone (CaO-$CaCO_3$) scrubbing medium and the SO_2 gas. The product is calcium sulfate ($CaSO_4$) with some calcium sulfite and some other sulfates. The sludge is generally combined with the ash and dust and disposed along with them.

Recovered Water - The scrubbing medium is introduced into the scrubber in a very watery slurry. After the medium is converted to the sludge product, the solids are allowed to settle out into a very thick slurry. In this way, much of the water can be recovered to use again.

Products

Electricity	1,000 megawatts
Ash	1,000 ton/day
Dust	280 ton/day
Water evaporation	40,000 ton/day
Vent gas:	
Carbon dioxide	24,100 ton/day
Water vapor.	4,900 ton/day
Nitrogen	85,000 ton/day
Oxygen	5,300 ton/day
Sulfur dioxide	60 ton/day
Nitrogen oxides	80 ton/day
Particulates	3 ton/day
Total	119,543 ton/day
Miscellaneous Loss	77 ton/day
Total	160,900 ton/day
If SO_2 control is necessary:	
Scrubber sludge	500 ton/day
Recovered wastes	1,375 ton/day
Total with SO_2 scrubber	162,775 ton/day

Electricity - the saleable product from this process will be electrical power, some 1,000 megawatts. This would likely be more than enough power for the local area; therefore, much of this power will likely be exported to a more distant market.

Ash - The 1,000 tons of ash produced each day is the by-product of coal burning. This will be mixed with the other solid wastes and watered to form a thick slurry which will probably have to be buried, either in the coal mine or at the plant site.

Dust - Dust is the fine particulate which is caught by the precipitator. This dust has the texture of talcum powder, and hence is not

Water - Of the 46,500 tons of water used each day, approximately 40,000 tons will go to cooling to make up evaporation loss. The remaining 6,500 tons is split between use as boiler feed water and solid waste disposal water.

Air - Over 160,000 tons of air are used in the process every day. This air is used primarily as the oxygen source for coal combustion, although the nitrogen in the air helps to significantly dilute the sulfur dioxide and nitrogen oxides which are products of the coal combustion.

If SO_2 control is necessary:

Scrubbing Medium - Assuming the use of a mixed calcium oxide-calcium carbonate ($CaO-CaCO_3$) chemical absorbent used for SO_2 scrubbing, something like 275 tons of finely ground material per day might be required. Calcium carbonate is limestone, and calcium oxide is limestone that has been treated or calcined at a high temperature.

Water - An additional 1,600 tons of water per day may be required to mix the scrubbing medium into the watery slurry required for sulfur dioxide control.

8A.2.1.4 Material and energy balances

Since the amount of water available to each company has been set at 12,500 acre-feet per year and since this would make feasible the consideration of a plant of roughly 1,000 megawatt capacity, it is possible to use available technical data to extrapolate a material balance for a hypothetical plant. The material balance represents a method to determine about how much raw material is required to produce all the various products, by-products, or wastes.

Raw materials

Coal	10,000 ton/day
Water	46,500 ton/day
Air	104,400 ton/day
Total	160,900 ton/day
If SO_2 control is necessary:	
Scrubbing medium ($CaCO_3$, CaO)	275 ton/day
Water	1,600 ton/day
Total with SO_2 scrubber .	162,775 ton/day

Coal - 10,000 tons of coal are processed in the plant each day. All the coal is burned to produce process heat, along with combustion gases and ash. The sulfur content of the coal will be the determining factor as to whether SO_2 scrubbing will be required. The inorganic ash content of the coal determines the amount of ash to be expected in coal combustion.

is more expensive than a regular tower. Therefore, these units are generally only practical where water is very expensive, over $200/acre-foot/year according to one estimate.

Dust Collection - Particulate matter or dust can be removed from stack gases leaving the plant, generally the power and steam generation area, with better than 99 percent efficiency using the electrostatic precipitator. Other methods of dust collection such as baghouses or cyclones may be used.

Sulfur Dioxide Scrubber - If sulfur dioxide (SO_2) emissions are above permitted standards, control will be necessary. SO_2 is scrubbed using a chemical absorbent or scrubbing medium (limestone, dolomite, etc.) or oxidizing SO_2 to SO_3 and converting SO_3 to sulfuric acid. SO_2 scrubbing using a scrubbing medium will yield a scrubber sludge which would be disposed of with the ash. A more complete discussion of SO_2 scrubbing is included in the gasification process description.

Solid Waste Disposal - Residual ash (inorganic residue) from coal combustion is quenched in water, thickened, allowed to settle into a thick, high density slurry, and finally disposed of along with dust from dust collection and scrubber sludges if SO_2 scrubbing is required.

Ancillary systems

The above mentioned systems are the principal features of a coal fired steam generation plant. In addition, any plant will have pumps for moving liquids; valves and piping to control gas flow; fans to direct air flows to combustion areas; stacks to vent exhaust gases; ponds and silos for storage; maintenance and construction equipment, buildings for shops and offices; and parking lots and loading areas.

magnetic field, which induces an electric current. This current is drawn from the electrode and provides a source of electric power.

Support components

Water Supply - In this component, water is supplied for all the various needs of the plant. Water to be used in the boilers must be treated to remove dissolved salts and other impurities. Makeup water to replace water lost in the water cooling component and water to slurry the solid wastes must also be supplied.

Water Cooling - Water cooling is commonly accomplished in four ways. The "once through" method is sometimes used when the plant is near a lake or river. Water is diverted from the body of water, run through the steam cooling unit once and allowed to reenter the water body. The fact that water reenters somewhat warmer than when it left and a much greater supply of water is required make this method unlikely. The evaporation pond method involves the use of a large holding pond from which water is pumped into the steam cooler, heated, and returned to the pond. As the name implies, considerable evaporation occurs as the water cools in the pond. The third method involves cooling towers which are structures over which the heated water from the steam cooler can be cascaded. As the water cascades, it is cooled by air contact and evaporation. Thus, the cooling tower method also loses considerable water to evaporation. The fourth method involves the "dry cooling towers" which are similar to the cooling towers above except that they are enclosed to prevent evaporation loss. These towers are very inefficient and thus require more towers to cool the same amount of water. Also, each cooling tower

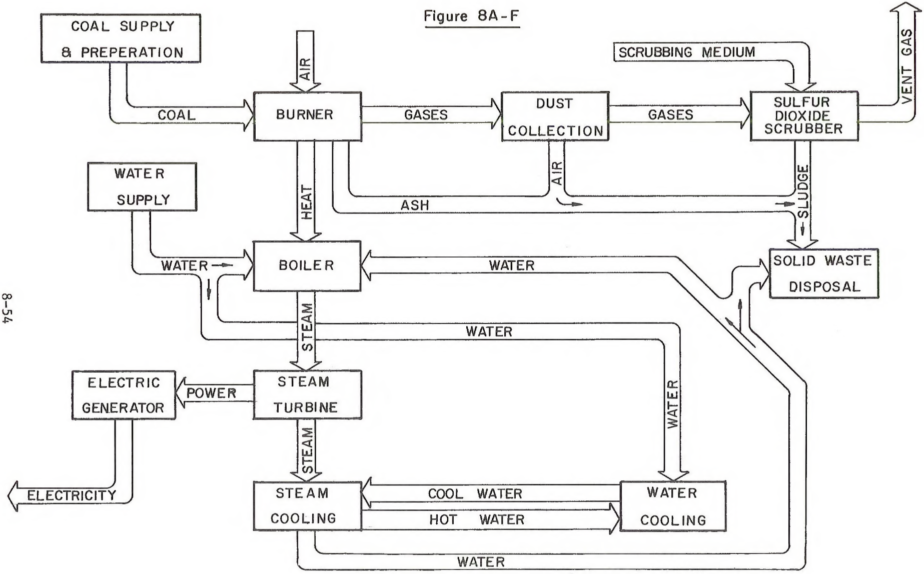
Boiler - The boiler consists of a network of tubes through which water or steam can run. The heat generated by coal combustion is transferred to the water in the tubes, causing it to vaporize and form a high temperature steam.

Steam Turbine - This component resembles, most nearly, a large fan with many blades. The high temperature steam from the boiler is allowed to expand against the blades of the turbine, causing the turbine to rotate rapidly. This rotary power can then be transferred to the electric generator. The steam is exhausted from the turbine to the steam cooler.

Steam Cooling - In passing through the turbine, the steam loses considerable energy and becomes cooler. The more the steam can be cooled, the more energy it loses and, therefore, the more energy it transfers to the rotation of the turbine. The steam is cooled by passing it through a network of tubes containing cool water. The steam is cooled by giving its heat to the water in the tubes. The water thereby is heated in the tubes and is exhausted from the cooling unit as hot water. Another function of steam cooling is the condensation of the steam to water which can be recycled to the boiler or some other water-requiring unit in the plant.

Electric Generator - The generator converts the rotary power supplied by the turbine to electrical power for public consumption. The unit consists basically of an electrode coil device which is surrounded by a large magnet. The electrode is rapidly spun in the

Figure 8A-F



COAL FIRED STEAM ELECTRIC
GENERATION FLOW DIAGRAM

methods are somewhat variable, water needs are flexible. But, with 12,500 acre-feet/year of water available to each company, a reasonable assumption as to plant capacity is 1,000 megawatts (MW). This would require about 10,000 tons of coal per day or some 3,500,000 tons per year. Land use for a plant this size is quite variable because land requirements are not necessarily related to the capacity of the plant. A reasonable assumption for the land needs of a 1,000 MW plant is somewhere between 100 and 500 acres.

8A.2.1.3 The coal fired steam electric generation plant

In building the generation plant, several engineering modifications or alternative subcomponents could be used. However, the process is still the same, basically, and the generation plant will follow the flow diagram on the following page. As in the other process descriptions, the process can be broken down into two sets of components--process components and support components.

Process components

Coal Preparation and Supply - This component includes the mining, crushing or grinding, transport, and storage of the coal. After mining, coal is transported by some means such as truck, rail, conveyor, or slurry pipeline. Then the coal will likely be crushed to a fine size for burner feed. Finally, if the coal is not to be immediately used, it may need to be stored.

Burner - Here the coal is mixed with air and combusted. A great deal of heat is generated and then transferred to the boiler. Combustion gases and ash are the by-products of coal burning, and both are sent from the burner for further processing.

ARTIST's CONCEPT of 860 MW PLANT

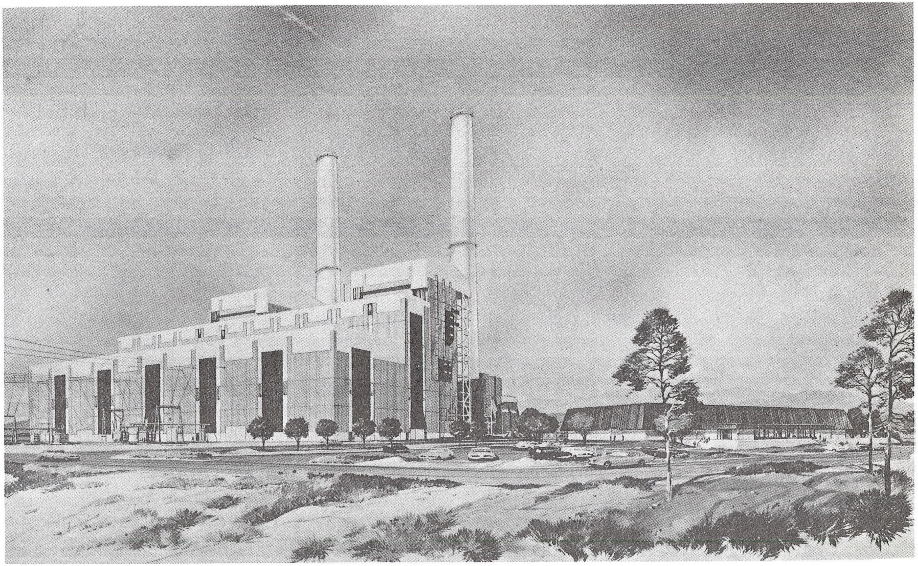


Figure 8A-E

FROM: Naughton Units 4 and 5 Environmental Impact Statement

The MHD system would be run most likely in series with either a steam or gas turbine because a great deal of the heat in the gas coming through the MHD channels is still available to drive a steam or gas turbine. Although the MHD system is still in an early stage of development, it has been estimated that this system could yield an efficiency as high as 65 percent.

Likely, within the area of study, and considering the state of the art of coal fired electric generation, the steam turbine system would be used if electric generation is considered as an alternative. In the study area, the steam turbine has been used traditionally by most companies. Gas turbines do not lend themselves well to using coal as fuel owing to the abrasive qualities of the combustion gas, and MHD systems are still in an early stage of commercial development.

8A.2.1.2 Plant disposition assumptions

A number of coal fired steam electric generation plants have been built, and the technology is well understood. Requirements of feed materials and the nature and amounts of products can be predicted with some accuracy. However, there are engineering modifications which make various plants differ as to particular coal or water usages. For example, where coal is expensive and water cheap, cooling water may be excessively used, with little concern for recycle, in an attempt to increase efficiency and thereby lower coal consumption.

The size of the electric generation plant is dependent to some extent on the amount of water available. Since most of the water used in a steam electric generation plant is used for cooling, and cooling the turbine, it is cooled as much as possible. This cooling is important because the efficiency of energy conversion in the turbine increases as the difference between the steam temperatures on the inlet and outlet sides of the turbine. Typically, the efficiency of a coal fired steam turbine operation will run from 35 to 40 percent, meaning that 35-40 percent of the energy available in the coal has been converted to electrical energy.

Gas Turbine (GT) - In the gas turbine system, the hot gases from combustion are used as the working medium. These gases expand directly against the turbine to impart rotational energy to the electric generator. A problem with coal combustion in GT units is that the combustion gases contain high amounts of water vapor, sulfur dioxide, and particulate ash matter which tend to be very abrasive to turbine blades. Therefore, natural gas (with minimum particulates and SO_2) is preferable to using coal as fuel. The gas turbine system is of roughly the same efficiency as the steam turbine; its big advantage over steam being that it does not require the rather complex steam generating system.

Magnetohydrodynamics (MHD) - The MHD system uses coal as a fuel to provide heat which propels an electrically charged gas through channels containing electrodes. Surrounding the channels are large magnets which cause current to be induced in the charged gas as it passes through. This current is drawn off by the electrodes to supply a direct electrical voltage source.

8A.2.1.1 Coal fired steam electric generation

Electricity can be generated by transferring the energy from coal to a working medium which in turn operates an electric generation device. The energy in the coal is released by the process of combustion in air. First, the volatile fraction of the coal, the hydrocarbons (CH_2), are combusted to yield carbon dioxide (CO_2), water vapor (H_2O), and heat energy:

$$CH_2 + \frac{3}{2} O_2 \text{ (from air)} \longrightarrow CO_2 + H_2O + \text{heat}$$

The fixed carbon (C) then burns to yield carbon dioxide and heat energy:

$$C + O_2 \longrightarrow CO_2 + \text{heat}$$

Some sulfur and nitrogen in the coal are oxidized to sulfur dioxide (SO_2) and nitrogen oxides (NO_x):

$$S + O_2 \longrightarrow SO_2$$

$$N + \frac{x}{2} O_2 \longrightarrow NO_x$$

The inorganic ash portion of the coal is not combusted but remains as a fine, dusty waste material, while the moisture in the coal is vaporized to water vapor. There are three commonly discussed systems which accomplish conversion of heat energy to electricity.

Steam Turbine (ST) - In this system, the working fluid, water, is heated until it becomes a high temperature steam. The steam is allowed to expand against a turbine, causing it to turn and thereby converting the heat energy to rotational energy. This rotational energy is transferred to an electriogenerator which in turn converts the energy to electrical energy. As soon as the steam passes through

8A.2.1 Assumptions and analysis guidelines for alternatives

Coal Fired Steam Electric Generation - 2 Plants

1.	Product	1,000 megawatts/plant
2.	Coal Use	3-4,000,000 tons/year/plant
3.	Water Use	16,275,000 tons/year/plant 12,500 acre-feet/year/plant 0.16 acre-feet/year/person
4.	Water Evaporation	14,000,000 tons/year/plant
5.	Waste Ash and Dust	500,000 tons/year/plant
6.	Emissions:	
	sulfur dioxide	21,000 tons/year/plant
	nitrogen oxides	28,000 tons/year/plant
	particulates (with dust control)	1,100 tons/year/plant
7.	Transport Systems:	
	coal	1-2 round trips/unit train/plant 100 round trips/100 ton truck/plant 1.5 foot slurry pipeline/plant
	water	3 foot pipeline/plant
8.	Land Use	100-500 acres/plant 0.16 acre/family 6 acres/pipeline mile 10 acres/transmission line mile
9.	Population:	
	construction labor	peak) 2,000-4,000/plant average) 2,000/plant
	operational labor	150-350/plant
	population multiplier factor	4-5
	construction population	8,000-20,000/plant
	operational population	600-1,800/plant
10.	Time Frame:	
	construction	4 years
	operation	30 years

8A.1.3 References

1. Clean Energy from Coal - Pittsburgh Energy Research Center - Energy Research and Development Administration, March 1975.

2. Clean Energy from Coal Technology, Department of the Interior, Office of Coal Research.

3. Coal Development Alternatives - An Assessment of Water Use and Economic Implications, David D. Freudenthal, Peter Ricciardelli, Michael N. York, Wyoming DEPAD, December 1974.

4. Environmental Impacts of Alternative Conversion Processes for Western Coal Development, Old West Regional Commission, Dr. Steven Miller and Thomas E. Carroll and Associates, October 1974.

5. Shaping Coal's Future through Technology, Office of Coal Research, Department of the Interior, 1974-75.

6. Solving the SO_2 Problem - Where We Stand with Applications and Costs, J. Jonakin, Coal Age, May 1975.

Fire protection

As with law enforcement, additional manpower and facilities would be required for fire protection. Inability of communities to respond to deficiencies in manpower and facilities could result in increased property damage and loss of life.

Water and sewer facilities

If water and sewer facilities are not expanded in a timely fashion to meet the demands of an expanding population, significant secondary impacts could develop. If water is not treated properly, serious health hazards could develop. Use of a poor quality water could result in a higher incidence of disease and possibly to epidemics of major diseases.

Overuse of the sewage facilities could result in more sewage being dumped into stream channels. This would lower water quality and impact fish and wildlife populations. The polluted water could also act as the source of diseases, especially if ground water aquifers become contaminated.

If timely accommodations are not provided for the increasing enrollments, the following impacts could result:

1. Classroom sizes would quickly reach capacity and necessitate very high students to teacher ratios;

2. Due to overcrowded conditions and the lack of classrooms in existing school facilities, it may be necessary to use temporary structures such as mobile trailers and modular units;

3. The lack of classrooms and adequate space (gymnasium, play areas) could cause a school district to operate certain schools on a double session basis;

4. Inter-county bussing of students between school districts could result and become necessary; and

5. The quality of education could be affected adversely.

Health and social services

The county or counties affected by the population increase would experience an increase in demand on their health and social services. As a result, health and social services manpower requirements would increase and shortages in manpower would likely occur.

Facilities and services would also receive increased demands. As a result, overcrowding of facilities and an over-extension of service capability may occur, ultimately causing a reduction in quality of health care.

Law enforcement

Population growth would create a need for increases in police manpower and facilities. If this increased need could not be met in a timely manner, crime incidence would rise.

incomes, and probably inflation of prices and property values, would be particularly adverse on that portion of the population living on fixed incomes, such as disabled, aged, and welfare recipients. Although this condition is almost universal, rapid industrial growth could likely worsen the situation.

Housing

Based on an assumed 3.5 persons per household and an estimated population increase of 18,750, there could be a demand for approximately 5,000 to 5,500 housing units to meet the needs of the population influx as a result of the development of the two coal gasification plants.

The influx of a work force with associated families would create an immediate housing demand in whichever community or communities the increased population located. The present supply of housing would be inadequate to meet the projected housing demands. Consequently, new housing would be required if the demand is to be met.

Impacts likely to occur as a result of this housing demand are a shortage of housing, inflated prices for housing, and the use of substandard housing units.

Public education

The rise in population levels and immigration of various work forces with associated families would cause an increase in public school enrollments. Increasing student enrollments in turn would impact enrollment capacities of existing school district facilities and teaching staffs.

Employment

An employment growth of 8,500 is possible as a result of construction of the liquefaction plants. Construction labor per plant could vary from 1,500 to a peak of 3,000. Construction could take three years per plant. Permanent employment to operate each liquefaction plant is estimated at 1,000.

The assumed industrial development would provide a large number of basic and secondary jobs which would compete for the available labor supply. Skilled labor shortages for construction peak may be severe and could be worsened by simultaneous plant construction.

The growth in industrial employment would attract labor from other sectors of the economy--agriculture, services, etc.--which could create at least short-term labor shortages in those sectors.

Jobs in the services sector (such as enforcement) would be difficult to fill, as salaries tend to be fixed with no allowarnce for areas of inflated incomes. The consequences could be recruitment problems, inferior personnel, and understaffing.

Income

Income levels for the entering industrial worker would probably range from $10,000 to $15,000 per year. Whether or not these incomes are sufficiently attractive to lure employees to the Eastern Powder River Basin is unknown. While incomes of the industrial workers would be high, incomes of the work force in supportive employment, e.g., government services and consumer services, may be relatively lower. The average income of the induced labor force would be greater than or at least equal to that of the region ($10,900). The effects of rising

8A.1.2.15 Socio-economic conditions

The assumed industrial development with associated increases in employment and population would have varying impacts on the socio-economic conditions of the area.

Population

The following population figures are estimates of population growth that might result if liquefaction plants are constructed. These figures do not reflect population and employment for coal mining.

Potential Population Growth in the Study Area

PROCESS	LIQUEFACTION 70-150,000 BPD (2 plants)
Low estimate, new permanent employment	2,000
Induced non-industrial employment 1/	2,000
Total new employment	4,000
Additional population 2/	12,000
Low estimate, average temporary construction employment	3,000
Induced non-construction employment 3/	1,500
Total new construction related employment	4,500
Additional population 4/	6,750
All new employment	8,500
All additional population	18,750

1/ Assumes 1 new non-industrial employee per each new industrial employee.
2/ Assumes 3 persons per each new employee.
3/ Assumes 1/2 new non-construction employee per each construction employee.
4/ Assumes 1-1/2 persons per each new construction related employee.

While the addition of 18,750 people is not necessarily adverse, the impact of population growth may generate negative secondary effects which are discussed in the following sections.

adjoining private land from federal grazing leases and division of grazing allotments by fenced rights-of-way may cause loss or realignment of leases.

Some grazing lands could be affected by increased erosion, sedimentation, and headcutting in productive drainage bottoms, resulting in additional losses of livestock forage. Sedimentation of livestock reservoirs would cause loss of water through reduction of storage capacities.

8A.1.2.13 Transportation networks

Impacts on transportation networks result from construction and operation of the plant sites, associated transport systems, and increased employment and population, all of which create additional use of existing networks likely requiring modification and/or upgrading.

Roads and highways would be affected throughout all phases of the development. Increased use of the existing roads and highways requires increased maintenance expenditures, upgrading to higher road standards in some cases, and possibly relocation of sections of particular routes.

Construction of the new transportation networks would result in conflicts with existing systems such as disruption of an existing facility while new ones--crossing or affecting systems in operation--are under construction. Once built, though, the new transportation facilities may complement or improve the existing facilities.

8A.1.2.14 Land use controls and constraints

Liquefaction development may precipitate a need to revise or develop land use controls and constraints, as existing planning may not adequately guide development.

8A.1.2.12 Agriculture

Agricultural use is a dominant use on lands within the area; therefore, industrial development would ultimately reduce available agricultural lands. Land use changes which would occur to accommodate plant sites, community development, and access systems are estimated at over 4,000 acres.

With regard to livestock grazing in the area of consideration, a loss of approximately six acres would represent an estimated loss of one animal unit month of grazing (AUM). An AUM is a measure of forage or feed requirement to maintain one animal (cow or five sheep) for a period of thirty days. Using the above acreages, which excludes the transportation systems, the annual loss of livestock forage could range from 600 to 700 AUMs.

Besides direct loss of livestock forage, secondary impacts associated with population increases would occur due to construction and related development. Vandalism and accidental property damage may increase due to larger numbers of hunters and outdoor recreationists. Animals may be harassed or harmed by recreation use, such as off-road vehicles.

Construction and fencing of railroads, highways, and service roads will lead to land separation and alter present ownership patterns. This would lead to separation and isolation of ranch properties, disruption of established use patterns, and access problems for watering and livestock care. Small isolated tracts could result which are too small in size to be used profitably. Livestock drifting during severe weather may be trapped by fences and lost. Physical separation of

8A.1.2.11 Recreation resources

Impacts on recreation resources would primarily result from increased population within the region due to construction and operation of coal liquefaction plants. Another potential source of impact would be the loss of land base committed to recreation use. Development of material sites, replacement agriculture lands, and increased recreational use, such as off-road vehicle use, would alter additional recreational land. Private land normally available for this type of use may be closed and posted, further reducing the recreation land base.

Much of the sand, gravel, and clinker material may be mined from stream courses, alluvial mountain slopes, or limestone outcrops within the study area. This would impact scenic recreation lands, either directly (streambeds) or indirectly (sightseeing).

The anticipated population growth would generate increased demand on recreation facilities. Recreation facilities near the population centers of Gillette and Douglas would experience the greatest demand and be subjected to greatest impacts.

Reduction in air quality from industrialization would impact the recreational sightseer. During inversion periods and high winds, visibility would be reduced, obscuring to some extent the scenic views of the area and reducing the visitor's enjoyment. Additional powerlines would also impact the sightseer and reduce his enjoyment of the view. It may also affect long-term economic strength for certain sectors by reducing nonresident recreation days. Increased use of recreation resources outside the area could result in the lowering of recreation quality in an ever-widening circle.

--Initial destruction of habitat followed, in time, by some degree of recovery in habitat value.

--Impairment or reduction in value of habitat near human development or activities.

--Increased introduction of hazards into the wildlife environment.

--Off-site and secondary impacts caused by displaced animals, disrupted food chains, changed land and water uses, etc.

--Improvement of habitat.

8A.1.2.9 Cultural resources

There would be approximately 4,000 acres disturbed during construction of the plants, community facilities, and access systems. If cultural sites exist in this acreage, they would be damaged and/or destroyed, making the values unavailable for future study and salvage. Besides the direct impact of construction, indirect impacts would result from population increase generated by construction and operation of the facilities. Recreational use associated with this population would impact known as well as unknown sites throughout the study area. Arrowhead hunters, rock collectors, pot hunters, and off-road vehicle users would disturb additional surface acreage, destroying evidence which could provide information on cultural sites. Beneficial impacts would result from inventory and recognition of the cultural values.

8A.1.2.10 Aesthetics

Construction, physical presence, and operation of liquefaction facilities, transportation systems, and residential and commercial development would generally have an adverse effect on the aesthetics of the area through alteration of the landscape, increased noise levels, and air contaminants such as dust and plant and vehicular emissions.

In addition to the loss of vegetation from physical disturbance, the potential would exist for damage to occur as a result of air contamination consisting mainly of particulates, salt drift from cooling tower water evaporation, sulfur dioxide (SO_2), and nitrogen oxides (NO_x).

Increased population would intensify recreation use which would destroy or decrease the vegetative cover. Secondary impacts from loss of vegetation would result, such as increased soil erosion (wind and water), loss of cover for wildlife, loss of livestock forage, and adverse effect on aesthetic values.

8A.1.2.8 Fish and wildlife

Liquefaction development would result in impacts on the fish and wildlife in that wildlife and its habitat would be destroyed and overall populations would be reduced. Also, the increased human activity would affect wildlife and its habitat.

There is a direct cause-effect relationship involved with impacts on fish and wildlife as a result of industrial development. Direct mortality is rare on big game and other types which have the ability to flee. The direct action of industrial development destroys or impairs habitat. This impact on habitat then translates itself into an impact on fish and animal residents, resulting in loss of population.

Each wildlife species in the study area would be subject to the cumulative effects of several of the different categories of impacts caused by industrial development. These include:

--Direct destruction of animals.

--Permanent destruction of habitat.

8A.1.2.5 Mineral resources

The primary impact on mineral resources in the area is the removal and subsequent use of 1,080,000,000 tons of coal during the projected thirty-year life of the liquefaction plants. Significant amounts of sand, gravel, fill dirt, and limestone may be used for construction purposes. Energy fuels would be consumed by the equipment used during construction and plant operations.

Depending upon the ultimate location of the plant sites and transportation facilities, there could be a conflict if construction occurs on mineralized areas, hampering the development of those minerals.

8A.1.2.6 Water resources

The consumptive water use for the assumed coal liquefaction plants would be approximately 25,000 acre-feet per year.

Other impacts on water resources in the Eastern Powder River Basin would result from the approximately 3,000 acre-feet/year required for the increased population supporting coal liquefaction developments. Water presently being used for other purposes such as agricultural use, recreation, and fish and wildlife populations would be needed to support added population.

8A.1.2.7 Vegetation

Vegetation would be destroyed in three principal areas--the two liquefaction plant sites (approximately 1,000 acres per site), the land area required for the transportation systems (roads, railroads, pipelines, etc.), and the land area required for residential and commercial development (2,000 acres) to meet increased population needs.

8A.1.2.3 Topography

The land surface would be altered during site preparation for the two assumed plants, which would require approximately 2,000 acres. Another 2,000 acres would be disturbed to accommodate community growth. Construction of roads, powerlines, pipelines, and railroads would result in alterations of the land surface. The disturbance would consist of earthwork and grading to facilitate construction of facilities.

8A.1.2.4 Soils

Soil disturbance would result from construction of the liquefaction plants, community development, and associated transportation systems. The soils on the majority of over 4,000 acres would be disturbed.

As sites are unknown, the length of rights-of-way for the transportation systems is also unknown. However, construction of these facilities will result in additional soil disturbance. An average disturbance of five acres per lineal mile for the various transportation facilities is estimated.

Disturbances on the construction sites would result in fine grained soil and parent material being exposed to wind and water actions. Soil productivity, permeability, and infiltration rates would be reduced, increasing runoff, soil erosion, and sedimentation. Wind action, which is almost constant over the entire area, would cause fine soil, silt, and clay particles to be lifted into the atmosphere, reducing air quality and adding to soil loss. Prior to revegetation of exposed soils, soil erosion resulting from high intensity storms would remove fine materials and 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, adding to soil loss and sedimentation.

8A.1.2.2 Air quality

Development of two coal liquefaction plants, transportation systems, residential areas, and disturbances of relatively large areas of land would create multiple sources of air pollutants which, with prevailing upper level wind direction (northwest), could affect existing communities to the south and east of the sites.

Potentially, the most serious cumulative impact on air quality, with possible adverse impact on humans, animals, and vegetation, is from gases emitted by the two liquefaction plants. Emissions include sulfur oxides, nitrogen oxides, carbon monoxide, hydrocarbons, hydrogen sulfide, and particulates. Relative amounts of emissions are too uncertain to predict.

The industrial development and attendant population increase (15-20,000) would increase use of internal combustion engines of all types. Engine emissions would result in the addition of carbon monoxide, hydrocarbons, particulates, nitrogen oxides, and sulfur oxides in the basin air.

Increases in airborne dust and similar particulate matter would result from development activities. Airborne particulate matter could reduce visibility and possibly cause traffic accidents during periods of inversions and periods of high winds. Particulate matter could also contribute to human allergies and similar irritations and coat vegetation with potentially harmful chemicals.

Present ambient air quality in the area is good, but it would decline with the development of complex pollution sources.

8A.1.2 Probable impacts of coal liquefaction

The impacts described below are those which can be anticipated as a result of the construction, operation and maintenance, and phase out of two 70-150 thousand barrel per day (BPD) coal liquefaction plants with related transportation systems and community facilities. Again, in view of other major energy development proposals in the area, the impacts of coal liquefaction must be reviewed as part of the cumulative impact of all of the potential projects in the Eastern Powder River Basin. As specific plant sites have not been identified, impacts described are those which would be common to most any future plant site(s) within the study area.

8A.1.2.1 Climate

The coal liquefaction plants would likely result in some minor changes in the micro-climate of the immediate plant areas, such as slight increases in air temperature and humidity.

In conjunction with other proposed and projected development in the Eastern Powder River Basin, climate could be affected to a significant degree.

As mentioned before, recent studies indicate that large urban-industrial areas affect precipitation. However, studies have not been conducted in semiarid climates; therefore, potential effects are inferred from theoretical studies of climate modification in other areas. Some evidence indicates that changes of atmospheric particulate loading and alteration of the earth-atmospheric energy balance may contribute to creation of drought conditions in semiarid climates.

8A.1.1.6 Typical liquefaction project summary

1.	Process used	Generalized from SRC and COED processes
	Synthetic liquid fuels	70-150 thousand BPD depending on the process
2.	Coal consumption	18 million tons per year
3.	Coal reserves required (assumed 30-year life)	540 million tons
4.	Water requirements	12,500 acre-feet
5.	Land needs	1,000 acres
6.	Employment	1,200-1,5000
7.	Construction employment (five years)	a) peak - 2,500-3,500 or higher b) average - 1,500-2,000 or higher
8.	Total plant investment (order of magnitude, 1975 dollars)	\$300-\$500 million(?) (too conjectural to estimate)
9.	By-products	sulfur - 30,000-50,000 tons/year ammonia - 50,000 tons/year tar acids - 24,000 tons/year phenol - 49,000 tons/year aqueous hydrogen cyanide - 3-30 tons/year ash - 1,600,000 tons/year particulate matter - too conjectural sulfur oxide - to nitrogen oxides - estimate
10.	Utilization factor	90 percent
11.	Thermal efficiency	70 percent (OCR estimate)

rather sudden closeout would not likely happen, a gradual phaseout being more likely.

Unless some sort of plant deconstruction plan is implemented, the plant may be abandoned. However, some of the equipment and structures may have salvage or second-hand value. The plant site can then be cleared of any remaining structures and the site may be returned to a natural topography. This would mean a short-term, several months, period of heavy vehicular traffic somewhat similar to the construction phase. Access systems may also be removed if no longer needed for transport systems. These rights-of-way can also be returned to a somewhat natural aspect.

The labor force may well reach over 3,500 workers. During various periods during the construction schedule, the force will include, in addition to a large number of manual workers, many equipment operators, welders, masons, iron workers, and pipe fitters. The construction schedule will likely resemble the schedule diagrammed for the gasification plant.

Routine plant operation

As construction of the site draws to a close, the operating crews will be trained and the plant systems will be tested and brought into production. When the plant is operating at a steady level, the labor force will stabilize. The operational phase time frame is somewhat dependent on economics and availability of raw materials, but a thirty-year life is a reasonable approximation. For the liquefaction plant, the operating crew will be approximately 1,200-1,500 workers. With the plant operational, a constant level of heavy duty commercial (rail and road) and light duty private traffic will persist.

Phase out and shutdown

Process plants are designed to run at full rated capacity or, occasionally, a bit higher and are often uneconomical to operate at reduced capacity. Thus, a plant will generally be run at as near full capacity as possible until the critical resource is depleted. When this happens, it is more economically sound to suddenly shutdown rather than gradually phase out operations. In the case of a liquefaction plant, product price and demand in addition to governmental policies can determine whether plant operation is economically feasible. However, this round trip, 100 car unit trains per day. Coal hauled by large, 100-ton, off-road trucks would require a road system capable of handling approximately 600 round trip truck hauls per day. Another alternative would be moving coal in a slurry pipeline. This would require approximately a three and one-half foot pipeline. The pipeline carrying raw water would be nearly as big as the slurry pipeline. Another one and one-half foot pipeline would have to be built to carry the synthetic crude oil to its market. Additional trains and/or trucks would need access to the plant to bring chemicals and haul away products, by-products, and wastes. Waste ash could be hauled back to the mine in the empty unit trains or in a pipeline paralleling the slurry pipeline. The right-of-way for the access systems would have to be cleared, leveled, and finally the system itself would be built. Also, before the plant becomes operational, access must be provided for employee roads, electric transmission lines, and telephone lines. The construction activities will resemble most nearly the construction of a two lane highway. Bulldozers, scrapers, trucks, and draglines, in addition to some specialized railroad or pipeline laying equipment, would generally be used. Crews would be fairly small and mobile.

During site preparation and setup, most of the 1,000-acre site will be leveled, storage and holding ponds dug, and finally buildings, storage structures, and processing equipment will be moved in and assembled. Many bulldozers, scrapers, trucks, draglines, cranes, and other vehicles will work at leveling the site.

ARTIST's CONCEPT of SRC TYPE PROCESS

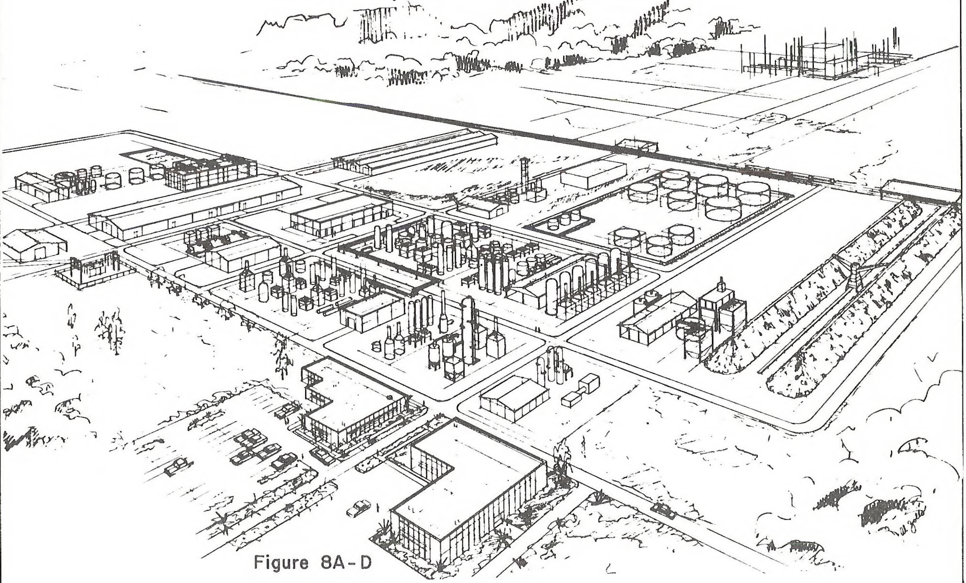
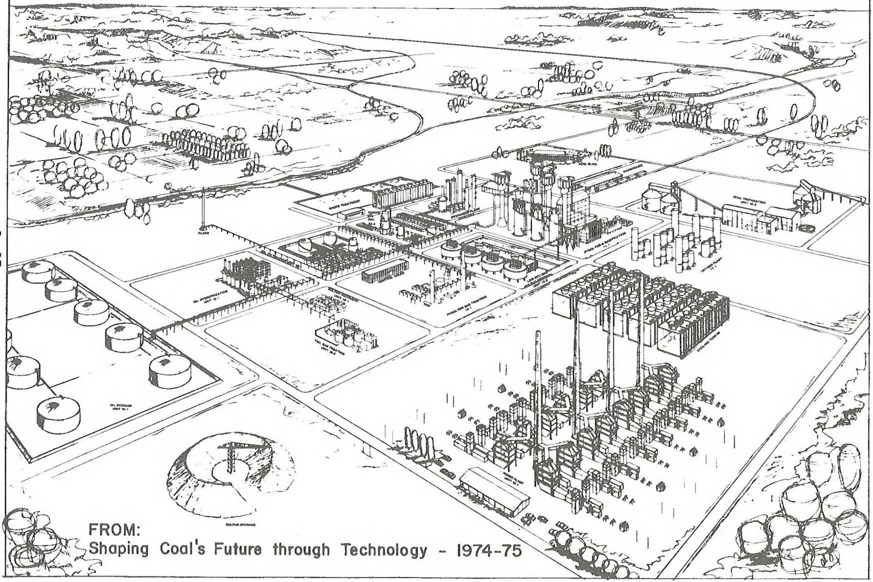


Figure 8A-D

FROM: Shaping Coal's Future through Technology - 1974-75

Figure 8A - C

ARTIST's CONCEPT of COED TYPE PROCESS



FROM:
Shaping Coal's Future through Technology - 1974-75

Heat balance - No heat balance for commercial scale coal liquefaction is yet available, but the Office of Coal Research has estimated that the thermal efficiency of liquefaction is approximately 70 percent.

8A.1.1.5 Physical plant

The coal liquefaction plant will most likely resemble the gasification plant previously described or a large oil refinery. Each plant site should cover approximately 1,000 acres, or some one and one-half square miles. As with the gasification plant, there are three phases during the lifetime of the plant--construction, routine operation, and phase out or shutdown.

Plant construction

Construction of the liquefaction plant will resemble gasification plant construction. Principle considerations are plant access and transport systems, site preparation and setup, and the labor force. The labor force will probably reach a peak of 3,000 to 3,500 individuals with some projections predicting a force of 6,000 people. Likely, most of the 1,000 acres will be disturbed or altered during construction.

Access to the plant is critical during all three phases of plant life. During construction, the site must be accessible to both equipment (caterpillars, scrapers, draglines) and labor, and provisions must be made for transport of large process components (reaction vessels, boilers, compressors, etc.) which cannot be assembled on site. Transport systems must be supplied for raw materials--coal, water, chemicals--as well as products, by-products, and waste products. If coal is to be shipped by rail, access must be provided, most probably, for five or six

Ammonia - The ammonia yield depends principally on the nitrogen content of the coal. It is not nearly so dependent on the process used, so regardless of the process, the yield might be something like 150 tons per day.

Tar acids and phenols - These are the organic products which tend to dissolve in the water used to condense the gaseous raw product from the liquefier in the COED process. In the SRC process, these compounds most likely will be incorporated in the main synthetic crude products and not show up as separate by-products. The COED type process may yield approximately 70 tons of tar acids and 140 tons of phenols per day.

Aqueous hydrogen cyanide - The COED process will not probably yield a large amount of hydrogen cyanide (HCN), possibly not even enough to constitute a by-product. Nominal HCN yield from the COED process might be some 3 tons per year (0.01 ton/day). The SRC process tends to produce more HCN, probably more like 30 tons per year (0.12 ton/day).

Ash - Based on the amount of coal being used each day and the amount of ash contained in the feed coal, approximately 4,500 tons of ash will be produced each day.

Air emissions - Emissions--sulfur dioxide, nitrogen oxides, and dust--are too conjectural to estimate, but if they are too high to meet Federal and State requirements, air emission controls may be necessary.

Raw materials

Water - Water is the limiting substance in this discussion. Each company has 12,500 acre-feet per year of available water.

Coal - The available water provides enough water to liquefy 50,000 tons of coal per day. If coal is used as a fuel for power and steam generation, or as feed for the gasifier, probably some additional 10,000 tons of coal would be required every day.

Air - A good deal of air will be required by the furnaces in power and steam generation, by the air separation plant, and by the gas treatment and sulfur treatment areas. Air should be readily available.

Chemicals - Some chemicals--catalysts, absorbents, biocides, corrosion inhibitors, pH controls, and various reaction media--will be required just as in gasification. This will be a relatively small item, amounting to something like one hundred tons per day.

Products

Synthetic crude oil - The various processes vary greatly in the amount of synthetic crude produced. The COED process would probably only yield some 70,000 barrels per day (BPD) or 11,000 tons per day because this process does not convert all the coal to liquid products but instead yields significant gas and solid products. The SRC process might yield up to 150,000 BPD or 24,000 tons per day of liquid products because this process yields nearly all the products in a liquid form.

Sulfur - The amount of sulfur recovery, again, depends on the process used and the amount of sulfur contained in the coal. The COED process recovers less sulfur, probably some 80 tons per day. The SRC process might yield something more like 140 tons per day.

product liquid fuels from this component would be somewhat similar to synthetic crude oil.

Gasifier - See COED process.

Hydrogen Plant - The hydrogen plant may include a shift convertor to enrich the gasification product gas in hydrogen if this unit is not a part of the gasifier. The hydrogen plant will also remove any carbon dioxide in the hydrogen using a specific carbon dioxide absorbent. The product from this component is a high purity hydrogen gas.

Support components

Gas Treatment - See COED process.

Sulfur Treatment - See COED process.

Ammonia and Hydrogen Cyanide Treatment - Both ammonia and hydrogen cyanide (HCN) are dissolved in water solution. Ammonia can then be separated from the solution and produced as anhydrous ammonia. Hydrogen cyanide is concentrated in water solution and yields aqueous hydrogen cyanide as a product.

Water Supply, Steam and Power Generation, Ash Disposal, Air Separation Plant, Emission Control Systems, and Ancillary Systems - See COED process.

8A.1.1.4 Material and energy balances

Since the various processes of coal liquefaction are in such an early stage of development, no commercial scale material or energy balances are available. However, from the bench scale work which has been done, an approximate idea has been obtained of what raw materials and in what quantity may be required. Some of the products, by-products, and wastes have also been tentatively identified and quantified.

and silos for storage; maintenance and construction equipment, buildings for laboratories and offices; and parking lots and loading areas.

8A.1.1.3.2 SCR Process*

Process components

Slurry preparation - In the slurry preparation component, finely crushed coal is mixed with light oil to form a thick coal-oil slurry.

Preheating and Dissolution - The coal-oil slurry is treated under high pressure with hydrogen gas to dissolve the coal in the oil and form a mixture of hydrocarbons. Gas is formed which is then sent to gas treatment.

Filtration - In this component, any undissolved char is filtered from the liquid raw product. This solid char cake is sent to be used in the gasifier.

Solvent Recovery - The liquid raw product is treated to separate light oil from heavier hydrocarbons. This light oil is then either recycled to prepare more slurry, or if enough is produced, some may be split out as a product light oil.

Solidification - The remaining heavier hydrocarbons may be split into two streams. One of these streams could be sent through solidification in which it would be converted to a solid fuel product.

Hydroconversion and Hydrotreating - Remaining heavier hydrocarbons could be sent through this component where they are reacted with hydrogen to bring the carbon:hydrogen ratio up to the desired 1:2. The

*Only components not common to both SRC and COED processes are described here to avoid duplication.

Ash Disposal - Residual ash (inorganic residue) from coal processing is quenched in water, thickened, allowed to settle into a thick, high density slurry, and finally disposed of--generally as fill in the coal mine.

Air Separation - Oxygen is required for the liquefier and in the gasifier to sustain the high temperatures required in the gasification reaction. This oxygen is supplied by cryogenic fractionation of air (separation of oxygen and nitrogen in the air by rapid cooling). The nitrogen created is vented back to the atmosphere.

Emission Control Systems - As in gasification, two air quality problems are presently dealt with using emission control devices. Particulate matter or dust can be removed from stack gases leaving the plant, generally the power and steam generation area, with better than 99 percent efficiency using the electrostatic precipitator. Other methods of dust collection such as baghouses or cyclones may be used.

The other emission control problem is countered by sulfur dioxide (SO_2) scrubbing. Primary sources of SO_2 are the steam and power generation area and the incinerated tail gas from the sulfur treatment area. SO_2 is scrubbed by using a chemical absorbent (limestone, dolomite, etc.) or oxidizing to SO_3 and converting to sulfuric acid, just as described in the gasification process.

Ancillary systems

The above mentioned systems are the principal features in a coal liquefaction plant. In addition, any plant will have pumps for moving liquids; values and piping to control gas flow; fans to direct air flows and combustion areas; stacks to vent exhaust gases; tanks, ponds

Sulfur Treatment - Acid sulfur gas can be converted to elemental sulfur much as it was in the gasification process. The gas leaving the sulfur unit may be incinerated to oxidize any remaining hydrogen sulfide to sulfur dioxide, which can then be controlled using a SO_2 scrubber.

Water Cleanup - Water from filtration and water from gas cleanup are treated in this component. Filtration water may contain dissolved organic products such as phenols and tar acids which are separated and saved as by-products. Ammonia dissolved in water can be separated and yielded as an anhydrous ammonia by-product. The purified water can be sent to the water supply unit and reused.

Water Supply - In this component, the incoming water for the process is purified and sent to steam and power generation to be used as boiler feed, or sent to the oil recovery unit to recover product gases. Water is also circulated through the plant for cooling purposes. Evaporation ponds and cooling tower structures are used to reclaim cooling water.

Power and Steam Generation - Heat, steam, and electricity needs for the plant are supplied in this area. Coal may be burned to provide process heat. Ash from coal combustion can be disposed of along with gasifier ash. Some heat from steam generation is recovered from cooling water by heat exchange. The gases yielded from coal combustion generally cause the greatest impact on air quality; thus, they must often have emission controls on the stacks from the power and steam generation area. The emission controls are discussed in more detail later in this section.

bearing gas is not condensed and is, thereby, separated and sent to gas cleanup.

Filtration - The raw product oil and water mixture is sent to the filtration plant where the water is separated and a liquid, water free raw product results. The water leaving the filtration stage may have considerable ammonia dissolved in it. This water would be combined with ammonia bearing water from the gas cleanup plant and sent to water cleanup.

Hydrotreater - The liquid product from filtration is enriched in hydrogen to yield the synthetic crude oil product. This may be accomplished using a catalyst and enough hydrogen to bring the carbon:hydrogen ratio up to 1:2. If carbon monoxide (CO) is present in the hydrogen feed, it will be oxidized to carbon dioxide and exhausted.

Gasifier - The hydrogen supply for the process is produced in the gasifier. Unreacted char left from the fourth stage of the liquefier is reacted with steam and oxygen to form hydrogen and carbon monoxide. In some processes this gas mixture would then undergo a shift conversion reaction to convert more water to hydrogen and carbon monoxide to carbon dioxide. Ash from the gasifier unit is sent to the ash disposal unit.

Support components

Gas Cleanup - Gases from the scrubber and oil recovery units are treated to recover by-products and wastes. Hydrogen sulfide (H_2S) is separated from the gas stream and sent to the sulfur treatment unit. The ammonia is dissolved in water and sent to water cleanup. The COED process produces little hydrogen cyanide (HCN), thus it may not be necessary to implement hydrogen cyanide treatment.

8A.1.1.3.1 COED process

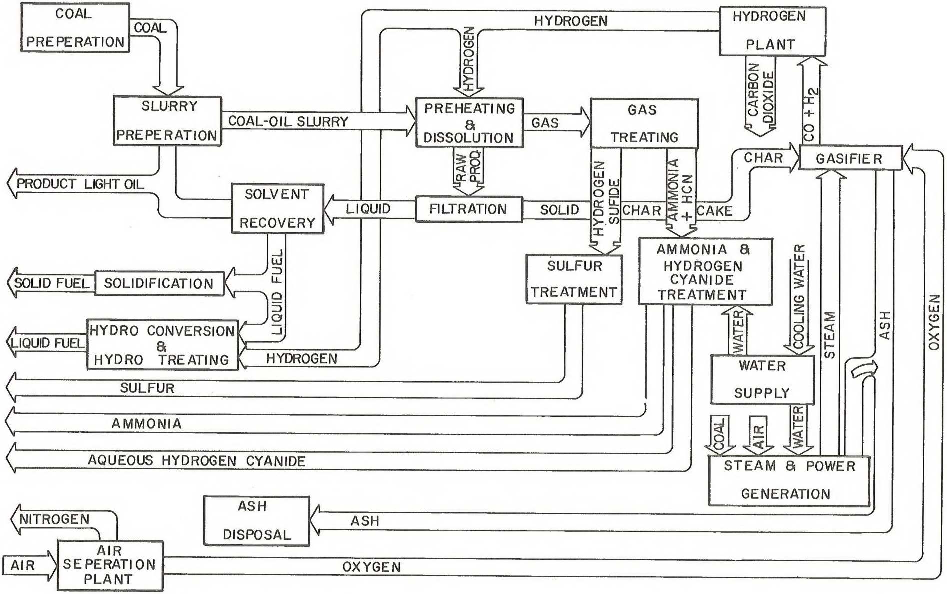
Process components

Coal Preparation - this is where the coal fed into the process is supplied and prepared. This includes coal mining, crushing, transport, and storage. Coal is mined, then transported to the plant by some means such as truck, rail, conveyor, or slurry pipeline. Then the coal may have to be crushed to a useable size. Finally, the coal may need to be stored until used.

Liquefier - The liquefier consists of four stages, each stage at a successively higher temperature. Coal is introduced into the first stage where, as it flows through the liquefier, it is first devolatized and converted to char, the carbon substance required in liquefaction. Oxygen and steam are introduced into the fourth stage of the liquifier and react with the char, yielding a raw product which further reacts in the other staging yielding a gaseous liquefaction raw product consisting of a mixture of hydrocarbons.

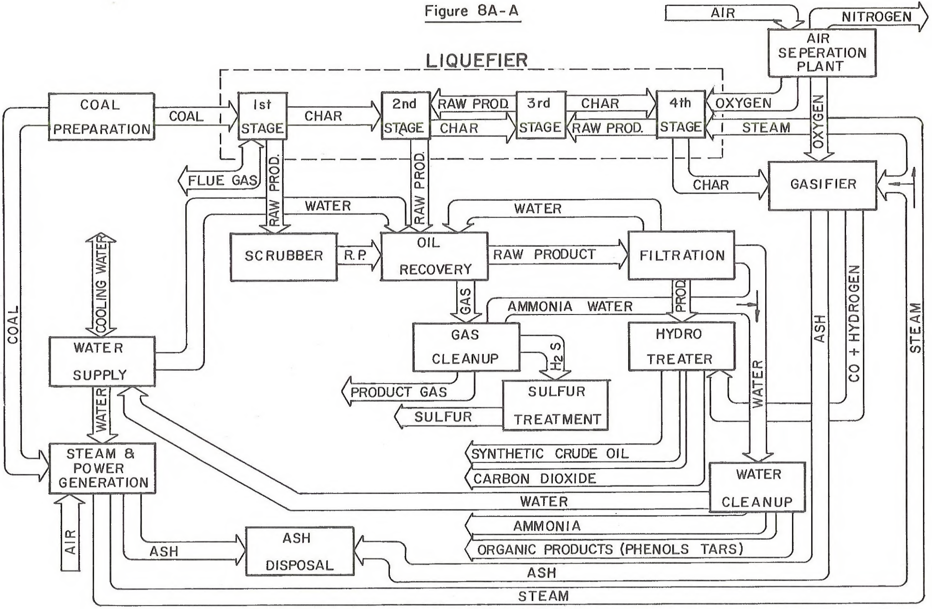
Scrubber - The raw product drawn from the first stage of the gasifier may contain some particulate matter dust loading. This is removed from the gas stream using some device for dust collection. Some of the raw product may be condensed and the nonproduct gas may be separated and sent to gas cleanup.

Oil Recovery - In the oil recovery system, the raw product gas is condensed to a liquid by cooling it with a water spray. The raw product then floats on the water and forms a water-oil emulsion. The nonproduct



SOLVENT REFINED COAL LIQUEFACTION

Figure 8A-A



COED PROCESS TYPE
COAL LIQUEFACTION

As in the case of coal gasification, the size of a liquefaction plant is related to the amount of water available. The quantity of water determines the amount of coal which can be processed. Coal liquefaction should use less water per ton of coal processed than the typical gasification process. Thus, with the 12,500 acre-feet water per year each company has available, a plant capable of processing approximately 50,000 tons of coal per day is possible. A plant of this size would probably yield between 70 and 150 thousand barrels per day (BPD) of synthetic crude oil type products. A liquefaction plant capable of converting 50,000 tons per day would likely require about 1,000 acres for the plant site.

8A.1.1.3 The coal liquefaction plant

There are many processes projected which will convert coal to a synthetic crude oil product. These fall into two classes, one typified by the COED process, and the other by the SRC process. Likely any liquefaction process that might be built would resemble one of these two processes with some slight engineering changes.

The following two pages illustrate typical flow diagrams for both the COED and the SRC processes. As in a gasification plant, these plants would consist of related components, combined to complete the process. These are broken down into two principal divisions--process components and support components.

The carbon dioxide (CO_2) is separated from the hydrogen, and the hydrogen is fed to the liquefaction reaction.

There are some advantages to liquefying coal as an alternative to gasification. These include:

(1) Liquefaction requires less water per unit of coal processed. Since lower hydrogen enrichment is required, and hydrogen is supplied from water, less water is required.

(2) Synthetic crude oil can be transported in a variety of ways (truck, rail, pipeline, etc.).

(3) Synthetic crude can be used to make many diversified products (petroleum products, petrochemical products, etc.).

(4) Synthetic crude oil is easy to store for future use.

Two processes are typical of coal liquefaction technology, each representing a class of liquefaction processes. The COED process is low pressure liquefaction which yields not only a liquid product but also some gas and solid products. THE SRC process is a high pressure liquefaction which yields almost entirely liquid product.

8A.1.1.2 Plant disposition assumptions

Very little is known about coal liquefaction, and at this time little can be projected as to what a commercial scale liquefaction plant would look like, what requirements it would have for feed materials, and what sort and quantity of products could be expected. Coal liquefaction is similar to gasification in many respects, and the plants would resemble each other, sharing many of the same component systems.

8A.1.1.1 Coal liquefaction

The chemical process behind coal liquefaction is similar to that used in gasification, the principal difference being that in gasification the carbon to hydrogen ratio is adjusted to 1:4, whereas in liquefaction the ratio is only increased to roughly 1:2.

The product from the liquefaction process is a synthetic crude oil substance which is made up of compounds known as hydrocarbons. These hydrocarbons consist of varying numbers of carbon atoms, chemically bound to form chains, each carbon atom also bound to two hydrogen atoms. Octane, a typical hydrocarbon found in crude oil, is a chain of eight carbon atoms and can be schematically represented as follows:

```
  H H H H H H H H
  | | | | | | | |
H-C-C-C-C-C-C-C-C-H
  | | | | | | | |
  H H H H H H H H
```

A typical symbol used to represent a hydrocarbon is $(CH_2)n$ where n stands for the number of carbon atoms in the chain. Using this symbol, the typical liquefaction reaction can be written as follows:

$$nC + nH_2 \longrightarrow (CH_2)n$$

where C is carbon and H_2 is hydrogen gas. The carbon is provided by coal and the hydrogen would most generally be provided using a partial coal gasification technique. The coal is first gasified to form a raw gas product consisting of carbon monoxide and hydrogen:

$$C + H_2O \longrightarrow CO + H_2$$

Then the gas is enriched in hydrogen using the shift conversion reaction.

$$CO + H_2O \longrightarrow CO_2 + H_2$$

8A.1.1 <u>Assumptions and analysis guidelines for alternatives</u>

Coal Liquefaction - 2 Plants

1. Product	70-150,000 BPD/plant 4-8,000,000 tons/year/plant
2. Coal Use	18,000,000 tons/year/plant
3. Water Use	16,275,000 tons/year/plant 12,500 acre-feet/year/plant 0.16 acre-feet/year/person
4. Water Evaporation	10,000,000 tons/year/plant
5. Waste Ash and Dust	1,500,000 tons/year/plant
6. Emissions:	
sulfur dioxide	Uncertain
nitrogen oxides	Uncertain
particulates (with dust control)	Uncertain
7. Transport Systems:	
coal	5-6 round trips/unit train/plant 600 round trips/100 ton truck/plant 3.5 foot slurry pipeline/plant
product	1.5 foot pipeline/plant
water	3 foot pipeline/plant
8. Land Use	1,000 acres/plant 0.16 acre/family 6 acres/pipeline mile 10 acres/transmission line
9. Population:	
construction labor	peak) 2,500-3,500/plant or higher average) 1,500-2,000/plant or higher
operational labor	1,000/plant
population multiplier factor	4-5
construction population	10,000-17,500/plant
operational population	4,000-5,000/plant
10. Time Frame;	
construction	5 years
operation	30 years

8A. Alternatives - Assumed industrial use of water

The industrial development of coal and water resources offers several alternatives to the developer. The production of synthetic natural gas by the process of coal gasification is discussed as the probable use of industrial water. The synthesis of crude oil from coal is possible using the coal liquefaction process; however, this process is still in the pilot stage and requires more development work. Coal fired steam generation of electricity is a quite common process (Jim Bridger plant or Dave Johnston plant); however, neither of the companies buying the water is traditionally in the business of electric power generation. Coal can be finely crushed, slurried with water, and transported through a pipeline to a market not in the area of study, but, again, this has not been the usual method for these companies.

Coal liquefaction, coal fired steam electric generation, and the coal slurry transport system are therefore discussed as alternative uses of the industrial water. Each process is described in some detail followed by an analysis of the probable impacts. Generally, these impacts are similar to those engendered by the gasification plants. If a substantially different impact seems likely, it will either be classed as an unavoidable impact, or a method of mitigation will be suggested.

route. The south route has about 2 miles of the unstable Thermopolis shale as compared to 3 miles of shale on the proposed route and less than 1 mile on the north bank route.

Alternative road impacts

Impacts of the proposed route can be found in Section 5 in the individual functions. Some comparisons with the proposed route will be made where significant differences occur.

The north bank route generally follows the sandstone outcrop, the most suitable roadbed formation of the other two routes.

Although none of the routes have been systematically invertoried for cultural resources, this route has the greatest potential for disturbance for both prehistoric and historic sites. This sandstone bench provided a good location for past use and contains more evidence than the other routes to substantiate this observation. Wildlife such as deer, which use the reservoir for watering, may cause more accidents between vehicles and animals.

The south route would least serve the recreational use of the reservoir. Since this route completely skirts the primary use area, close to the minimum pool, an additional road would be required to provide for recreational use.

Wildlife would be affected to similar degrees by this route as compared to the proposed route. In each case, habitat would be dissected and disturbed to a greater extent than the north bank route.

Although this route has the opportunity for the best alignment, due to the gentle curvilinear draws, additional distance is 3.6 miles to Barnum, as compared to the next longest or proposed route.

The quality of the roadbed materials for the south road are not as good as the north bank route, but appreciably better than the proposed

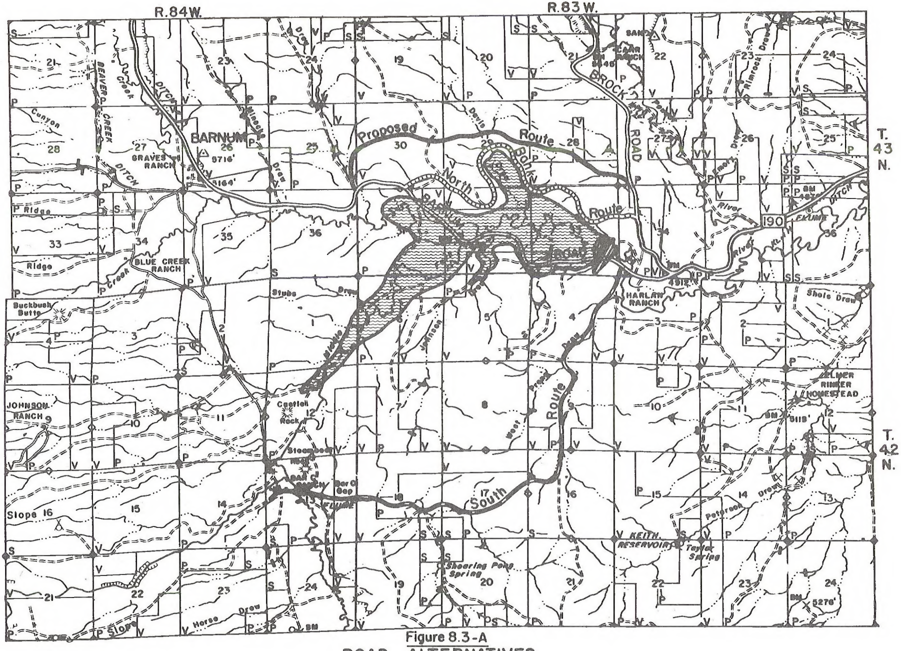


Figure 8.3-A
ROAD ALTERNATIVES

8.3 Alternatives of highway relocation

The no action alternative of the proposed state secondary Highway 190 cannot be considered with the proposed reservoir site. This site would cause inundation of the existing highway when the reservoir becomes operational and the major borrow area, the emergency spillway cuts the existing highway at one point.

Neither the applicant nor any of the preceding investigations, Bureau of Reclamation or J. T. Banner and Associates, did any road alternative studies and at least two other routes appear reasonable enough for consideration. These alternative routes are depicted on Figure 8.3-A and for purposes of discussion are designated the proposed route which the applicant submits, the north bank route which follows the north edge of the reservoir as close as topography permits, and the south route which lies south of the reservoir and proceeds south up Arminto Draw to its divide then drops down into and follows Bar C Draw to the Bar C Road.

Approximate distances were estimated for a length comparison of the three routes. Since these routes do not begin nor terminate at the same points, the common junctures of the Brock Road and Highway 190 and the town of Barnum were selected to compare the overall distance.

	New Construction	Brock Road and Highway 190 Junction to Begin Route	Terminus of Route to Barnum	Total
Proposed Route	6 miles	1.2 miles	2	8.2
North Bank Route	5 miles	.9 miles	3	8.9
South Route	7 miles	.5 miles	5	12.5

to grant the loan to the Middle Fork Reservoir Company and the State Engineer's Office to terminate the water rights based on the inability to make use of the water.

The alternative of no action would make it possible to avoid adverse impacts on the cultural resources at the reservoir site. Fish and wildlife resources would be maintained on their existing level. Riparian habitat on the free-flowing condition of the water body would continue in its present condition subject to natural changes. (See the existing environment for a description of this present condition.)

8.2.2 <u>Delay action until specific information is received</u>

More specific information on the reservoir operation and agricultural water use could be available within a short time since an agreement appears imminent on the already-formulated most probable operation plan.

The amount of delay in the availability of information on the industrial use would depend upon how specific the information needs to be. Detailed plans on specific sites may not be formulated for several years.

The significant item in consideration of this alternative is that both the loan application and the water right would still be in jeopardy if the right-of-way application were placed in a holding status. The strong demand from other potential users for the water under this particular right and the strong demand for the funds involved in the loan would cause considerable pressure on the State Engineer's Office and the Farm Loan Board to take adverse action.

8.2 Alternative of no action

8.2.1 Reject right-of-way application

If the Bureau of Land Management were to refuse to grant the right-of-way the reservoir could not be constructed. National resource land is located at low elevations near the dam site, and a dam at the proposed site small enough to eliminate the need for a Bureau of Land Management right-of-way would not store sufficient water for serious consideration.

This alternative of no action would cause the applicants and the industrial firms to consider their alternatives for water supply. As far as industrial use of water is concerned, the no action alternative could possibly contribute to the eventual adoption of a larger scale alternative of transporting coal to distant areas where water is more abundant. Under this alternative, utilization of large quantities of water in an area of water shortage would not be necessary. The influx of new people would be reduced somewhat and the effect of increased population on the economy would not be felt as strongly. However, the other water supply sources would have to be eliminated by similar non-development decisions. The reservoir company would consider alternative construction sites. Since all other sites were considered unfeasible, the project would probably be abandoned.

Few irrigation wells would be attempted due to the small potential benefit. The ranchers would probably continue as they have for many years in the past with their present water supply. BLM's refusal to grant the right-of-way might also cause the State of Wyoming to refuse

8.1.3 Flood water diversion

As considered here, this alternative would involve further development and sophistication of the existing practice of utilizing flood waters. The problem would be to divert high flood flows in the peak season from the Middle Fork into storage in areas near the land to be irrigated. This would necessitate large diversion structures at strategic points on the river, each with a canal or canals leading to rougher terrain away from the flood plain where earthen dams could be constructed for storage until later in the season. Other canals and facilities would be needed to move water to the irrigated lands when needed.

Considerable expense and surface disturbance would be necessary, since fairly long distances are present between the stream channel and the draws and ravines above the flood plain. Large water losses could be expected since water would be transported relatively longer distances by canal, and evaporation and seepage rates would be high in the smaller reservoirs.

The only other variation to accomplish utilization of the high flood flows in the peak flow period would be further development of the flood irrigation system to actually irrigate without storage. Alternatives along these lines would not have the advantages of providing water late in the growing season when most needed.

pumping the aquifer. This alternative is highly conjectural and would require further study to determine conclusively whether it is feasible. Based on what is known about the area and the needs and capabilities of the people involved it is highly unlikely that any reasonable possibilities could be found.

8.1.2 Water wells

The initiative of filing for a water right was taken to insure a substantial supply. This water right is very valuable in this area of water shortage because of appropriate rights, based on filing date. Alternative sources of irrigation water would be considered if this initiative were lost and the reservoir not constructed. To be used, the water must be impounded so that it can be applied to the land when needed.

The only other source of irrigation water in this area is through the drilling of irrigation wells. The Bureau of Reclamation evaluated this possibility in their 1967 Report on the Kaycee Unit and concluded: "The development of ground water for irrigation on the Kaycee Unit appears to be unfeasible. Ground water is not considered as a potential supply, and no further investigations are planned." According to the Geological Survey Water Supply Paper 1360-E, the amount of water obtainable by pumping from wells ranges up to a maximum rate of about one cubic foot per second. This is inadequate production for irrigation wells. It appears that the ground water potential could only supply a small proportion of the quantity needed for irrigation.

8.1 Alternative agricultural water sources

8.1.1 Reservoirs

The possibility of an impoundment of Powder River in Johnson County near the point of emergence from the Big Horn Mountains has been the subject of considerable study for many years. The first report on a reservoir on the Middle Fork of Powder River dates back to 1940, and the subject was under consideration before this. The conclusion of all studies is that the proposed location is the most feasible one because of the geology and topography of the area and quality of the water. The North and Red Forks of Powder River were eliminated because of geology and topography. Other reasons were that much of the available water on the North Fork is already appropriated in connection with the Dull Knife Reservoir and the Red Fork carries a high load of sediment.

Other reservoir sites exist which are located farther from the mountains, but they would not have the advantages of this location. Advantages are the ease of water transport to the irrigated land, better water quality for industrial use due to lower dissolved solids and sediment loads, and topography favorable for dam construction.

Another alternative considered was the use of underground reservoirs. If an aquifer possessing the necessary hydrologic characteristics could be found, water from high runoff periods could be diverted and stored in the aquifer (underground "reservoir"). The aquifer would be charged through wells or infiltration ponds. The recharge method selected would depend upon the infiltration rates and hydraulic conductivity of the overlying soil, water quality, and aquifer type. During low runoff periods, the required water would be obtained by

8. Alternatives

This section documents the conclusions of the study of possible alternatives. In 8.1 the situation considered was the need for an additional and better timed water supply on the irrigated and irrigable lands involved. The conclusion was that no reasonable alternatives exist which would satisfy this need. The no action alternative is discussed in 8.2 involving either rejection or delaying of action on the right-of-way application.

In 8.3 the road relocation alternatives are discussed even though they are not full alternatives to the proposed action. The road relocation must be authorized by a separate action but it is still considered a part of and essential to the proposed project.

Section 8A deals with the alternatives on assumed industrial use of the water.

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Law enforcement

Quality of law enforcement would be adversely affected due to manpower shortages and inadequate facilities.

Fire protection

Inability of communities to respond to deficiencies in manpower and facilities could result in increased property damage and loss of life.

Water and sewer facilities

Population increases could render existing water and sewer systems inadequate, creating water shortages, water treatment and distribution problems, and sewage treatment deficiencies resulting in reduced water quality.

Employment

The growth in industrial employment will attract labor from other sectors of the economy, which could create labor shortages in those sectors such as agriculture and services.

Income

Industrial growth may induce inflation of local prices and property values, which would be particularly adverse on that portion of the population living on fixed incomes such as disabled, aged, and welfare recipients.

Housing

Industrial development will induce new population that will demand housing. As housing probably will not be immediately available, the adverse impact of the incoming population having to accept inferior quality housing cannot be avoided. Other unavoidable impacts would be inflated prices for housing and a shortage of housing.

Public education

Population growth would increase student enrollments which in turn would impact enrollment capacities of existing school district facilities and teaching staffs.

Health and social services

Quality of health care and social services would be reduced due to shortages of manpower, overcrowding of facilities, and an overextension of service capability.

Increased population and accessability to agricultural lands will further affect agricultural land use. Other uses such as recreation will increasingly compete for land area.

Increased vandalism of livestock watering facilities and fences cannot be avoided. Separation and alteration of ranching operations would occur. Livestock water sources could be affected, and ranchers would be inconvenienced by changes in access patterns and use patterns. Increased mortality and molestation of cattle and sheep would take place.

7A.13 Transportation networks

Increased traffic on existing transportation facilities cannot be avoided. This increased use would result in increased maintenance costs, possible upgrading of systems, and in some cases relocation of sections of particular routes.

In some cases, construction of the new transportation networks would result in conflicts with existing systems such as disruption of use on an existing facility while new ones are being constructed which cross or in some other way affect those systems in operation.

7A.14 Socio-economic conditions

Population

The estimated population increase of 18,750 is not necessarily adverse; however, the impact of population growth would generate unavoidable secondary effects which are discussed in the following sections.

7A.10 Aesthetics

The change in scenic characteristics cannot be avoided. The major changes will take place in the plant site areas and along the lineal rights-of-way for transportation systems. The landscape will be crossed by transmission lines, new roads, and pipelines. Vegetative patterns will be altered on rights-of-way and other disturbed areas. New vertical intrusions will be added to the landscape (plant buildings, power transmission line poles or towers).

Increased noise levels and air contaminants such as dust and plant emissions would unavoidably have adverse impacts on aesthetic qualities.

7A.11 Recreation resources

The increased population will intensify recreation demand. The increased demand could cause deterioration and overuse throughout the area and on existing facilities. The generally unavoidable adverse effect is the lowering of recreation quality within the study and adjacent areas.

7A.12 Agriculture

There will be an unavoidable loss of agricultural land, primarily for livestock grazing. Loss of irrigated and non-irrigated croplands cannot be determined as specific site locations are unknown.

Agricultural lands could be reduced by approximately 4,000 acres to accommodate plant sites and community development. Acreage of agricultural land which would be lost to transportation systems is unknown. If the 4,000 acres lost are grazing land, the annual loss of livestock forage could range from 600 to 700 AUMs.

7A.8 Fish and wildlife

Unavoidable loss of habitat and reductions in population will occur as a result of the assumed industrial development. As specific site locations are unknown, quantification of populations and acres of habitat which would be lost cannot be determined.

The estimated increase in population will result in more intense human activity on existing wildlife habitat. This increased activity will cause some species to abandon their immediate habitat.

Hazards introduced into the environment such as increased vehicular traffic, fences, off-road vehicle use, and power transmission lines will cause further losses in population numbers.

7A.9 Cultural resources

Subsurface material and sites will be damaged or destroyed under the most responsible construction program, with much more lost from surface activities of population expansion. Losses to expansion could be expected from lack of surface evidence, time, money, and trained personnel to conduct surveys.

Impact on the historical sites from increased population with attendant increase in vandalism and pot hunters cannot be totally avoided. Some damage to these sites will undoubtedly occur as a result of development.

Visual impacts resulting from construction of rail lines, power transmission lines, pipelines, and the gasification plants are unavoidable. Increased access will increase the use pressure on all historical sites and could result in unavoidable damage.

Water used to meet the needs of the population increase and resultant growth would decrease water available for other uses such as grazing, recreation, and fish and wildlife populations.

Reduction in water quality would result from increased erosion, sedimentation, overtaxed sewage facilities, and toxic substances which may be discharged or leached into surface and ground water supplies.

7A.7 Vegetation

Existing vegetation will be destroyed on the plant sites, housing sites for increased population, transmission line and pipeline rights-of-way, raods, and railroad rights-of-way. There will be an unavoidable permanent loss of vegetation on an undetermined acreage due to construction of permanent facilities.

Areas disturbed by rights-of-way will be reclaimed shortly after disturbance. With the semiarid climate prevalent for the study area, successful revegetation on the severely disturbed areas is unknown at this time.

All plant succession is unavoidably destroyed at the time of disturbance. Fifty years or more of plant succession will be required for these areas to return to their present state as the existing soil structure and microclimate have been changed and altered.

Adverse impact of stack emissions, especially sulfur dioxide, on vegetation is unknown. Increased population will intensify recreation use which will destroy or decrease the vegetative cover depending on the amount of use an area receives.

of topsoil will lower to some degree the natural soil productivity of the area by compaction, mixing natural soils, and causing accelerated soil erosion. An undetermined amount of soil disturbance would occur as a result of increased activity on the land from the increased population. One of the principal activities would be increased recreation use.

Reduction of soil productivity, permeability, and infiltration rates is unavoidable. Increase in erosion and sedimentation rates will occur, but amount of soil loss through time cannot be determined.

7A.5 Mineral resources

The consumptive use of mineral materials necessary for construction and operation of the plant sites and associated facilities (including the necessary residential and commercial development) cannot be avoided.

Coal reserves, a nonrenewable mineral commodity, will be depleted. An estimated 27 million tons per year of coal would be consumed by the two plants.

The consumption of energy fuels by construction and operation equipment is unavoidable.

7A.6 Water resources

The increased use and consumption of water cannot be avoided. This includes the 25,000 acre-feet per year for the two coal gasification plants, approximately 3,000 acre-feet per year to meet the culinary water needs of the population increase, and an undetermined amount for other uses which would result from the "growth" in the area.

Figure 7A.2-A

Estimated Stack Emissions

Tons of Emissions	Particulates*	Sulfur** Dioxide	Scrubbed*** SO_2	Nitrogen Oxides	Hydro-carbons
24 hours	10	44	22	66	20
1 year	3,600	16,000	8,000	24,000	7,500
30 years	108,000	480,000	240,000	720,000	225,000

*With electrostatic precipitator.
**Without scrubbing for SO_2.
***With 50 percent efficient scrubbing to meet Wyoming emission standards.

7A.3 Topography

Alteration of the natural features of the landscape is unavoidable where grading and leveling is required for construction of plant and transportation facilities. The exact shape and slope of the present topography is unrestorable.

Drainage pattern changes and possible creation of new patterns is unavoidable. Even though these changes may be minimized by utilization of sound planning of operations, a certain amount will still occur.

7A.4 Soils

Disturbance of topsoil on approximately 4,000± acres for plant and community development cannot be avoided. In addition, disturbance of top soil on approximately five acres per mile on lineal rights-of-way cannot be avoided. Loss of productivity from the acreage of topsoil occupied by facilities is unavoidable. This acreage will be occupied by roads, railroads, buildings, and gasification plants. The disturbance

7A. Probable adverse environmental effects which cannot be avoided - Assumed industrial use of water

7A.1 Climate

Since emissions cannot be completely controlled, an increase of atmospheric particulates is anticipated.

Vehicle and equipment emissions, airborne dust resulting from construction activities, and emissions from the gasification plants would result in a decline in air quality which may result in unavoidable impacts to the climate. Specific impacts are unknown.

7A.2 Air quality

Construction and operation of the two coal gasification plants together with the related activities such as transportation systems and the residential and commercial development associated with the population increase would have an unavoidable adverse effect on local and regional air quality. Increases in particulates, sulfur dioxide, nitrogen oxides, trace elements, and hydrocarbons will occur even though emission controls are employed and air quality standards are enforced. These emissions will decrease the ambient air quality in parts of the Wyoming and Casper intrastate air quality control regions.

Deleterious stack emissions cannot be completely eliminated with existing technology so adverse impact to air quality is unavoidable. Figure 7A.2-A gives total estimated stack emissions for comparison to Wyoming Emission Standards given in section 6A.2.

7.13 Land tenure

The loss of agricultural and grazing land to the reservoir and the road right-of-way cannot be avoided.

Population growth and increased demand for services resulting from recreational use of the reservoir could result in conversion of land from agricultural and grazing use to residential and commercial uses.

7.14 Socio-economic conditions

Unavoidable adverse effects would depend to a large degree upon when the proposed project is constructed. If it is initiated before 1980, additional demands should be minimal and can probably be absorbed by existing social facilities. On the assumption that the project would precede regional development, the anticipated adverse effects would be a temporary housing shortage and perhaps some local disruption resulting from behavioral patterns of a construction force anticipated to be largely young, single males and unaccompanied married men.

Should the project begin when anticipated regional development is underway, probably in the 1980's, adverse effects would be more keenly felt on social services already expected to be overtaxed.

habitat destruction. Opportunities for observation of certain species would be lost.

The potential for 36 visitor days of stream fishing from the reservoir inlet to the dam would be lost permanently. From the dam downstream, the stream fishery would be seriously limited by the proposed low winter flows.

With construction of the dam and reservoir there would be an unavoidable loss of sightseeing and scenic values of the existing riparian setting.

There would be unavoidable adverse effects on recreational access to the reservoir caused by annual drawdowns and exposure of mud flats. Vehicular access would be especially difficult.

7.11 Agriculture

The acreages cited in Figure 5.12-A would be removed from agricultural production by construction of the reservoir, and an estimated total of from 900 to 1,000 animal units of carrying capacity would be reduced from the eight ranch units involved.

7.12 Transportation networks

Increased traffic on the highways providing access to the proposed reservoir site during and after construction for recreational use of the reservoir cannot be avoided. This would probably result in increases in traffic accidents and in unavoidable increases in road maintenance.

Inconvenience and poor travel conditions during the construction period are unavoidable.

is constructed. The actual visual and physical remains of many sites in undisturbed context could not be maintained. Vandalism will continue to have adverse impacts no matter how strongly existing laws are enforced.

7.9 Aesthetics

Unavoidable adverse effects on aesthetic resources would arise from the construction phases of the proposed dam and road. Noise levels from heavy equipment, dust, smoke, and water quality degradation would temporarily detract from aesthetic values.

The relocated road and accompanying surface disturbance would unavoidably alter the scenic factors of line, form, texture, color, and scale, even with rehabilitation of disturbed areas.

Vegetation would be lost due to removal or by flooding.

The reservoir would result in permanent loss of the riparian scene and block the free-flowing Middle Fork Powder River. The river downstream from the dam would undergo a drastic change in natural flow patterns. Quality of the winter scene would be especially affected due to the low water release planned for that period.

Wide annual fluctuations in the reservoir level are unavoidable under any of the proposed operational plans. The exposed portion of the pool area would probably be unsightly and a source of blowing dust.

Overall, the visual contrast created by the project would increase significantly and would be considered an adverse environmental impact.

7.10 Recreation

Construction of the proposed dam and reservoir would result in the loss of approximately 90 hunter days annually as an indirect result of

The only unavoidable adverse effect identified with the irrigated lands is an added drainage problem which could be expected to occur despite efforts at mitigation.

7.7 Wildlife and fish

Construction of the reservoir would mean unavoidable loss of 1,160 acres of excellent habitat, along with most or all of the resident fauna, including 130 deer, 30 turkeys, unknown numbers of rabbits and furbearers, a few partridge and pheasants, and numerous non-game mammals, amphibians, and reptiles.

Six and one half miles of the free flowing Middle Fork Powder River, plus about two miles of Beaver Creek would be lost.

7.8 Cultural resources

No matter how complete or thorough the stages of mitigation outlined earlier are followed, there would be adverse impacts upon cultural resources as a result of the Middle Fork Reservoir. If the mitigating measures are not carried out, the loss of cultural resources would be far greater. During mitigation or salvage operations, selected cultural resources would be excavated; by the nature of salvage excavations and current methods, not all the available scientific data could be recovered from each site excavated. Further, some of the sites not selected for excavation could contain valuable information not identified in preliminary investigations. Not all the cultural resources would be identified by surface indications, and thus an unknown number of sites could be lost.

The introduction of physical and visual elements which are out of character with the historic setting could not be avoided if the reservoir between the surface of the stream and the water table in the aquifers. Reduction in the spring peak flows will reduce or eliminate the gradient slowing or ending recharge from the stream. The result may be a lowering of the water table, necessitating the deepening of wells that penetrate them. In some instances, a complete dewatering of the aquifer is possible, resulting in losses of wells.

Ground water quality in the vicinity of the irrigated areas may be degraded. Increased application of irrigation water with a moderate total dissolved solids content may result in the increased salinity of the local ground water as the salts are leached out of the profile and some are carried down to the water table. In addition, applied agricultural chemicals and their oxidation products could be carried down to the water table.

7.6 Vegetation

Existing vegetation would be lost on the lands to be inundated. Eventually some vegetation would return to the areas of infrequent inundation, but the composition would change to species more adapted to periodic flooding.

In the embankment and spillway area, vegetation would be almost completely destroyed by construction activities. Natural revegetation by native species on disturbed soil would probably require decades.

The proposed road would eliminate vegetation on 40 acres. Native vegetation would require years to reestablish on unpaved disturbances.

Salt accumulation around the shoreline would limit vegetative growth at the edge of the reservoir, depending on its concentration.

Middle Fork Channel, headcutting in tributary channels between the dam and the confluence with the Red Fork will probably occur.

Storage in the reservoir and subsequent irrigation of new lands will result of an estimated 2,350 acre-feet-per-year evaporation loss. This represents a loss of water from the Powder River Basin that could have been available for other purposes. Of this, 1,625 acre-feet represents reservoir evaporation and 725 acre-feet is consumptive use on 363 acres of irrigated land.

Reservoir storage will result in an increase in mean total dissolved solids. Present flow weighted mean total dissolved solids is 560 mg/l. Because of concentration due primarily to evaporation from the reservoir, the mean total dissolved solids will be increased to 580 mg/l. The significance of this increase will be increased salinity of the irrigation and industrial water. For irrigation, water requirements for leaching will increase approximately 20%. In general, it represents a decrease in water quality.

Accompanying the increased availability of irrigation water will probably be an increased use of agricultural chemicals including fertilizer (such as ammonium nitrate), herbicides (such as 2,4-D), and insecticides (such as malathion). Application of irrigation water or rainstorms soon after application may result in direct transport of a portion of these chemicals and their oxidation products to the stream, resulting in further degradation in water quality.

7.5.2 Ground water resources

Recharge of floodplain alluvial aquifers along some reaches of the Middle Fork and mainstem Powder River depends upon the head gradient

7.5 Water resources

Unavoidable adverse environmental effects on water resources will probably occur as a result of the modification of the streamflow regime and increased use of water for irrigation.

Several unavoidable adverse environmental effects will occur. The degree of the effects of some of these can be quantified. For others, quantification will be possible only after intensive and extensive study. For these latter impacts, the discussion is therefore in qualitative terms.

7.5.1 Surface water resources

The storage of spring runoff in the Middle Fork Reservoir will result in a reduction of peak flows. During May, the month of highest average runoff, the average runoff is 13,750 acre-feet. The average reservoir release, assuming the industrial water is diverted downstream, will be approximately 3,000 acre-feet. Even if all water is released and diverted downstream, the reduction in peak flows represents an adverse, unmitigated impact in that the flushing of sediments deposited during the year by these flows will no longer occur. Accumulation of sediments will aggravate damage by future floods because of decreased channel capacity.

The release of relatively clean water from the reservoir will result in channel degradation below the dam, probably down to the Red Fork. This will occur as the clean water reentrains sediment up to the stream's carrying capacity. This will occur until the streambed is composed of particles whose size exceeds the sediment size that the stream is capable of carrying. Because of the resultant lowering of the

7. Probable adverse environmental effects which cannot be avoided - Agricultural use of water

7.1 Air quality

Some impact on air quality resulting from construction activity would be unavoidable. During the construction period, temporary degradation of air would result locally from dust, vehicle emissions, emissions from concrete or asphalt plants, and possibly smoke from burning vegetation.

A possible long-term source of blowing dust would be the exposed mud flats resulting from reservoir drawdown. Long-term, but minimal pollution would result from mechanical cultivation of additional land.

7.2 Topography

Alteration of natural features of the landscape would be unavoidable. Cliffs and abrupt breaks, now part of the natural scene, would be eroded and altered by periodic inundation and drainage of the reservoir.

Changes in topographic features caused by cuts and fills along the bed of the proposed new road would be unavoidable.

Some drainage and erosion problems would probably arise along the road bed during unusually intense storms. These could not reasonably be avoided.

7.3 Mineral resources

The extraction and consumption of construction materials could not be avoided under present plans and proposals. Potential material extraction sites located within the confines of the reservoir would no longer be available for use.

7.4 Soils

Unavoidable adverse impacts at the reservoir site would include some increased erosion and loss of permeability and productivity due to compaction by heavy equipment.

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of power, privilege or authority. This legislation enables, specifically, two or more agencies to jointly plan, create, finance and operate (control) water, sewage, or solid waste facilities; fire protection agency facilities; transportation systems facilities; and public school facilities.

In summary, all of the respective jurisdictions (Federal, State, and counties) have authority to impose land and resource use controls as mitigating measures.

6A.15 Socio-economic conditions

Socio-economic impacts can best be mitigated by establishing additional manpower--doctors, teachers, and policemen--in conjunction with facilities--hospitals, schools, and jails. Impacts may be temporarily mitigated by a more intensive use of existing manpower and facilities, but long-term mitigation will require funds to lure trained and professional manpower and build adequate facilities. This type of mitigation would indicate some form of government or private assistance.

State air and water quality laws and regulations control industrial air emissions and all discharges of water, or into water, in the State. Solid waste disposal is also controlled by State legislation, the basic authority for all the foregoing being the Environmental Quality Act of 1973.

The 1975 State Industrial Facilities Siting Law requires application for a permit for construction of such major facilities as power plants and synthetic fuels plants, plus any other facility estimated to cost over 50 million dollars; control includes the authority to deny a permit for any of certain specified reasons.

The 1975 State land use planning legislation provides State oversight to local planning activities, authorizes grants to local governments for planning, and mandates such governments to develop local land use plans.

Under Wyoming statutes, counties have the authority to effect a wide variety of controls in matters not specifically reserved to the State. The authority applies only to those portions of the county that are unincorporated. A county may regulate and restrict location and use of buildings and structures and use, condition of use or occupancy of lands for residency, recreation, agriculture, industry, commerce, public use and other purposes.

Less than 1 percent of the lands in the study area is owned by county governments. Use and control of these lands would be governed by State law and county ordinances.

Where a county or city lacks a specific authority, provisions of the Wyoming Joint Powers Act are available to enable joint exercise

6A.14 Land use controls and constraints

In the study area, a large number of separate jurisdictional entities exercise certain types of land and resource use controls. The Federal sector includes the National Park Service, Bureau of Reclamation (withdrawn lands in Natrona County), Forest Service (Big Horn, Medicine Bow, Black Hills National Forests and Thunder Basin National Grasslands), and Bureau of Land Management (national resource lands and mineral estate under certain private lands).

Development, management, use, and control of use on Federal lands have been delegated to these agencies. With certain exceptions, uses and controls come under the discretionary authority of the agency head. Controls are effected through issuance or nonissuance 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. In certain situations, there is a joint or multiagency sharing of particular management and control functions and responsibilities. The surface and subsurface estate vested in private or State ownership would normally be governed by applicable State of Wyoming statutes.

A number of State agencies have development and administrative authority over State of Wyoming owned lands. Additionally, under State of Wyoming statutes the State is authorized to perform, administer, and control certain surface land use development and planning activities on State, county, municipal, and privately-owned properties. Control does not apply to Federal properties except as provided by law.

will interfere with existing traffic patterns and perhaps cause a safety hazard. The effects can be mitigated to some extent using good planning, adequate traffic routing around construction areas, and safety measures when construction can not be avoided. It will be necessary to provide alternate routes of access to any ranching or other local operations that will be isolated due to obliteration of roads during site or access system construction.

Existing traffic networks will receive increased use due to industrial activities and population increase, leading to a decrease in their quality. Mitigation is possible if these routes are upgraded by the industrial developers, or sufficient company aid is supplied to allow the respective street or highway department to maintain them. New transportation facilities may be necessary, for example, an airport, which might be, at least in part, financed by the company.

Rights-of-way will have to be established for the new access systems. These will not be located across high erosion hazard areas or areas of unique values. Construction will be conducted in a manner that will minimize soil erosion. Rights-of-way will not be used for "short cut" trails or roads unless properly constructed for such purposes. Deep vertical cuts and long fill slopes of clinker pits, roads, pipelines, or other construction sites will be graded by reducing slopes, backfilling to conform to the adjacent terrain. To prevent erosion, waterbreaks, terraces, or diversion ditches should be installed and the water spilled onto areas relatively resistant to erosion.

following topsoiling and reshaping. Revegetation will be accomplished by a standard acceptable method. Revegetation shall be attempted until a satisfactory stand and cover of perennial vegetation is achieved and maintained.

Measures that will minimize the effect of development activity on farming must be adequately timed. The following measures will be considered minimal in an adequate development plan.

Acreages to be disturbed by construction should be posted one year prior to anticipated activity to prevent economic loss due to unnecessary summer fallow operations or destruction of growing crops. Written notification to operator of cropland will be sufficient.

No less than one access route will be maintained to each cropped field. Temporary fencing will be installed to protect crops from destruction by drifting livestock when permanent fencing is destroyed by development activity.

Cut slopes, materials piles, and denuded areas will be mulched to reduce accelerated erosion and sedimentation due to wind or water. The mulch shall be disked into the material surface. Active areas, such as haul roads, will be treated to reduce windblown mineral particles to an acceptable level.

6A.13 Transportation networks

The establishing of two gasification plants, in conjunction with the associated access systems, will result in two new transportation networks for the study area. In some cases, these new transportation networks will be built over, under, or through existing networks. This

Disruption of air quality and aesthetics of the area may reduce the visitor's sightseeing enjoyment, and hence reduce visitors. Air quality reduction is mitigated to some extent by emission and ambient air quality requirements (see Air Quality), and aesthetic value reduction is mitigated to some extent by visual resource stipulations (see Aesthetics).

6A.12 Agriculture

Principal impacts on agriculture are the withdrawal of lands from agricultural purposes to be used for plant sites, access systems, and anticipated population growth. Two principal agricultural activities, livestock grazing and farming, are pursued in the area, and both could potentially be impacted.

Measures that may be taken to minimize the effects of industrial development on livestock grazing should be initiated at the appropriate stages of the development. Temporary fences should be erected around the areas actively involved in construction so that the remainder of the area will be available for livestock use and the hazards from excavation and construction equipment to livestock minimized.

All operations will be conducted to avoid wildfire and spontaneous combustion. Open burning of all materials will be in accordance with suitable practices for fire prevention and control.

Metal and all other nonmineral material waste will be disposed of, buried, or removed. Noxious and toxic species of invader plants will be controlled by using approved herbicides. The owner will be reimbursed at the appraised price for the loss of all facilities destroyed by construction activity. Disturbed areas will be revegetated within one year

Probably the most critical factor in reducing the impact of a lineal project--railroad, powerlines, etc.--is location in relation to naturally occurring lines in the landscape. Lineal projects will be located where natural lines already occur to the extent possible, following contours and depressions and avoiding a crossing at the crest of a hill.

Air contaminants will be mitigated to some extent by the air emission and ambient air standards outlined under Air quality.

Noise should be abated in the plant using noise control devices and baffles wherever possible.

6A.11 Recreation resources

The chief effect on recreation resources, other than the withdrawal from recreation of the plant sites and access systems rights-of-way, is the increased load on recreational facilities from population increase.

Mitigation of the expected increase in demand for recreation, with anticipated decrease in supply due to more private land being closed and posted, can be partially accomplished by a program to rehabilitate lands disturbed by plant or access system construction. Programs may be instituted with area communities such as Gillette or Douglas to provide funds or aid to upgrade and establish facilities and ease the recreation load.

Stipulations should be issued providing for return of disturbed areas to a natural and scenically attractive state. This again would likely be part of the program to rehabilitate disturbed lands.

evidence indicates further evaluation is necessary. In addition, approvals will be conditioned to require notification to the appropriate officer of the surface administrating agency of sites discovered during right-of-way construction prior to disturbance. The Antiquities Act of 1906 and Wyoming statutes make it unlawful to excavate sites which are discovered without a permit.

Furthermore, it will be required that the alluvium to be displaced during the construction operation be surveyed and that all surveys be coordinated with the Wyoming State Historic Preservation Officer to insure competent, professional inventories, salvage, and preservation of archeological and paleontological data.

6A.10 Aesthetics

The gasification plants will impair the aesthetic values of the sites visually through construction and later through the existence of structures, access systems, and air contaminants; and audibly through increased noise levels. Much of this impairment would be mitigated if the plants were located where no one would see them, but this may not be feasible.

Construction plans should contain stipulations requiring dust abatement and noise control devices on construction equipment.

Development plans should contain stipulations guided by Federal visual resource standards. These stipulations will provide that construction design blend with the natural landscape, keeping a low profile for process structures and facilities to the extent possible.

obtained before excavation of any archeological or paleontological deposits on either State or Federal public lands (sec. 36-11 W.S. 1957).

Archeological and paleontological values on Federal lands will be protected by surveys and salvage excavations. The Wyoming Antiquities Act similarly requires a permit for excavation of antiquities on State lands, permission to be granted by the State Board of Land Commissioners.

To protect historic values, the approving Federal agencies will insure that permits include a program for historic inventory, evaluation, and nomination of sites, districts, buildings, and objects in cooperation and consultation with the State Historic Preservation Officer.

Surface surveys for evidence of archeological values in the alluvium are fundamental to establishing responsible stipulations for their protection. Therefore, those stipulations in the permit that require surveys will be followed to insure archeological and paleontological protection.

No permits or rights-of-way will be approved until the company has coordinated its archeological surveys with the Wyoming State Historic Preservation Officer. Company survey reports will be submitted to the State Historic Preservation Officer with a copy to agencies approving plans and permits. The report will be certified by the Preservation Officer and forwarded to the approving agencies with a statement that surveys have been conducted by competent, professional archeologists and a recommendation for additional surveys to be required before permits are approved. These additional surveys may be necessary if surface of the State designated unique, irreplacable, historical, archeological, scenic, or natural. The Historic Preservation Act established a system of historic preservation in the nation and requires that certain Federal undertakings be submitted for review by the National Advisory Council on Historic Preservation. NEPA states in Section 101(b)(4) that one objective of national environmental policy is to "preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment which supports diversity and variety of individual choice." Finally, Executive Order 11593 affects Federal agencies most intimately in that they are instructed to cooperate with the nonfederal agencies, groups, and individuals and to insure that Federal plans and programs contribute to the preservation and enhancement of nonfederally owned historic and cultural values. Agencies are directed to inventory, evaluate, and nominate properties in their jurisdiction to the National Register of Historic Places.

Under the mandate of the Executive Order, Federal agencies must insure that until inventories and evaluations are completed, the agencies will use caution to assure that federally owned properties which might qualify for nomination to the National Register of Historic Places are not inadvertently transferred, sold, demolished, or substantially altered and that Federal plans and programs contribute to the preservation and enhancement of nonfederally owned sites.

The Antiquities Act of 1906 prohibits damage, collection, or excavation of plant and animal antiquities on Federal lands without a permit (see 43 CFR Part 3). The Wyoming statutes require that permits be

Reestablished riparian vegetation along drainage courses and around aquatic habitats would eventually result in reestablishment of many animals associated with this habitat type. Potential also exists to enhance offsite habitat which would offset losses created by industrial development.

6A.9 Cultural resources

The threat to cultural resources--archeological, historical, and paleontological--values lies in the accidental unearthing and destruction of cultural items during construction of the plants or access systems. Cultural sites which exist on the effected acreage may be damaged or destroyed, and even off-site cultural values may be impacted by increased population levels.

Authorities and obligations which establish guidelines for protection of cultural resources are the statute commonly referred to as Antiquities Act of 1906 (34 Stat. 225, 16 U.S.C. 431-433); Wyoming statutes relating to archeological and paleontological sites (sections 36-11 to 56-13 and 18-330.7 W.S. 1957); Wyoming Environmental Quality Act of 1973 (section 35-502.12(a)(v)); an act for historic preservation (80 Stat. 915, 16 U.S.C. 470-470m); National Environmental Policy Act of 1969 (83 Stat. 852, 42 U.S.C. 4321 et seq); and Executive Order 11593, May 13, 1971 (36 F.R.-8921).

Both Federal and State antiquities acts regulate antiquities excavation and collections, and both protect historical values on public lands. They provide for fine and/or imprisonment for violators of their provisions. The Wyoming Environmental Quality Act protects areas

Opportunities for mitigation of wildlife losses, as opposed to legal requirements, are available. Attempts to provide a variety of topography, reestablish shrub and riparian land ecosystems, and expand quality aquatic habitats could be expected to meet with sufficient success to reduce at least part of total long-term impacts on a variety of species. Due to the nature of gasification plant operations and the long time-period required to reestablish these vegetative types, their mitigation would be a long-term project, probably extending beyond the operational phase of the plant.

A variety of native species representing shrub, forb, and grass groups should be well represented. Palatable varieties of big sagebrush and rabbitbrush as well as skunkbush sumac, chokecherry, and juniper would help mitigate losses of deer, antelope, sage grouse, and nongame species. Varied topography would increase habitat diversity and result in greater variety and abundance of wildlife.

Powerlines constructed as needed for the plants and other facilities may be designed to minimize dangers to raptors and other species of wildlife.

Fencing barriers and hazards to deer and antelope movement could be reduced by using less fencing, using fences passable to antelope and deer, and using various crossing structures. These measures should be planned and located on the ground with the State Game and Fish Department as the development proceeds.

nitrogen oxides is mitigated to some extent by emission and ambient air quality standards (see Air quality). Salt drift from cooling tower water evaporation may be mitigated by devising a catchment or screening device to catch the drift.

The problem of vegetative damage from increased recreational use can be mitigated by restricting, at least in part, the damaged areas from recreational use and establishing a revegetation scheme similar to that which would be implemented for disturbed lands.

6A.8 Fish and wildlife

Principal impacts on fish or wildlife result from disruption or destruction of habitats. Industrial and community development will remove 4,000 acres, plus a number of acres for access rights-of-way, from potential use as wildlife habitat. Measures which result in a degree of mitigation of impacts on some wildlife species are primarily those which will come about incidental to attempts to reestablish topography, soils, and vegetation. The potential may exist to significantly improve the habitat for some species. Existing State and Federal air, water, and land quality laws will insure some mitigation of impacts through broad requirements of revegetation, nondegradation of water quality, and limitation of gross air pollution. These legal authorities may reduce total and long-term impacts on fish, waterfowl, some birds, rodents, and invertebrates. They can be expected to have only slight mitigating effects on total impacts on other species.

Several seeding methods are available for planting grasses and legumes. Drilling the seed by readily available farm equipment has proven to be the most successful method of planting. Seed distribution and coverage are assured and uniform. Broadcast seeding is satisfactory for small or relatively inaccessible areas. Broadcast seed should be covered by raking, harrowing, or other means.

Rehabilitation of disturbed land is usually performed under less than ideal farming conditions. Standard seeding rates are usually doubled or increased significantly to allow for seed and seedling mortality due to adverse conditions present on rehabilitation areas. Revegetation failures will occur. The operator will be required to attempt revegetation as many times as necessary to achieve reasonable success.

Maintenance of vegetation on disturbed areas depends to a large extent upon soil development. Applying manure, sewage sludge, or other organic material will materially enhance the soil's capability to supply plants with water and nutrients. Commercial fertilizers are convenient to handle and easy to obtain. The effectiveness of nitrogen fertilizers, however, is dependent on the amount of moisture available. It is generally considered that annual precipitation should be at least 10 to 12 inches to receive benefit from commercial fertilizer on rehabilitation areas. The type of fertilizer and rate of application should be specified when appropriate.

Plants may be damaged or destroyed by airborne emissions from the gasification plants. Damage from particulates, sulfur dioxide, and

The dryland farming practice of summer fallowing prior to seeding may be required to allow for an adequate accumulation of soil moisture reserves to assure successful vegetation establishment. If such a practice is used, adequate erosion controls on unprotected areas (such as surface manipulation and mulching) will be provided.

The species selected for planting must be adapted to local soil and climatic conditions. Native species may be desirable since they now exist on the site and are adapted to local climatic and soil conditions. The unavailability of seed and unreliability of seed sources limit the use of native species.

Hodder, 1970, considered that some introduced species possessed superior qualities essential for rapid establishment. Many species of introduced grasses and legumes have been used successfully for stabilizing road cuts and arid ranges (National Academy of Science, 1974).

Trees and shrubs may be used on lands being reclaimed. Most woody species should be planted from stock rather than seed for best success. Hodder (1973) lists several innovations or techniques being tested for tree and shrub establishment such as condensation traps, supplemental root transplanting, and tubelings. Sites selected for woody species should be capable of supporting this type of vegetation. Some shrubs such as big sagebrush and fourwing saltbush have been seeded successfully. A mixture of native shrubs, trees, grasses, forbs, and introduced species of vegetation may be required on suitable areas where soils and topographic conditions are varied. This mixture would provide a greater opportunity for diverse land uses such as recreation, livestock grazing, and wildlife habitat.

Vegetation can be established only with difficulty on soils being rapidly eroded. Replaced topsoil is characteristically loose, friable, and susceptible to both wind and water erosion. Mulches increase infiltration, reduce erosional soil movement and evaporation, and materially enhance revegetational potential, especially where poor soil conditions exist. Mulches are effective in areas where annual precipitation is between 9 and 14 inches (National Academy of Science, 1974).

Mulch composed of plant residues or other suitable materials will be required as part of seedbed preparation. Acceptable mulching materials are grass, hay, manure, and small grain straw. The mulch material should be applied at two tons or more per acre and anchored by discing, special mulch machine, or a Colter type machine to a depth of two inches. Other types of mulch material such as straw mat, fine wood fiber, excelsior mesh, plastic mesh, wood chips, gravel, and jute mesh can be used. The type, rate, and anchorage of mulch will be specified.

The time of planting is critical for dryland seeding. In the Northern Great Plains area, early spring or late fall seedings are the most reliable. Planting of cool-season grasses that are capable of germinating under very cold conditions and can survive in a dormant state when soil moisture is depleted is desirable (Hodder, 1970).

Most land reclamation seeding will take place under dryland condition unless irrigation water is available. Snow or spring rains provide moisture for germination, initial growth, and establishment. New seedlings, when producing rudimentary root systems and a primary leaf, cannot tolerate extended drought. Supplying irrigation water will be required when drought conditions threaten seed germination and plant survival.

1. Federal Water Pollution Control Act, as amended in 1972, and as it may be hereafter amended;

2. Wyoming Environmental Quality Act of 1973; and

3. Water Quality Standard for Wyoming, Wyoming Department of Health and Social Services, State of Wyoming, June 28, 1973.

In the event that gasification plants are producing liquid effluents, monitoring programs will be instituted. Water samples will be collected to determine if water quality is being changed by gasification, and if so, changes will be instituted to bring water quality to the standards outlined in the acts listed above.

Ground water may leach toxic or deleterious substances from buried wastes or surface waste pits. Disposal systems for solid and liquid wastes will be designed so as not to cause damage to adjoining lands or drainages. Solid waste should be buried or disposed of between impervious overburden layers to prevent its reaching surface water courses or aquifers. Liquid disposal pits containing toxic, deleterious materials will be lined or constructed so as to avoid downward percolation and contamination of ground water aquifers.

6A.7 Vegetation

Vegetation will be impacted in three ways--loss from land disturbance, loss as a result of airborne emissions, and possible loss from increased recreational use.

Revegetation is the third step in mitigation of land disturbed by construction activities. After the topography and soils have been rehabilitated, vegetation is reestablished by seeding in conjunction with mulching and fertilizing if necessary.