TENNESSEE VALLEY AUTHORITY

DRAFT ENVIRONMENTAL STATEMENT

EDGEMONT URANIUM MINE

SUMMARY SHEET
ENVIRONMENTAL STATEMENT
EDGEMONT URANIUM MINING PROJECT

(X) Draft ( ) Final environmental statement prepared by the Tennessee Valley Authority. For additional information, please get in touch with:

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1. (X) Administrative Action ( ) Legislative Action

2. The proposed action is for TVA to mine, through its operator, the uranium-vanadium deposits located in the Southwestern Black Hills area of Fall River and Custer Counties in South Dakota and in Weston and Niobrara Counties in Wyoming.

3. Construction and operation of the initial underground mines are expected to have the following environmental effects: Dewatering operations will cause a depression of ground water levels in the Lakota Formation which will result in some wells to cease flowing; however, water will still be available by pumping. The impacts on the Fall River Formation because of shaft construction and mining operation will result in a decrease in water levels in wells. Following mining, it is possible that areal potentiometric heads in the Fall River will not recover to pre-mining levels within the affected nearby area because open flow from private wells exceeds recharge under present conditions.

   Some population increase will be caused by the project placing additional pressure on the surrounding communities and counties to provide needed community services. At the same time, state and local revenues will be increased. Specific topographic features near the underground and surface mine sites will be altered. There will be a temporary minor degradation of air quality in the immediate vicinity of the mining operations. There will be a loss of some plant and animal species on the site due to the disruptions of natural habitat. There will be a temporary change in land use from rangeland and forest to mineral extraction during the life of the project.

4. Alternatives of securing uranium ore by other methods were considered, but were found impracticable from standpoints of both scheduling and economics. The alternatives explored showed no ultimate environmental advantage over the proposed project.

Table of Contents

Introduction

The Tennessee Valley Authority (TVA), a corporate agency of the United States,* in order to comply with statutory obligations under the TVA Act to ensure an ample supply of electrical power to the area it serves, has committed to a total installation of approximately 21,500 megawatts of nuclear-fueled generating capacity to be in service by the end of 1986. This capacity will be supplied by 7 plants containing a total of 17 light-water reactors. Browns Ferry, a 3-reactor plant, is now in commercial operation. TVA estimates a requirement of approximately 41.5 million kg (kilograms) (91.5 x 10^6 lb, (pounds)) of uranium oxide (U_3O_8) to meet the nuclear fuel needs for the 17 committed reactors through 1990.

As one of many activities TVA has undertaken to ensure an adequate supply of uranium, TVA purchased, on August 16, 1974, the mineral rights on about 41,000 ha (hectare) (101,000 acre) in Fall River and Custer Counties, South Dakota and Weston and Niobrara Counties, Wyoming (Figure 1.1.1-1). Since that time, minable reserves of uranium have been delineated through the discovery of a major new ore deposit and the extension of existing ore deposits in Fall River and Custer counties. Exploration on the subject properties is continuing and the identified reserves of uranium are expected to increase.

TVA, through its operator, proposes to mine the uranium/vanadium ore deposits in the project area. Mining is scheduled to begin in late 1979.

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*TVA was created by the Tennessee Valley Authority Act of 1933 (48 Stat., 58 as amended, 16 U.S.C. SS 831-831dd (1970; Supp. VI, 1976))

1.1 Mining

1.1.1 Mine Site Location - All of the proposed mine site locations delineated are located in western Fall River and southern Custer Counties in South Dakota. These sites are within 24 km (kilometer) (15 mi (miles)) of Edgemont, South Dakota. The Edgemont Uranium Mining Project encompasses approximately 41,000 ha (101,000 acre) of uranium property, consisting of 151 claim groups, 23 state leases, and 65 private leases. (Figure 1.1.1-1.) As planned, the initial shaft for the underground mine, Burdock, will be located on the Francis Peterson Lease in Section 15, T7S, R1E (Township 7 South, Range 1 East); the surface mine, the Spencer-Richardson, is located on the Bud Claims in Section 35, T6S, R1E.

1.1.2 Mining Techniques

1.1.2.1 Underground Mining - Because of the depth and size of the uranium ore bodies, underground mining is considered by TVA as the most feasible method of extracting the ore contained in the Burdock, Darrow, and Runge East deposits. (Figure 1.1.1-1.) The Burdock deposit, which comprises most of the reserves, will be developed and mined from shafts, the first of which is scheduled for construction in late-1980. Minor production is anticipated from the Darrow and Runge East deposits; however, additional drilling is necessary to further delineate these reserves. These deposits will not require extensive development for production because development will be limited to the extension of existing mines. Production from these mines is scheduled for 1981.

Burdock Development and Mining - Two shaft sites have been selected near Burdock. The possibility of a third shaft is being considered, and others may be required as development drilling and mining progress. The shafts will be positioned adjacent to known ore deposits and downdip from them to facilitate water drainage. The rock units that will be penetrated by the shafts will be cored to determine their structural characteristics. Each shaft site will be leveled and prepared for surface facilities. (Figure 1.1.2.1-1.) Roads will be upgraded and all utilities will be made available to service the mine. The initial 4.3 m (Meter) (14 ft (foot)) diameter production shaft at Burdock will extend to a depth of approximately 180 m (600 ft) and the second approximately 130 m (425 ft). One station will be cut about 15 m (50 ft) above the bottom of each shaft to handle men, material, and rock. Figure 1.1.2.1-2 depicts a generalized underground uranium mine and support facilities.

Hydrologic tests have been conducted to determine the water quality and quantity expected in the mines. Plans call for a partial dewatering of the shaft area by two or three wells. (See Section 2.5 for location.) Dewatering may commence up to six months before penetration of the target aquifer by the shaft. These wells are 20 cm (centimeter) (8 in (inch)) or larger in diameter and will each be pumped at an average rate of 14.2 l/sec (liter/second) (225 gal/min (gallon/minute)). Additional water wells may be necessary to ensure greater recovery of ore and for safety of operation personnel.

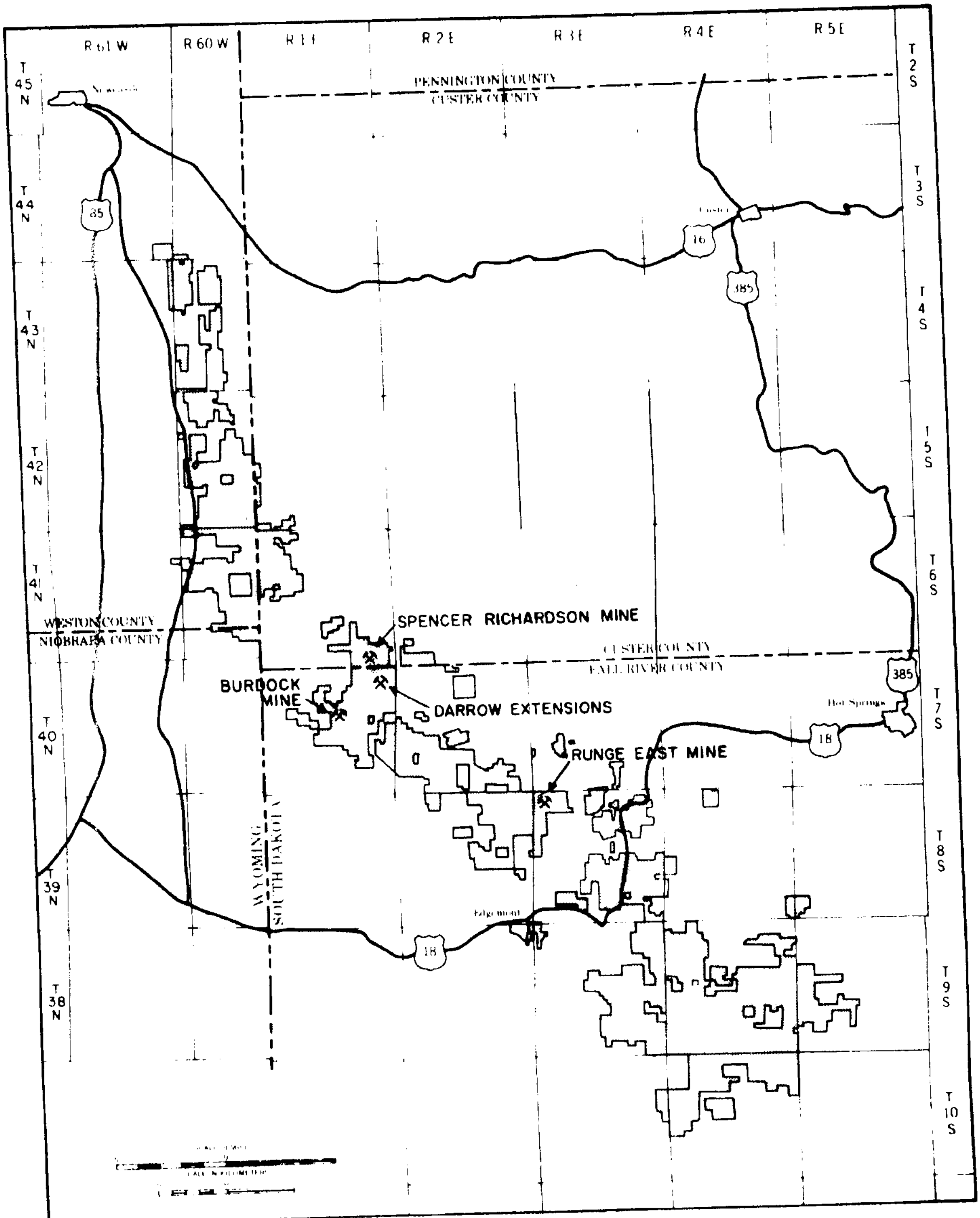

Figure 1.1.1-1 Regional Location of TVA's Edgemont Uranium Mining Project

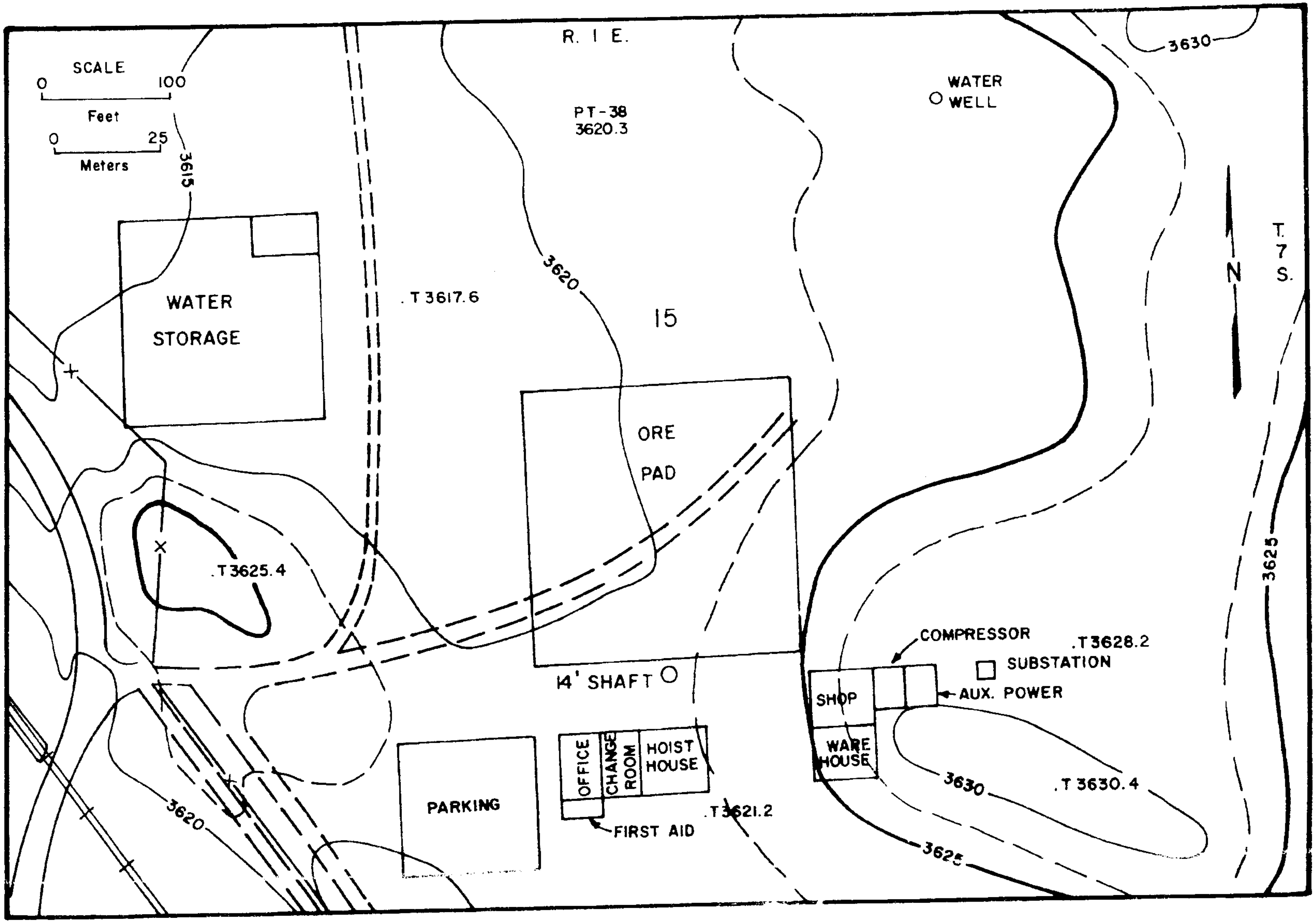

Figure 1.1.2.1-1 Proposed Initial Shaft Site Layout

5

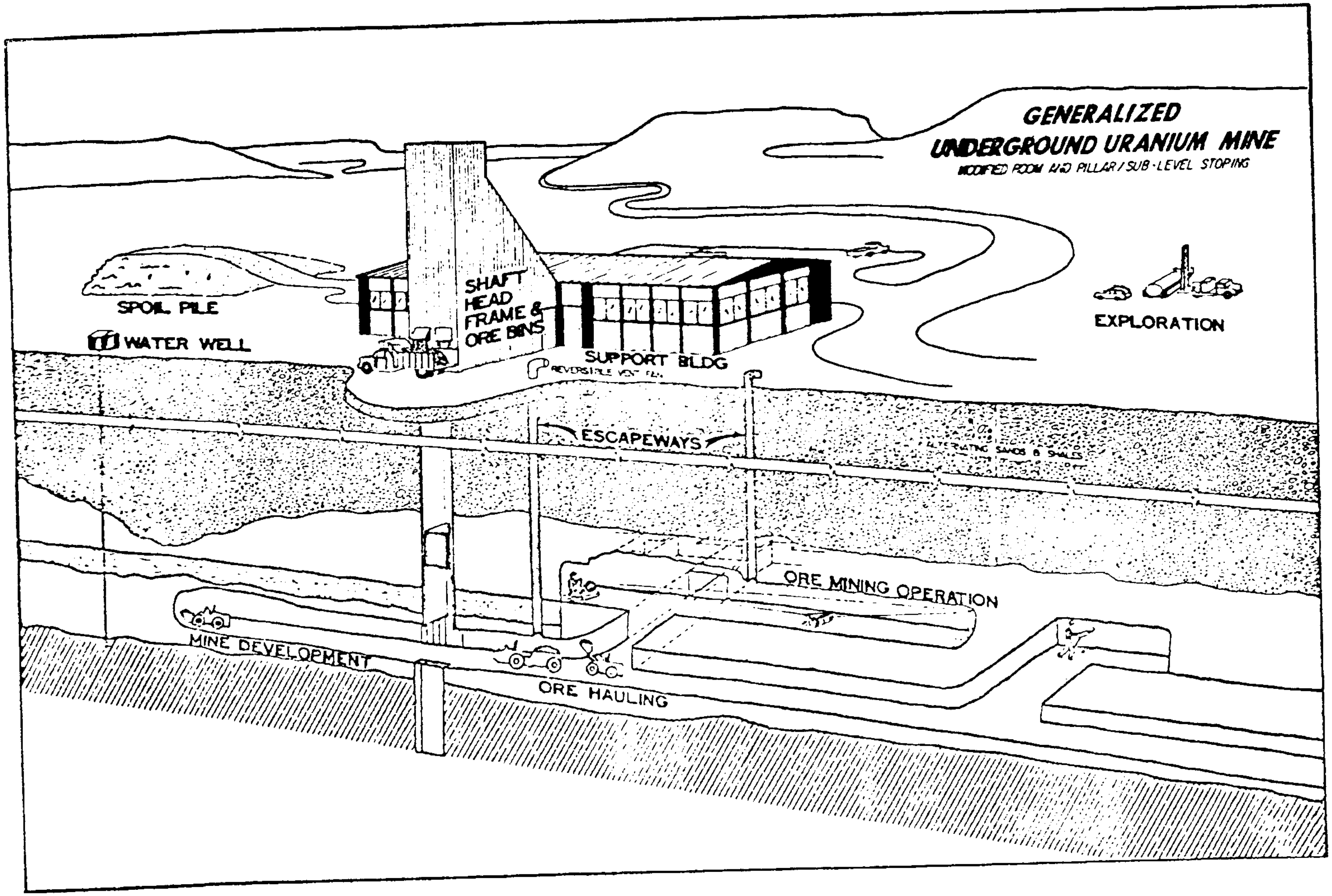

Figure 1.1.2.1-2 Trackless Haulage

At least three 1.2 m (48 in) diameter ventilation shafts are planned with one located within 91 m (300 ft) of the initial production shaft. The ventilation shaft will be equipped with surface hoisting facilities and used for emergency escape. Additional ventilation shafts will be positioned along the axis of the ore deposit in conformance with 30 CFR 57.5 (Air Quality, Ventilation, Radiation and Physical Agents). Refuge chambers and additional escapeways through ventilation shafts will be provided in conformance with 30 CFR 57.11-50.

As necessary, longholes will be drilled to delineate the ore body and to assist in dewatering the ore horizon. Mine water will be drained to a sump in the station where it will be pumped to the surface. Ore production from the stoping operation can begin as soon as sufficient mine development has been completed.

Major equipment to be used underground and in surface support facilities for each shaft is listed in Table 1.1.2.1-1. The ore will be transported to the shaft stations where it will be hoisted to the surface. Waste material will be handled in a similar manner. At the surface, it will be automatically dumped and transported to storage areas.

Permanent roof supports in the mine will consist of timber sets, roof bolts, wire mesh, steel arches, and shotcrete These supports will be used in the main haulage drifts and shaft stations and as required in the mining areas.

Mine ventilation will be provided by axivane-type blowers mounted in the ventilation shafts. Plans are to draw air down the ventilation shafts, through the mine and out the production shafts. The total ventilation rate for each production shaft is estimated to be 3,400 m^3/min (120,000 ft^3/min). Provisions will be made to allow for reversal of the direction of ventilation flow, if required in an emergency.

It is estimated that approximately 100 people (excluding supervisory and technical staff) will be employed in the underground mining operation. A 2-shift, 5-day workweek is planned for ore production. It is expected that shaft sinking and development will be on a 3-shift, 7-day workweek.

Other Underground Mines - Based on present knowledge of ore reserves, less than 5 percent of the total production of the project is expected from the Runge East and Darrow deposits. Detailed mine plans will be prepared after the extent of the deposits is determined by additional drilling. Both mines will be further developed when ore production from them is needed. Mining of the Runge East, an existing mine developed by means of a decline, will involve about 4 ha (10 acre) of surface disturbance for constructing or upgrading support facilities. Mining of the Darrow deposits will be accomplished through a series of adits developed into existing pit walls along ore trends. The five existing pits and associated surface facilities cover approximately 125 ha (310 acre); no significant new surface disturbance should be necessary for mine development.

1.1.2.2 Surface Development and Mining - A schematic open pit mining operation is shown in Figure 1.1.2.2-1. The only proposed surface mining operation is the Spencer-Richardson mine,

Table 1.1.2.1-1

Burdock Mining Equipment
(Partial List Per Mine Shaft)

Underground	No.	Operating Frequency (Hrs/Day)	Specifications	Fuel Requirements
Pumps	4	12	150 HP, 450 gal/min	
Loaders	3	10	2 yd^3, 78 HP Diesel	19 l/hr (5 gal/hr)
	1	6	14 m^3/min (500 ft^3/min) Air	
	3	10	50 HP Electric	
Trucks	4	10	4 yd^3, 76 HP Diesel	19 l/hr (5 gal/hr)
Locomotive	1	6	4.5 tonne (5 ton) Battery	
Drills	20	6	3 m^3/min (100 ft^3/min) Air	
	2	10	8 m^3/min (300 ft^3/min) Air	
Fans	12	24	15 HP, Electric	
	3	24	30 HP, Electric	
Slushers	10	6	25 HP, Electric	
	5	6	10 HP, Air	
	1	10	50 HP, Electric	
Surface				
Hoists	1	10	300 HP, DBL Drum	
	1	10	400 HP, Sal. Drum	
	1	-	Escape Hoist	
Compressors	2	16	350 HP, Electric	
Dewatering Well Pumps	3	24	Electric 50 HP, 225 gal/min	

8

Table 1.1.2.1-1 (Continued)

Surface	No.	Operating Frequency (Hrs/Day)	Specifications	Fuel Requirements
Ventilation Fans	2	24	150 HP, Electric	
Auxiliary Generators	1	Standby	675 KW, Diesel	
Haul Trucks	1	10	300 HP, Diesel	19 l/hr (5 gal/hr)
Heating Plant	1	0-24	400,000 BTU/Hr	11 l/hr (3 gal/hr)
Utility Truck	1	10	2.7 tonne (3 ton)	11 l/hr (3 gal/hr)
End Loader	1	10	5 yd^3, Diesel	11 l/hr (3 gal/hr)
Road Grader	1	8	225 HP, Diesel	11 l/hr (3 gal/hr)
Forklift	1	8	50 HP, Diesel	8 l/hr (2 gal/hr)

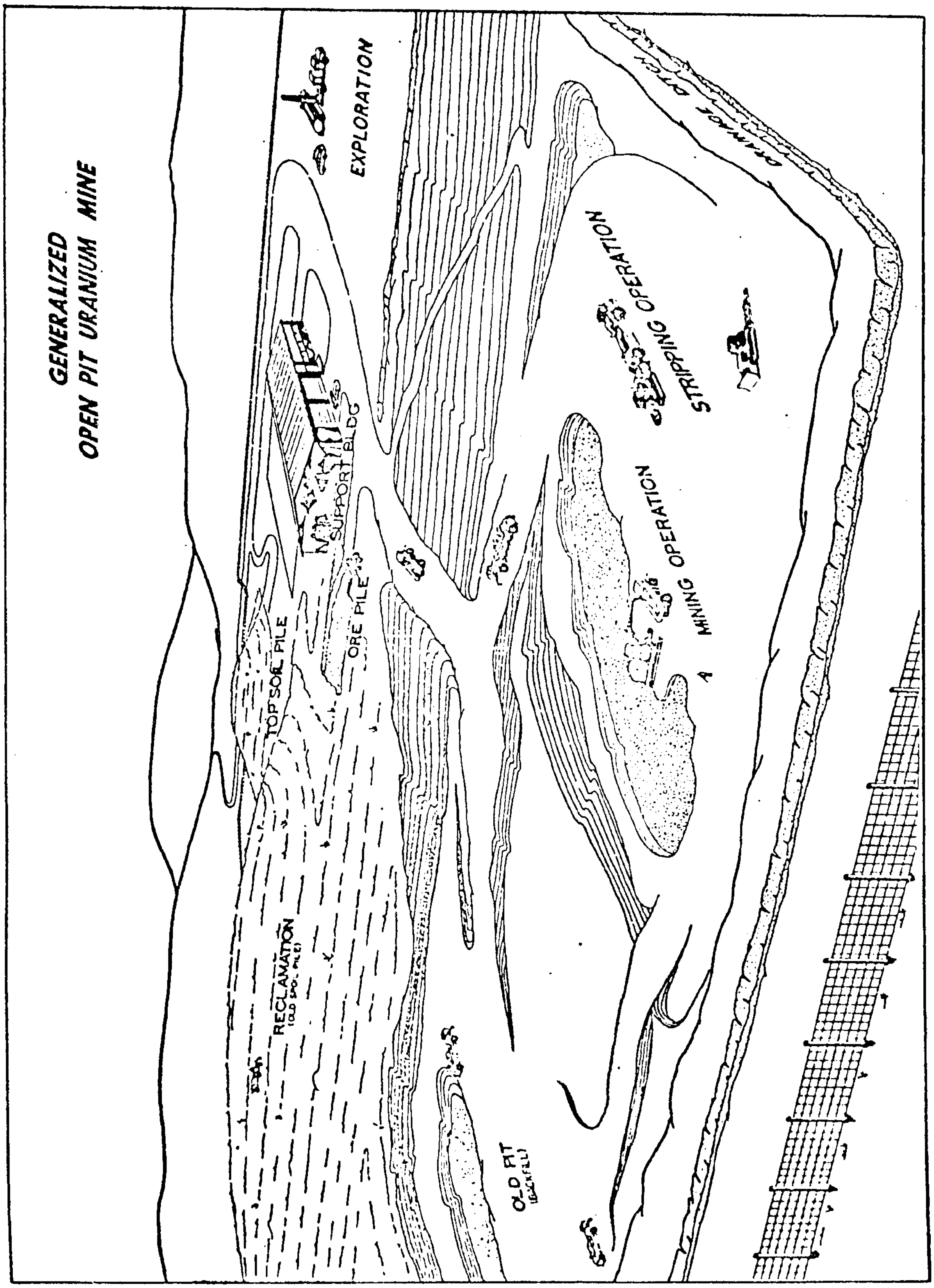

Figure 1.1.2.2-1

an existing open pit where approximately 70 percent of the overburden was removed by the previous owner of the mineral rights. This deposit will be held as a contingency reserve to be mined when necessary to maintain production schedules. Exploration and development drilling is continuing and additional surface mining areas may be delineated.

Where feasible for the existing open pit, topsoil and suitable subsoil will be segregated from the other overburden and stockpiled. Conservation measures will be taken to control erosion. If the stockpiled material is not to be used for an extended period of time, it will be seeded within 5 months to provide temporary cover and stabilization. (See Section 3 for more details.)

In the initial pit, which presently occupies approximately 8.1 ha (20 acre), the remaining overburden will be removed with bulldozers and scrapers; extensive blasting is not anticipated. Removed overburden will be placed on a nearby existing spoil pile. All material moved e.g., waste, ore, topsoil, etc., will be placed in separate piles and conspicuously marked as to content.

Ore production will commence following overburden removal. Proposed surface mining equipment is listed in Table 1.1.2.2-1. Each truck-load of material will be sampled and assayed to determine the ore grade and will then be hauled to the proper stockpile or waste area. Under certain circumstances it may be necessary to drive adits into the wall of the open pit to recover ore from small, narrow trends. The adits will be timbered, with portal sets extending into the open pit to provide adequate protection against pit wall sloughing. Adits are commonly driven by conventional drilling and blasting techniques directly along the ore trends. All material handling is typically accomplished by diesel-powered load-haul-dump vehicles with built-in scrubbers.

A work force of approximately 10 people (excluding supervisory and technical staff) will be employed in the open pit development and ore production operation. This operation is expected to require 6 months.

1.1.3 Surface Facilities

Mine Water Installations - During the development and mining phases of the underground workings, water from underground dewatering will be pumped to the surface and directed to holding ponds to reduce sediments. Based on subsurface hydrologic studies, it is estimated that dewatering will produce 28.4 to 42.6 l/sec (450-675 gal/min). A permit is being applied for under the National Pollutant Discharge Elimination System (NPDES), as implemented by the South Dakota Environmental Protection Agency. If the water meets applicable requirements, as will be delineated in the NPDES permit, it will be discharged into local drainages. Otherwise, it will be treated in conformance with the NPDES permit prior to release.

A drainage system will be built and maintained to minimize the accumulation of surface water and to control runoff at the Spencer-Richardson mine. The system will include:

Table 1.1.2.2-1

Surface Mine Machinery

Equipment	Number	Operating Frequency (hrs/day)	Specifications	Fuel Requirements
Scrapers	2	8	420 HP Diesel	57 l/hr (15 gal/hr) each
Hydraulic Backhoe	1	8	130 HP Diesel	38 l/hr (10 gal/hr)
Tractor	1	8	240 HP Diesel	57 l/hr (15 gal/hr)
Ore Trucks	1	8	300 HP Diesel	57 l/hr (15 gal/hr)
Utility Truck	1	8	175 HP Diesel or Gasoline	11 l/hr (3 gal/hr)

- Dikes and ditches to direct surface runoff away from the open pit area.
- Drainage ditches constructed below the spoil piles to collect runoff.
- Sump pumps and piping systems to remove water from the floors of the open pit mines if required.
- Dikes around impervious ore pads.

Figure 1.1.3-1 shows a typical layout of surface-water control facility in an open pit mine and waste dump area.

Roads - Access to the proposed underground and open pit mine locations will be provided by existing dirt and asphalt roads. However, some will require upgrading and widening. All roads will have culverts where they cross major drainage channels; drainage ditches will be constructed alongside the roads. Unpaved roads will be sprinkled as weather and ground conditions require to control dust.

Utility Services - The utility requirements for the proposed mines and their surface support facilities include electric power, telephone, industrial and potable water, and sanitary sewage disposal.

It is expected that electric power required at the underground sites will be supplied via a 14.4/24.9 kV (kilovolt) primary transmission line. A transformer substation will be installed in the vicinity of the initial underground mine site to supply required voltages for use at the underground mine. The estimated connected electrical load at the underground mine sites is 3,500±500 kVA (kilovoltampere). All underground and surface mining electrical installations will comply with Mine Safety and Health Administration (MSHA) standards.

Natural gas is not available near any of the mine sites and propane will be used where necessary. No. 6 fuel oil is planned for space heating use.

Offices at Edgemont are serviced by the Peoples Telephone and Telegraph System. Current and future field communications will utilize telephone and radio with the base station located at the Edgemont offices. Telephone routing has not yet been established. At the underground mine sites, communications between the shaft stations and surface will be by telephones and a bell system. These communications systems will comply with MSHA safety regulations.

It is anticipated that industrial water required at the underground mine will be provided by dewatering discharge which will be treated as necessary. Industrial water, will be utilized in the mine operations for dust suppression on active haul roads. Maximum use of water for dust suppression may approach 22,800 l/d (6,000 gal/d) during the summer period. Little of this water will run off because of the porous nature of the materials used to upgrade the haul roads. Potable water will be supplied from an approved source.

An approved sanitary sewage system consisting of a combination of septic tanks, sewage lagoons and/or another acceptable system will be constructed at the Burdock underground

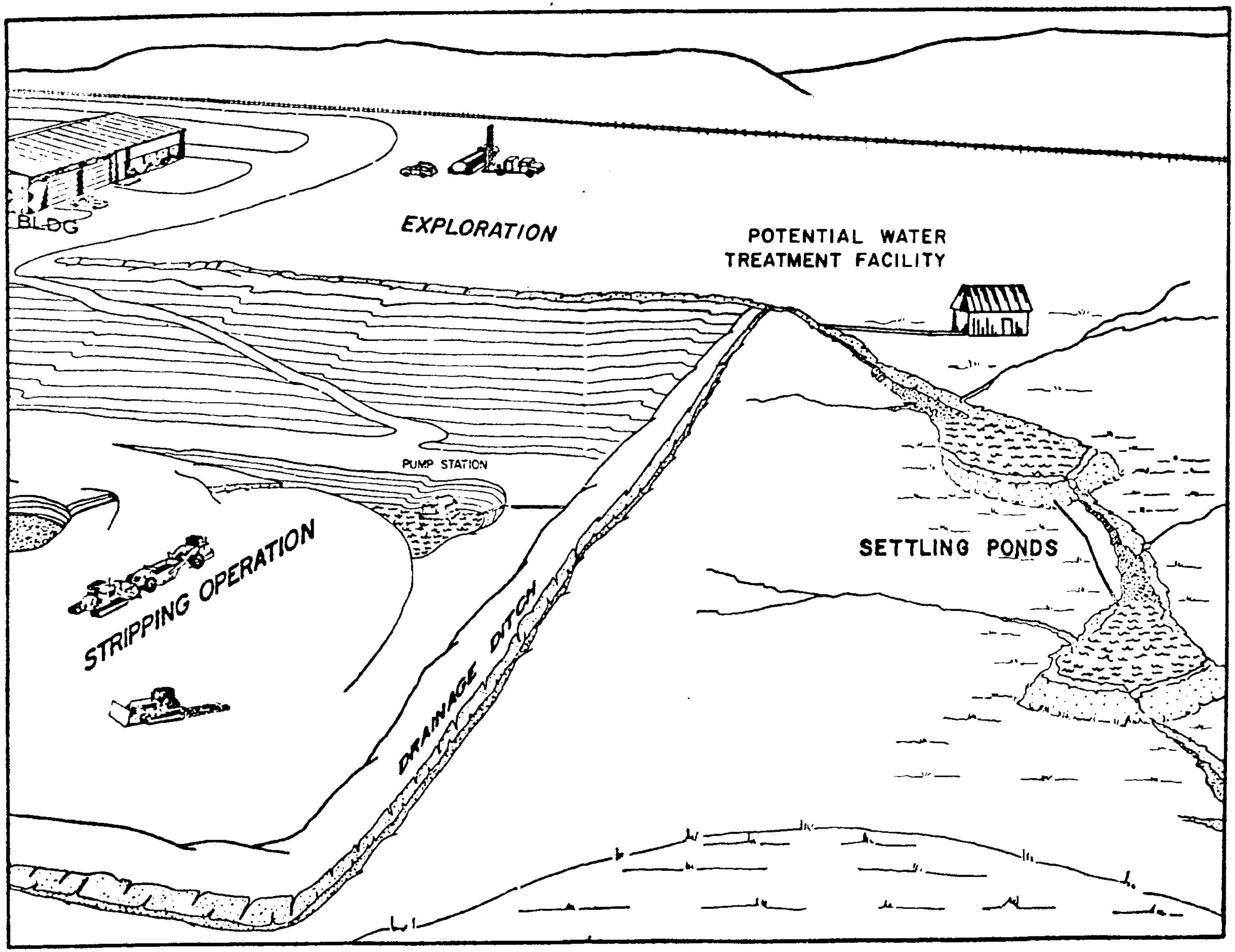

Figure 1.1.3-1 Generalized Water Treatment Facility

site. This facility will accommodate in excess of 19,000 l (5,000 gal) of sanitary sewage daily. At the other proposed mine sites, portable toilet facilities will be provided.

Office and Shop Buildings - Present plans call for several single story steel paneled buildings to be constructed at each Burdock shaft site. They will be set on concrete slab foundations with approximately 929 m^2 (10,000 ft^2) of floor space. The buildings will contain hoists, mine offices, change rooms, warehouse, shops, mine rescue and first aid station, compressors, and auxiliary power.

A 26 m (85 ft) high head frame will be erected. It will be fabricated steel, and will support three sheave wheels. Skips will dump ore and waste material into a surge bin in front of the head frame to be trucked to separate storage areas. One compartment in the main shaft will be an emergency escapeway equipped with a ladder. Explosives magazines will be located on the surface in compliance with Federal and state requirements. These will provide safe storage for explosives required by the project.

Mine Ore Control Facilities - Adequate facilities equipped with ore sample dryers, pulverizers and beta-gamma or X-ray detection units, used to determine ore grades and to maintain ore stockpile control, will be located adjacent to mines and/or mine haulage roadways.

Fixed Equipment - There is no proposed major fixed, energy-consuming equipment planned for the surface mining operation. Major fixed, energy consuming equipment at the initial underground shaft site is shown in Table 1.1.2.1-1.

On-Highway Support Equipment - About 40 vehicles will be used on the project, consuming approximately 325 l/d (85 gal/d) of gasoline.

1.1.4 Health and Safety - The proposed mine will operate under applicable Federal mine safety regulations. New employees at the mines will be given initial training in safety rules and safe working procedures.

First aid training will be made available to all employees. Fire prevention and fire-fighting instruction will also be given.

All underground employees will be instructed in the use of self-contained respirators and on the location of mine escape routes and procedures applicable in the event of mine fires or other emergencies.

A mine rescue team will be selected, trained, and available for rescue operations at any of the shafts.

On the surface, selected ventilation shafts will be equipped with an emergency hoist and torpedo-shaped man cage. Each shaft site and ventilation shaft will have a 1.83 m (6 ft) chainlink fence on the perimeter to prevent inadvertent access by livestock and humans.

1.1.4.1 Fire Control - All surface structures within 30.5 m (100 ft) of each shaft will be constructed with fireproof materials. The headframes will be structural steel. Any nonfireproof structures will be placed more than 30.5 m (100 ft) from the shaft. The areas surrounding the surface building will be kept clear of combustible materials. Fuel and lubricating oils will be stored at least 30.5 m (100 ft) from any mine opening and will be surrounded by retention dikes capable of retaining 110 percent of the volume of the storage tanks.

Shaft lining will be concrete and supporting frameworks within the shafts will be steel. Where timber is used for sets and lagging at the shaft access station, the timber will be treated with fire-resistant coatings. Where fire doors are used underground, they will be constructed of steel.

Underground storage of lubricating oils and diesel fuel will comply with applicable Federal regulations regarding quantity and location.

Water for firefighting will be available throughout the active areas of the mine. Fire extinguishers will be available at the shaft stations, shops, and storage areas for fuel and lubricating oils. Extinguishers designed for electrical fires will be placed near the electrical substations. Each diesel-powered locomotive will carry a fire extinguisher for use on diesel fuels. Routine inspections will be made of all in-place extinguishers, and used extinguishers will be replaced immediately. All personnel will receive instruction in the use of each type of fire extinguisher.

Emergency exits from each mine will be provided at selected ventilation shafts by means of emergency hoists with man cages. At several locations within the mine, rescue chambers will be constructed. Each chamber will contain food, air, and potable water.

1.1.4.2 Ground Control - Ground control (support) practices at each mine site will be tailored to the particular geological conditions that exist at that site.

During the driving of drifts, temporary supports consisting of jacks with headboards or stulls with headboards will be used until permanent supports can be installed. Permanent support, where required, will be installed within 3 m (10 ft) of the drift face. For roof support in haulage drifts and other permanent mine openings, roof bolts in conjunction with wire mesh will generally be used. Steel sets will be used in large openings near the shaft station. Timber sets will be used for temporary support and, where practical, for permanent support. In mined-out areas of the mine where ground conditions present a hazard, induced caving of the roofs may be employed. Also waste rock from other areas of excavation may be used as backfill material in excavated areas where caving would not be desirable.

Compliance with all applicable Federal Mine Safety regulations will be maintained.

1.1.4.3 Radiation - The Mine Safety and Health Administration (MSHA) requires that when radiation measurements in areas where personnel are working indicate exposure to concentrations of radon daughters in excess of 0.3 working level (WL), complete individual exposure records shall be kept for all employees entering these areas. A working level is defined by 30 CFR 57.2 as follows:

> In those standards which relate to radiation, a working level" (WL) means any combination of the short-lived radon daughters in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV (million electron volts) of potential alpha energy, and exposure to these radon daughters over a period of time is expressed in terms of "working level months" (WLM). Inhalation of air containing a radon daughter concentration of 1 WL for 173 hours results in an exposure of 1 WLM.

In order to maintain concentrations less than a 0.3 WL, the ventilation program will be regularly updated; and every area of the mine where men are working will be checked for radon or its short-lived daughters on a scheduled basis and spot checked when necessary. Radon (daughter) checks will be made in compliance with federal regulations at all working areas throughout the underground mine. Individual radon (daughter) exposure records will be kept up-to-date monthly, based on the results of the periodic readings. Records will be made available for inspection at the Safety Director's office at any time.

2. Environmental Description, Impacts, and Interim Mitigation

2.1 Land Use

2.1.1 Description - Land use for Fall River County is shown on Figure 2.1.1-1 and statistics which were derived from the map are contained in Table 2.1.1-1.[1] The predominant land use is rangeland (85 percent) with the remaining consisting mostly of forest (11 percent) and cropland (3 percent). The county is very sparsely settled as indicated by the average population density of 1.9 persons/km² (5 persons/mi²). A combination of the population and land areas of Edgemont and Hot Springs results in a rural population density of 0.4 persons/km² (one person/mi²).

2.1.2 Impacts - Mining activities will disturb and/or restrict the use of 32 ha (80 acre) of shrubland, woodland, and grassland. Rangeland and forest total over 404,700 ha (1 x 10^6 acre) so the small amount temporarily impacted will have no significant effect on land use in Fall River County. Further, because of the sparse settlement pattern, the operation should have no significant effect on inhabitants (see Section 2.10). After production, the reclamation procedures should result in land uses which would be essentially the same as present uses; thus no permanent impacts are expected.

The only planned mining activity outside Fall River County will be the surface mining operation at the existing Spencer-Richardson open pit mine which occupies 8.1 ha (20 acre) in Custer County, less than 1 km (.6 mile) north of the Fall River County line (refer to Figure 1.1.1-1). No additional land disturbance is expected from this mining operation and therefore, no land use changes will occur.

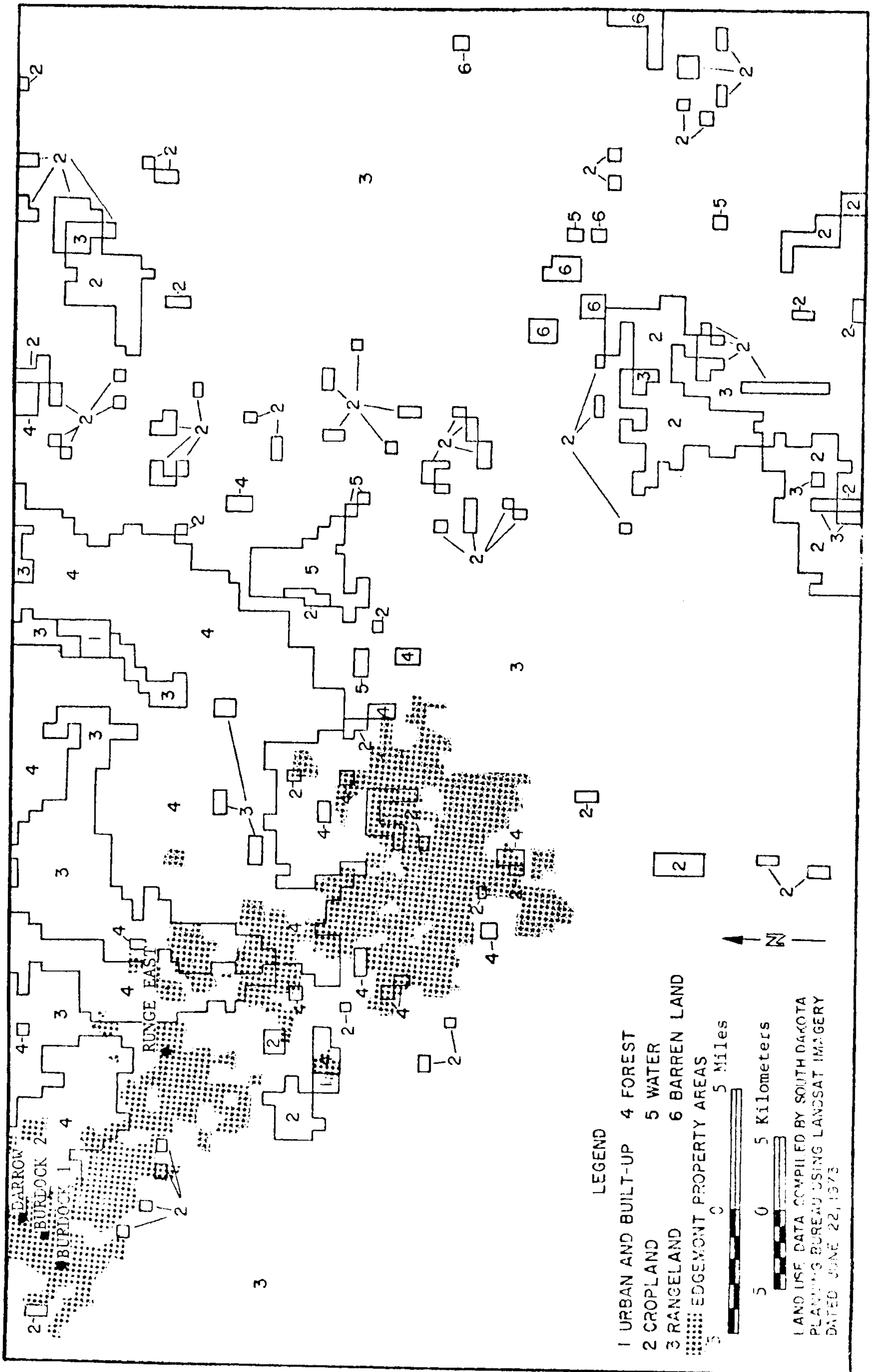

Figure 2.1.1-1 Existing Land Use Fall River County

Table 2.1.1-1

Fall River County Land Use

1973*

	Acres	Percent
Urban and Built-Up	1,920	0.2
Cropland	33,600	3.0
Rangeland	947,520	84.9
Forest	122,880	11.0
Water	6,240	0.6
Barren Land	3,520	0.3
Total	1,115,680	100.0

*Land use data is based on interpretation of LANDSAT scene 1334-17130 taken June 22, 1973. The interpretation and estimations were prepared by the South Dakota State Planning Bureau.

2.1 References

1. Loveland, Thomas A. Land Use Data Analyst. South Dakota State Planning Bureau, letter and enclosure to George DeVenny, TVA. November 8, 1977.

2.2 Geology

2.2.1 Geomorphology - The Edgemont project is located on the southwest flank of the Black Hills Uplift in the southwest corner of the State of South Dakota. Flat to rolling topography, deep intersecting canyons, numerous small mesas, cuestas, and hogbacks characterizes the area which is drained by the Cheyenne River and its tributaries. Elevations in the project area range from 1,006 m (3,300 ft) in the low areas of the Cheyenne River Drainage to 1,417 m (4,675 ft) at the crests of the surrounding ridges. In the project area, the local relief is about 75 m (250 ft).

2.2.2 Stratigraphy - The stratigraphy of the southwestern flank of the Black Hills Uplift is composed of a sequence of rocks which range in age from Precambrian to Recent (Table 2.2.2-1). Precambrian rocks outcrop near the center of the Black Hills Uplift and progressively younger rocks outcrop southwesterly to the Powder River Basin. Within the project area, the outcropping rocks range in age from Jurassic to Recent (Table 2.2.2-2).

To date, all of the economically significant uranium occurrences are contained within the Fall River and Lakota Formations of the Inyan Kara Group of Lower Cretaceous age (Figure 2.2.2-1). The Lakota and Fall River Formations were deposited in continental and marginal marine environments, respectively. The Inyan Kara Group is composed of subequal amounts of complexly interbedded and intertonguing sandstones and claystones.[1] The Inyan Kara Group is underlain by continental sedimentary rocks of the Morrison Formation of Jurassic age and is overlain by the marine Skull Creek Shale of Lower Cretaceous age. Resistant Inyan Kara sediments form the outermost hogback ridges circumscribing the Black Hills.[2]

2.2.3 Geologic Structures - The project area is on the southwest flank of the Black Hills Uplift, an elongate north-west trending dome of Laramide age about 200 km (125 mi) long and 97 km (60 mi) wide.[3] To the west and southwest of the project area is the Powder River Basin.[4] Superimposed on the Black Hills Uplift are numerous folds plunging radially outward. Within the project area, local structures of this type are the Chilson Anticline and Sheep Canyon Monocline east of the community of Edgemont, and the Cottonwood Creek Anticline trending southwest from the community of Edgemont (Figure 2.2.2-1). The regional dip of the sedimentary rocks in the project area is 2 to 4 degrees southwesterly.

Two major structural zones, Dewey and Long Mountain, are conspicuous within the project area (Figure 2.2.2-1). These structural zones consist principally of a number of <u>en echelon</u> faults. Two subordinate fracture systems are prevalent within the project area. One set of fractures strikes about N 30-60 degrees W and the second set strikes about N 30-60 degrees E. Movement along the fractures appears to have been less than 2 m

Table 2.2.2-1

Generalized Stratigraphic Section of the Black Hills

(Modified from the Geologic Map of South Dakota by N. H. Darton 1951)[2]

Age	Formation	Description
Upper Cretaceous	Pierre shale	Dark shale
Upper Cretaceous	Niobrara	Impure chalk and limy shale
Upper Cretaceous	Carlile shale	Dark shale
Upper Cretaceous	Greenhorn limestone	Limestone
Upper Cretaecous	Belle Fourche and Mowry Shales	Dark shales
Lower Cretaceous	Skull Creek Shale, Inyan Kara Group Fall River, Lakota	(See Table 2.2.2-2)
Jurassic	Morrison	Shale, mostly gray; sandstone and limestone
Unconformity		
Jurassic	Sundance	Greenish shale, buff, and red sandstone
Triassic (?)	Spearfish	Red sandy shale and sandstone; gypsum members
Permian	Goose Egg Formation Minnekahta Member Opeche Member	Limestone Red sandy shale
Pennsylvanian	Minnelusa	Gray, red, and buff, sandstone, mostly limy; red shale at base
Mississippian	Pahasapa & Englewood	Limestone Limestone
Unconformity		
Ordovician	Whitewood	Limestone
Unconformity		
Upper Cambrian	Deadwood	Sandstone, shale, congomerates
Unconformity		
Precambrian		Igneous and Metamorphic Rocks

Table 2.2.2-2

Generalized Stratigraphic Section for the Project Area

Age	Formation	Member	Thickness meters (feet)	
Quaternary	Alluvium & Terrace Deposits		0-2 (0-5)	Alluvial sand, gravel, and clay.
Cretaceous	Mowry Shale		0-30 (0-100)	Gray, siliceous shale and many thin bentonite beds.
Cretaceous	Newcastle Sandstone		0-12 (0-40)	Sandstone, gray and brown shale, and some bentonite and shaly coal.
Cretaceous	Skull Creek Shale		0-60 (0-200)	Grayish-black shale and a few thin beds of sandstone.
Cretaceous	Fall River Formation	Upper	12-36 (40-120)	Variegated mudstone at the base overlain by fluvial sandstone and its fine-grained equivalents. Highly argillaceous and is characteristically mottled red and gray.
		Middle	10-34 (30-110)	Typically fine-grained fluvial sandstone and the associated marginal fine-grained deposits cemented with calcite and silica. Forms prominent vertical cliffs in canyons.
		Lower	0-16 (0-50)	Principally laminated micaceous carbonaceous siltstone interlayered with thin fine-grained slightly micaceous sandstone. Commonly stained brown or yellowish brown on outcrop.
Cretaceous	Lakota Formation	Fuson	12-18 (40-60)	Typically gray to black to maroon non-calcerous bentonitic shales. Internal sand lenses are common.
		Minnewaste Limestone	0-4 (0-10)	White to gray massive limestone commonly highly brecciated and recemented with calcite. Generally considered to be lacustrine in origin.
		Chilson	30-46(100-150)	Complex intertonguing of sandstones, siltstones and mudstones typical of a fluctuating alluvial depositional environment. Generally contains two well developed sandstone units and has a dark organic fissile shale near the base.
Jurassic	Morrison Formation		24-36 (80-120)	Red and green claystone interbedded near the base with light gray sandstone and limestone.

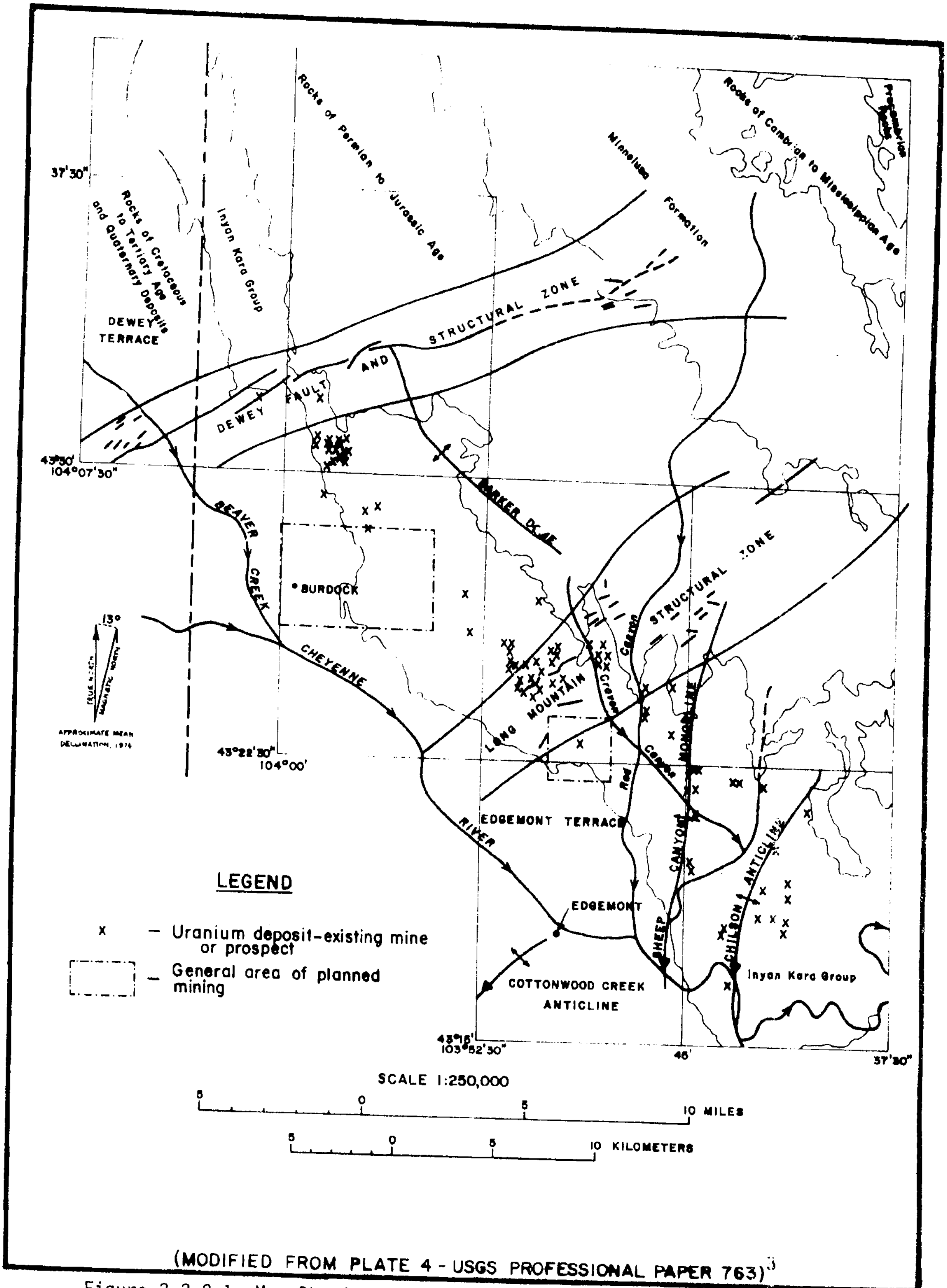

Figure 2.2.2-1 Map Showing Major Structures and Uranium Deposits Edgemont, South Dakota Project

25

(6 ft) based on observations in existing pits and on information based on electric logs derived from drill holes.

Many small subsidence structures exist in and around the project area.[2] Most of these collapse structures are associated with breccia pipes or with dissolution of beds of anhydrite, gypsum, limestone, dolomite, and possibly salt.

2.2.4 Uranium Deposits - The project area is located within an identified uranium mining district established in 1951.[1] Past production records of this district indicate that production was in excess of 680,400 kg (1.5 x 10^6 lb) of U_3O_8 between 1951 and 1964.

According to O. M. Hart:

> Primary minerals in the deposits are coffinite and uraninite with minor amounts of paramontroseite and haggite. The ore minerals coat sand grains and fill interstices of complexly cross-stratified sandstone along solution fronts similar to "roll" type deposits of the other districts. Minerals of oxidized deposits are typically carnotite and tyuyamunite with different proportions of secondary vanadium accessory minerals. Ground water was the transportation medium and deposition of primary uranium and vanadium minerals occurred in reducing environments produced and controlled by physiochemical characteristics of the sedimentary rocks.[5]

The geochemical cells containing the uranium minerals are typically narrow, 5 to 30 m (15-100 ft), highly sinuous, often kilometers in length and the known deposits occur 1 to 8 km (0.6-5 mi) downdip from the outcrop of the respective sandstone unit.[1] Economic uranium deposits occur intermittently along the trend of the geochemical cells at depths from up to 220 m (720 ft).

2.2.5 Other Mineral Resources - Vanadium generally occurs in association with the uranium in a ratio of approximately 1.5:1 and has been economically recovered during uranium milling operations. No other minerals of economic value have been identified in the project area.

2.2.6 Geologic Impacts - Potential geologic impacts in the project area may be caused by slope instability and subsidence.

Slope Instability - Only minor slope stability problems are anticipated. Some caving and sloughing may occur in open pit mining in areas where pit walls encounter faults or major fracture systems. If these conditions are encountered, action will be taken to avoid unnecessary slumping and to assure safe working conditions for employees. Existing pits within the project area, mined in the 1960's to depths of up to 48 m (150 ft), have had no significant caving or slumping except along

fault zones. The existing pit walls are stable with an overall slope ratio of approximately 0.5:1. Existing road cuts in the project area are stable with a slope ratio of 1:1.

Subsidence - Subsidence of less than 1 percent is estimated for uncompacted material from surface mining. In underground mining, no significant surface ground subsidence is anticipated for the following reasons: (a) Existing shallow mines, (15-45m, 50-150 ft, below surface) in and around the project area which were mined in the 1950's and 1960's, show no surface subsidence over the mine workings except for the Gould Mine at which about 6 m (20 ft) of unconsolidated siltstone overlying the adit portal has collapsed. (b) Ground support techniques such as roofbolting, lagging, and timbering will be used when support is necessary, e.g., when faults are encountered which produce unstable ground. The Hauber Mine, located in the northwestern Black Hills, mined in the 1950's and 1960's, has shown no surface subsidence to date. This uranium mine was developed within the Lakota Formation. Ground conditions at the proposed Burdock shaft sites are expected to be similar to those at the Hauber mine.

2.2 References

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2. Darton, H. H. Geologic map of South Dakota. U.S. Geol. Survey, 1951.

3. Gott, G. B., Wolcott, D. E., and Bowles, C. G. Stratigraphy of the Inyan Kara Group and Localization of Uranium Deposits Southern Black Hills, South Dakota and Wyoming. U.S. Geol. Survey Prof. Paper 763. 1974.

4. Robinson, C. S., Mapel, W. J., and Bergendahl, M. H. Stratigraphy and structure of the Northern and Western Flanks of the Black Hills Uplift, Wyoming, Montana, and South Dakota. U.S. Geol. Survey Prof. Paper 404, 1964.

5. Hart, O. M. Uranium in the Black Hills. Ore deposits in the United States 1933/1967, Vol I. AIME. Salt Lake City, 1968.

2.3 Seismicity

Seismic events in the Black Hills area have been few in number and of low to moderate magnitude. The National Geophysical and Solar-Terrestrial Data Center files show that only 7 earthquakes of any significance have occurred within a 200 km (124 mi) radius of the planned mines during the period from the first documented earthquake in 1895 through 1976[1] (Figure 2.3-1).

The strongest observed earthquake, which had an intensity of VII based on the Modified Mercalli intensity scale,[2] occurred in 1964 and was centered approximately 178 km (110 mi) east-southeast of the mining sites. Some damage was reported in Alliance and Rushville, Nebraska (Figure 2.3-1). Using attenuation curves for maximum accelerations,[3] the maximum estimated acceleration that could be expected at the mining sites from such an earthquake would be less than 0.04g (gravity). The nearest tremor to the sites occurred in 1895. The epicenter was located approximately 80 km (50 mi) northeast of the sites and the tremor was reported to have had an intensity of V. There was no reported damage associated with that tremor. The maximum acceleration at the sites for a seismic event of this intensity is so small that it cannot be estimated from an attenuation curve.

According to the recent probabilistic acceleration map of the U.S.[4], the proposed project site lies within an area of low seismic risk. The probability that accelerations larger than 0.04g would be experienced at the proposed project sites is 10 percent in 50 years.

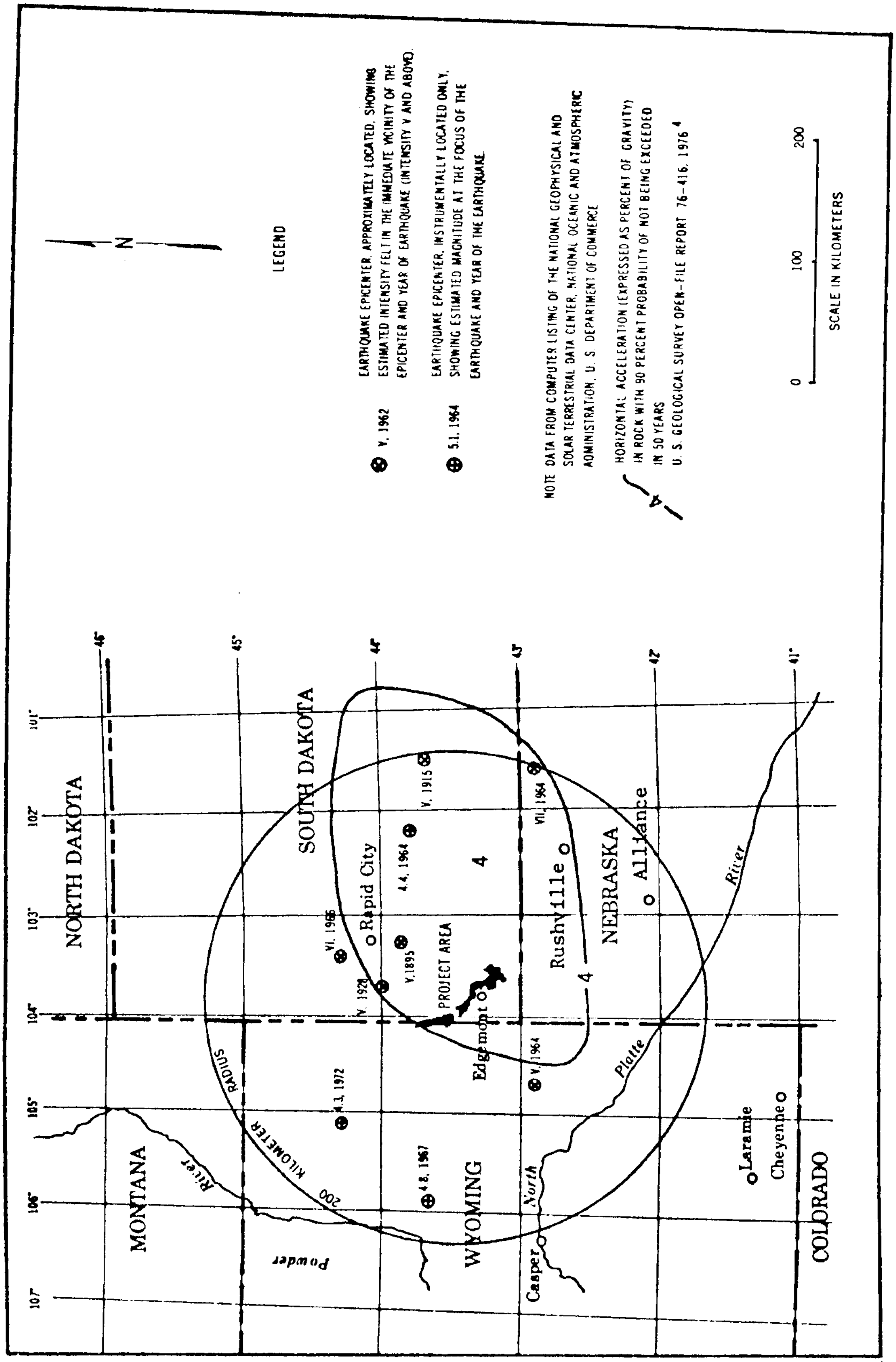


Figure 2.3-1 Regional Seismicity and Seismic Risk

2.3 References

1. National Geophysical and Solar Terrestial Data Center. (Undated). Environmental Data Service Report. NOAA, Department of Commerce.

2. Wood, H. O., and F. Neumann. Modified Mercalli intensity scale of 1931. Bull. Seis. Soc. Am. 21:278-283. 1931.

3. Schnabel, R. B., and H. B. Seed. Acceleration in rock for earthquakes in the western United States. Earthquake Engineering Center Report, #EECR 72-7, p. 15. University of California, Berkley. 1972.

4. Algermissen, S. T. and D. M. Perkins. Probabilistic estimate of maximum acceleration in rock in the contiguous United States. U.S. Geol. Survey Open-file Report 76-416, 45 pp. 1976.

2.4 Soils

2.4.1 Description - The generalized soils of the Edgemont property are shown in Figure 2.4.1-1 and may be divided into eight broad groups that differ in major characteristics.[1,2] A brief description of each of the broad groups follows.

MANUEL-SHINGLE-GRUMMIT ASSOCIATION - All of the surface disturbance from the proposed mining activity will fall within this soil association. The soil series which compose this association range from light brownish gray clays to light brown silty clay loams and are found on nearly level to very steep uplands. Many of the soils within this association provide only fair to poor source material for topsoil due to excessive lime and high clay content. Figure 2.4.1-2 displays, in map form, the soil series that will be potentially disturbed from the proposed mining activity. Detailed information displaying the associated soil interpretations and estimated engineering properties of these series are presented in Appendix A. Interpretations in relation to engineering use can be made from the estimated engineering properties of each soil series listed in Appendix A. These interpretations indicate that the soils of the Manuel-Shingle-Grummit Association have limitations as a source of road fill material because of their low strength and high shrink-swell potential. These soil series also have limitations as septic tank absorption fields because of their high clay content and shallow depth to bedrock. They also generally exhibit a moderate to high corrosivity in relation to untreated steel pipe. Because soil associations include a number of soil series with varying characteristics, a detailed soils engineering study will be performed as part of project engineering. This soils engineering study will be used to determine the site specific soil suitability for the various mining activities anticipated. Other soil associations that surround the proposed mining disturbance on the Edgemont property are briefly described below.

BUTCHE ASSOCIATION - This association is found mainly on broad uplift ridges that have gentle or very steep slopes. Drainageways are deeply entrenched. These soils are shallow with interbedded sandstone and siltstone found below a depth of 23 cm (9 in). Butche soils are poor source material for topsoil because of large stones, thin layers, and because they generally occur on slope positions where they cannot be easily obtained for stockpiling.

TILFORD ASSOCIATION - This soil association is nearly level to gently sloping and is found on stream terraces. Tilford soils are deep and well-developed and provide fair material for topsoil.

NORKA ASSOCIATION - This soil association is found on gently to moderately sloping uplands and valley sideslopes. Norka soils are deep and provide good material for topsoil.

TUTHILL-DAILEY ASSOCIATION - Both of the soils in this association are found on very gently sloping to moderately sloping upland deposits of tablelands and terraces. Tuthill soils are good source material for topsoil while the abundance of sand in the Dailey soils contributes to drought conditions due to its poor water retention characteristics.

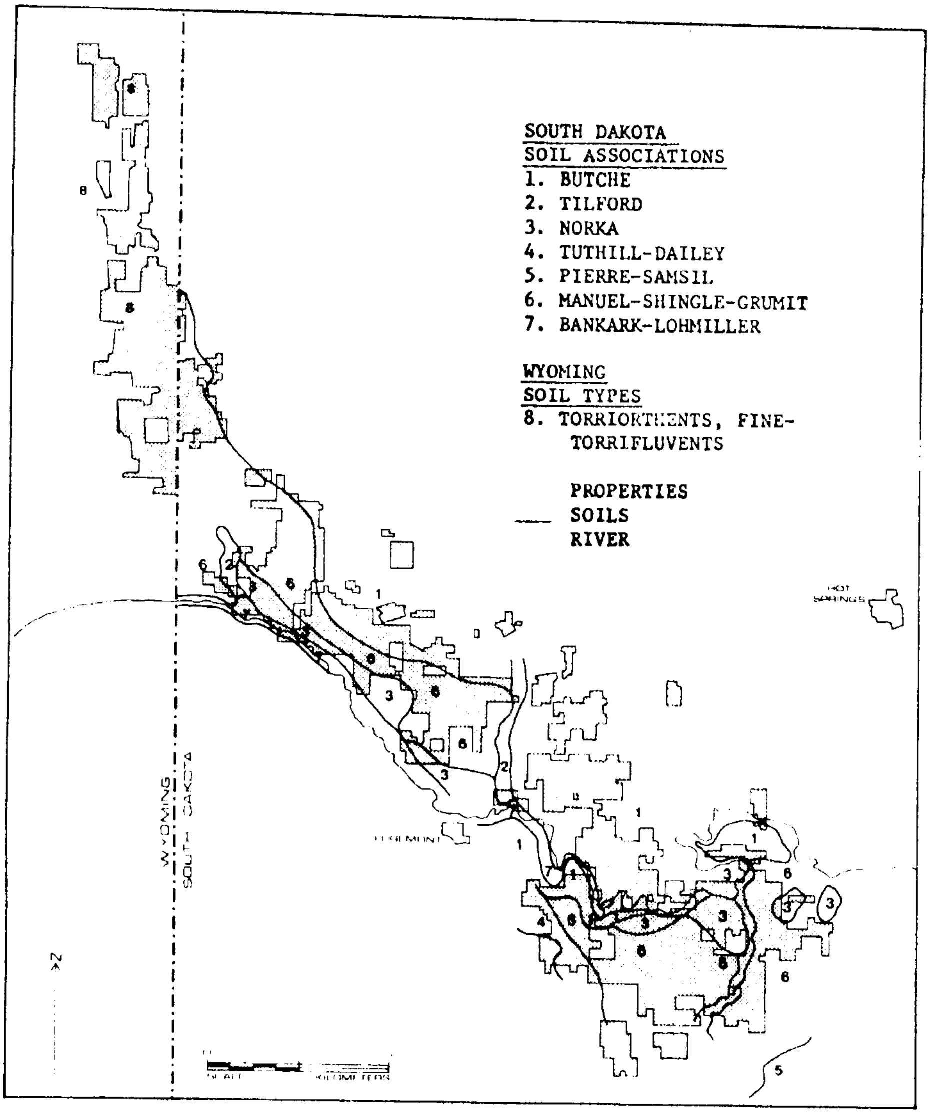


Figure 2.4.1-1

General Soils Map of the Edgemont Project Area

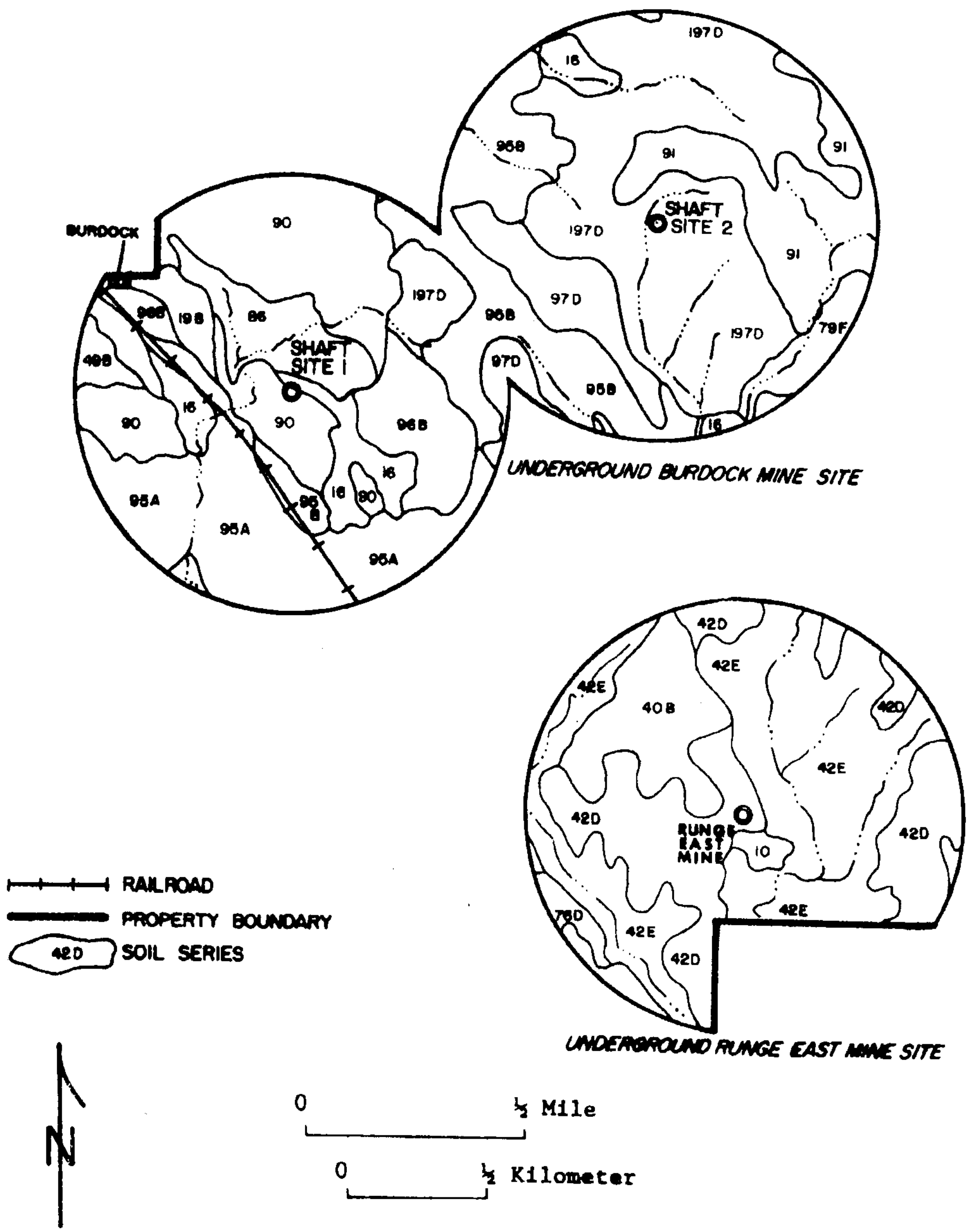


Figure 2.4.1-2 Soils Series of the Immediate Area Surrounding the Burdock and Runge East Mine Sites (Interpretations are Presented in Appendix A)

Shaft site locations are shown in Figure 1.1.1-1.

2.5 Hydrology

2.5.1 Surface Water

Description - The Edgemont project area is drained by the Cheyenne River and tributary streams in an area which lies in Weston and Niobrara Counties along the eastern edge of Wyoming and in Fall River and Custer Counties in southwestern South Dakota. The principal tributaries in this area which enter the Cheyenne River from the north are: Pass Creek; Bennett, Driftwood, Red, and Sheep Canyons; and Beaver Creek and its tributaries (Stockade Beaver, Lime and Hat Creeks). Cottonwood and Hat Creeks are the principal tributaries which enter the Cheyenne River from the south. With the possible exception of Stockade Beaver Creek, all of these streams including the Cheyenne River experience extended periods of no flow.

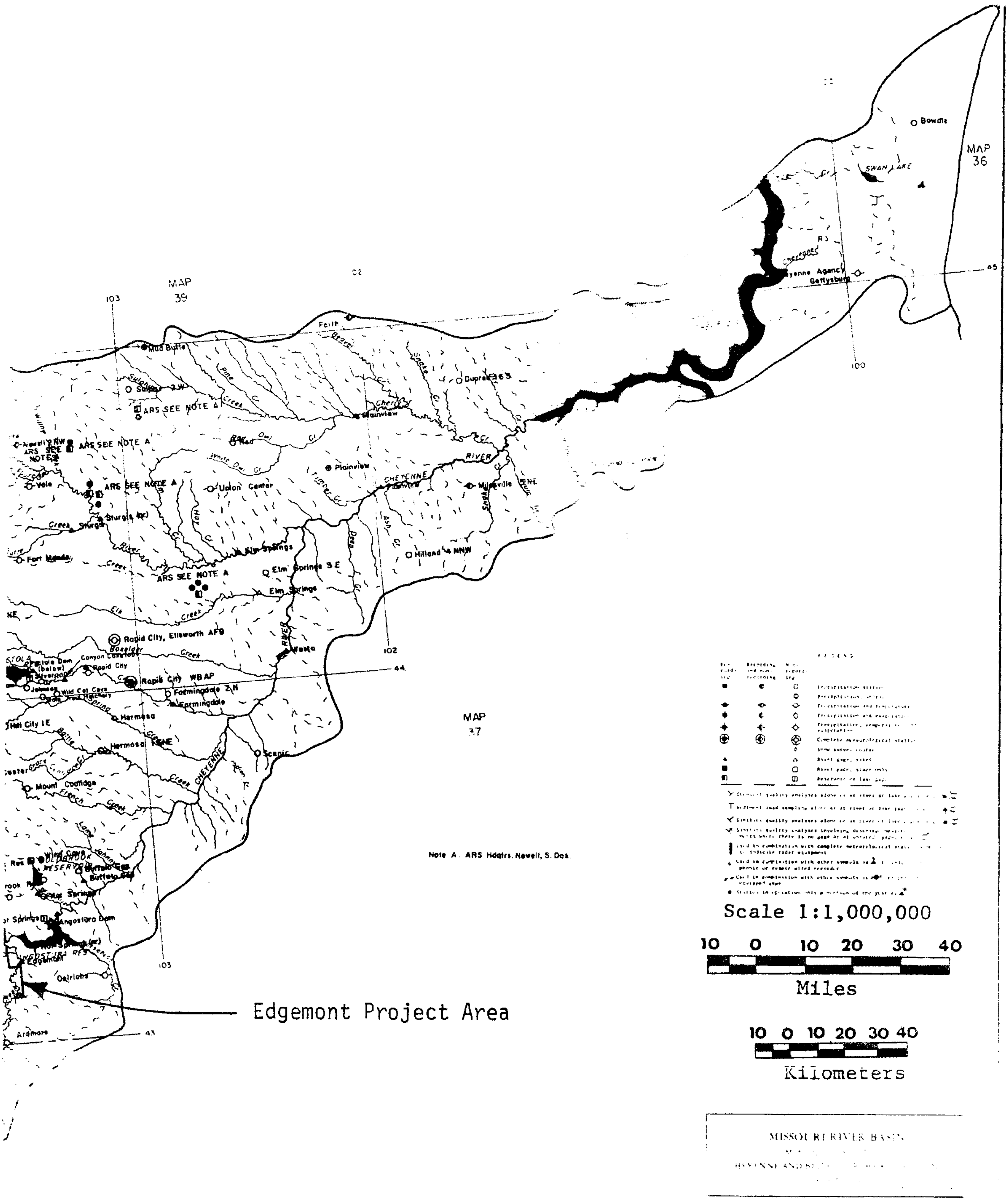
The Cheyenne River begins on Pine Ridge about 185 km (115 mi) west of Edgemont. The course of the river approximates the boundary between the Black Hills Section and Missouri Plateau Section of the Great Plains Physiographic Province and has a drainage area of 18,500 km² (7,143 mi²) at Edgemont. The river channel is braided, reflecting the low gradient of about 0.0014 in the vicinity of Edgemont. The Cheyenne River is impounded for irrigation, flood control, and power generation purposes by Angostura Reservoir about 54 km (34 mi) downstream from Edgemont. Angostura Dam is about 10.4 km (6.5 mi) southeast of Hot Springs. Contents of the reservoir since initial filling in October, 1949 have ranged from a minimum of 55.96 hm³ (cubic hectometers) (45,350 acre-ft) in September 1960 to a maximum of 179 hm³ (145,200 acre-ft) in June 1962.[1] The Cheyenne River flows northeasterly from Angostura Dam for another 80 km (50 mi) and empties into Oahe Reservoir which is impounded by Oahe Dam on the Missouri River near Pierre, South Dakota. Figure 2.5.1-1 shows the regional drainage surrounding the Edgemont property area.

The U.S. Geological Survey operates or has operated several stream gages in the vicinity of the Edgemont properties. Basic information on the streamflow characteristics of these gaged streams is shown in Table 2.5.1-1.[1,2] Annual runoff at these gaging stations varies widely as indicated[1] by values in the table. The same is true for the ungaged tributary streams draining the Edgemont properties.

The runoff distribution during the year based on the average of the monthly percentages for the Cheyenne River and Hat Creek gages and for the monthly percentages for the Beaver Creek near New Castle gage is shown in Table 2.5.1-2.[2] As indicated in this table, May, June, and July are the months of highest runoff, generally as the result of snowmelt and higher precipitation amounts experienced during these months. Runoff is generally lowest during the fall and winter months when precipitation is low and occurs mostly as snow.

Surface water drainage in the vicinity of the proposed mine locations as shown on Figures 2.5.1-2, and 3, is described in the following paragraphs.


MAP 34
MAP 42
MONTANA
WYOMING
Moorcroft
Rapid City WBAP
Rapid City, Ellsworth AFB
Spearfish
Sundance
Osage
Newcastle
Hermosa
Belle Fourche
Dumont 2 ENE
ARS SEE NOTE A



1.1 Regional Drainage Edgemont Project Area

Table 2.5.1-1

Streamflow Characteristics at Stream Gages in the Vicinity of Edgemont Uranium Mining Project[1,2]

	Period of Record	Drainage Area mi² (km²)	Streamflow Characteristics for Period of Record: Average Discharge cfs (m^3/sec)	Range of Average Annual Discharge Min. cfs (m^3/sec)	Range of Average Annual Discharge Max. cfs (m^3/sec)	Maximum Discharge cfs (m^3/sec)	Minimum Discharge cfs (m^3/sec)	Remarks
Cheyenne River near Edgemont, SD	1903-1906 1928-1933 1946-1976	7,143 (18,500)	99.5 (2.82)	12.9 (0.37)	434 (12.3)	13,800 (391)	0	Small reservoirs for stock irrigation water upstream. No flow for extended periods most years.
Cheyenne River near Hot Springs, SD	1914-1920 1943-1972	8,710 (22,559)	233 (6.60)	30.9 (0.88)	453 (12.8)	114,000 (3,228)	0.5 (0.014)	Small reservoirs for stock and irrigation water upstream.
Beaver Creek near Newcastle, WY	1944-1976	1,320 (3,419)	32.8 (0.93)	5.1 (0.14)	130 (3.68)	11,900 (337)	0	Diversions for irrigation and small stock reservoirs upstream.
Stockade Beaver Creek near Newcastle, WY	1974-1976	107 (277)	12.8 (0.36)	12.7 (0.36)	12.8 (0.36)	39 (1.10)	8.9 (0.25)	A few small diversions for irrigation upstream.
Hat Creek near Edgemont, SD	1905-1906 1950-1976	1,044 (2,704)	21.3 (0.60)	1.27 (0.036)	112 (3.17)	13,300 (377)	0	No flow many days each year. Flow diversions for irrigation upstream.

Table 2.5.1-2

Average Annual Runoff Distribution for Beaver Creek and the Cheyenne River and Hat Creek

	Percent of Annual Runoff	
	Beaver Creek	Cheyenne River and Hat Creek
January	2.3	0.7
February	8.2	2.5
March	21.3	8.7
April	9.2	7.4
May	12.0	19.1
June	22.9	31.5
July	10.5	15.2
August	4.6	7.8
September	2.1	3.7
October	2.4	1.4
November	2.4	1.1
December	2.1	0.9

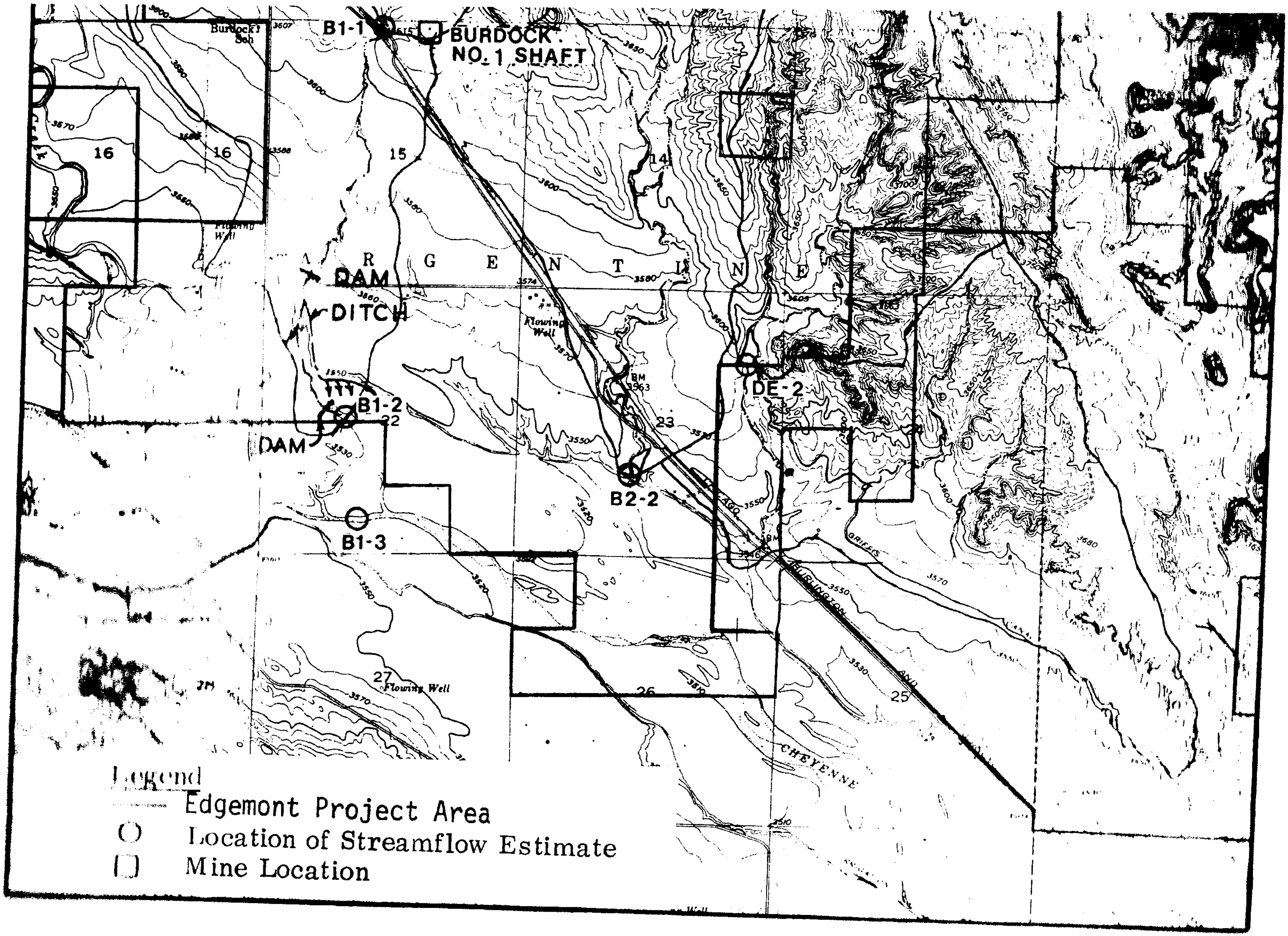
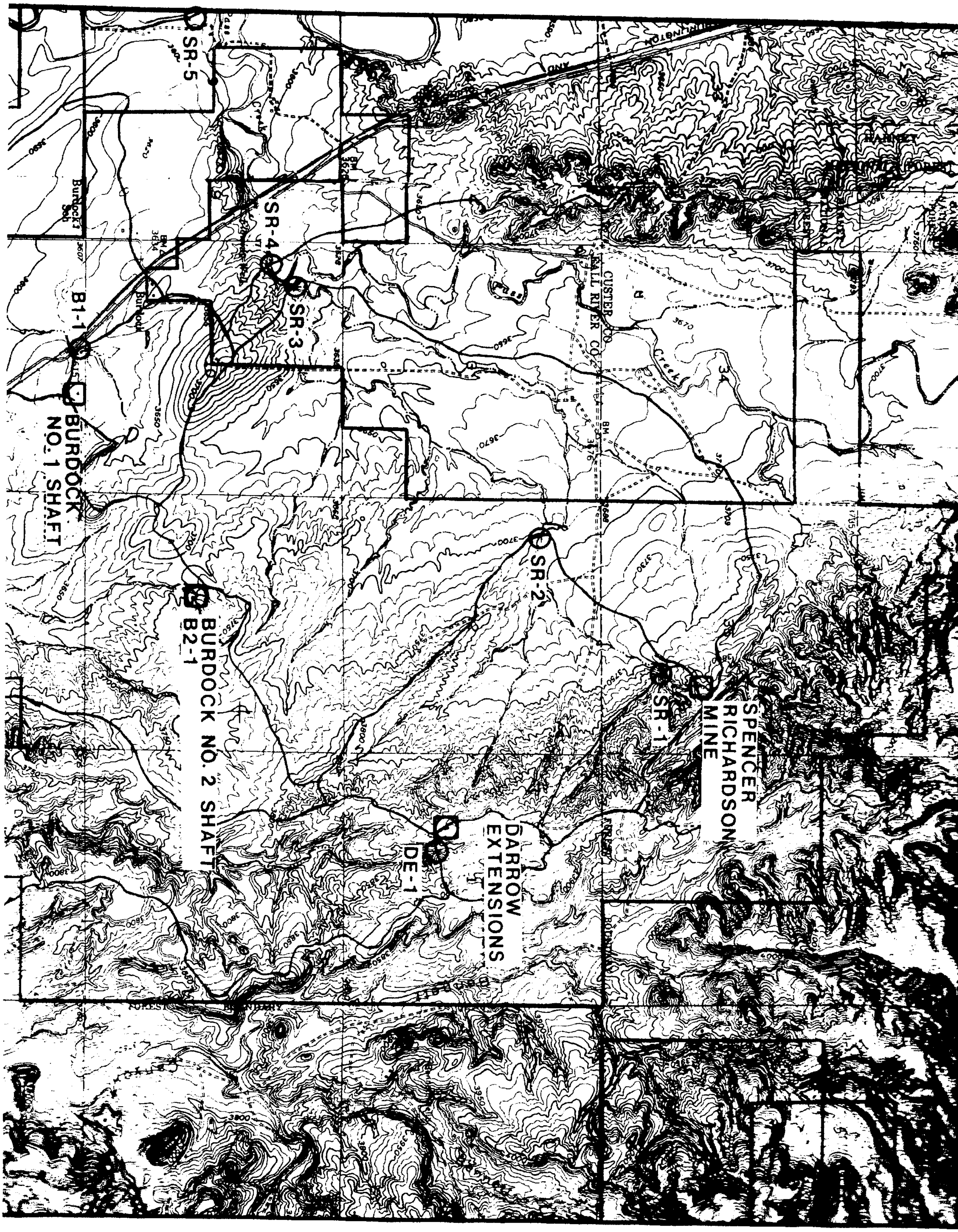


Figure 2.5.1-2 Streams and Subwatersheds - Edgemont Project Area


SR-5
SR-4
SR-3
B1-1
BURDOCK NO. 1 SHAFT
BURDOCK NO. 2 SHAFT
B2-1
SR-2
SR-1
SPENCER RICHARDSON MINE
DARROW EXTENSIONS
DE-1
CUSTER CO
FALL RIVER CO

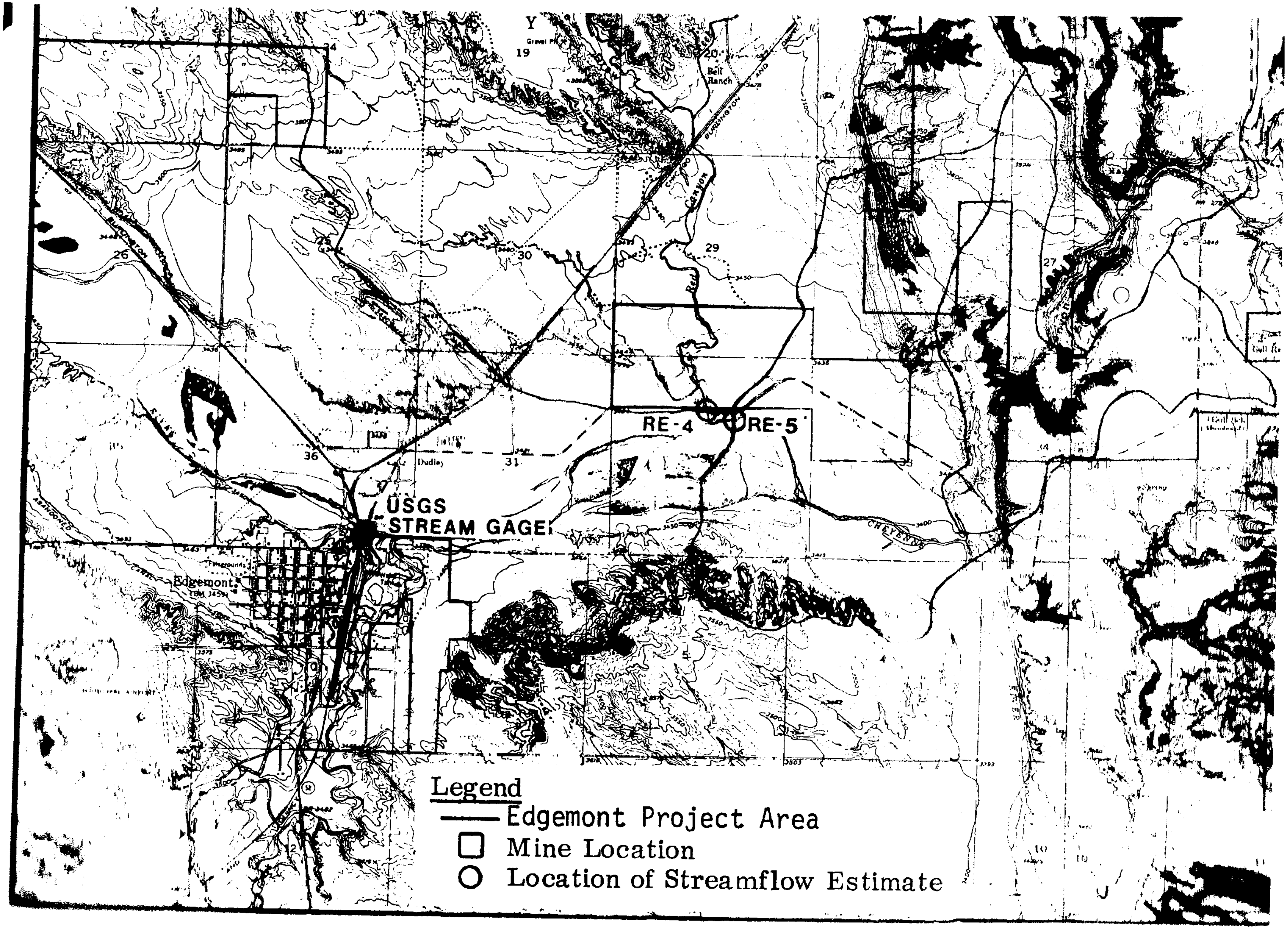
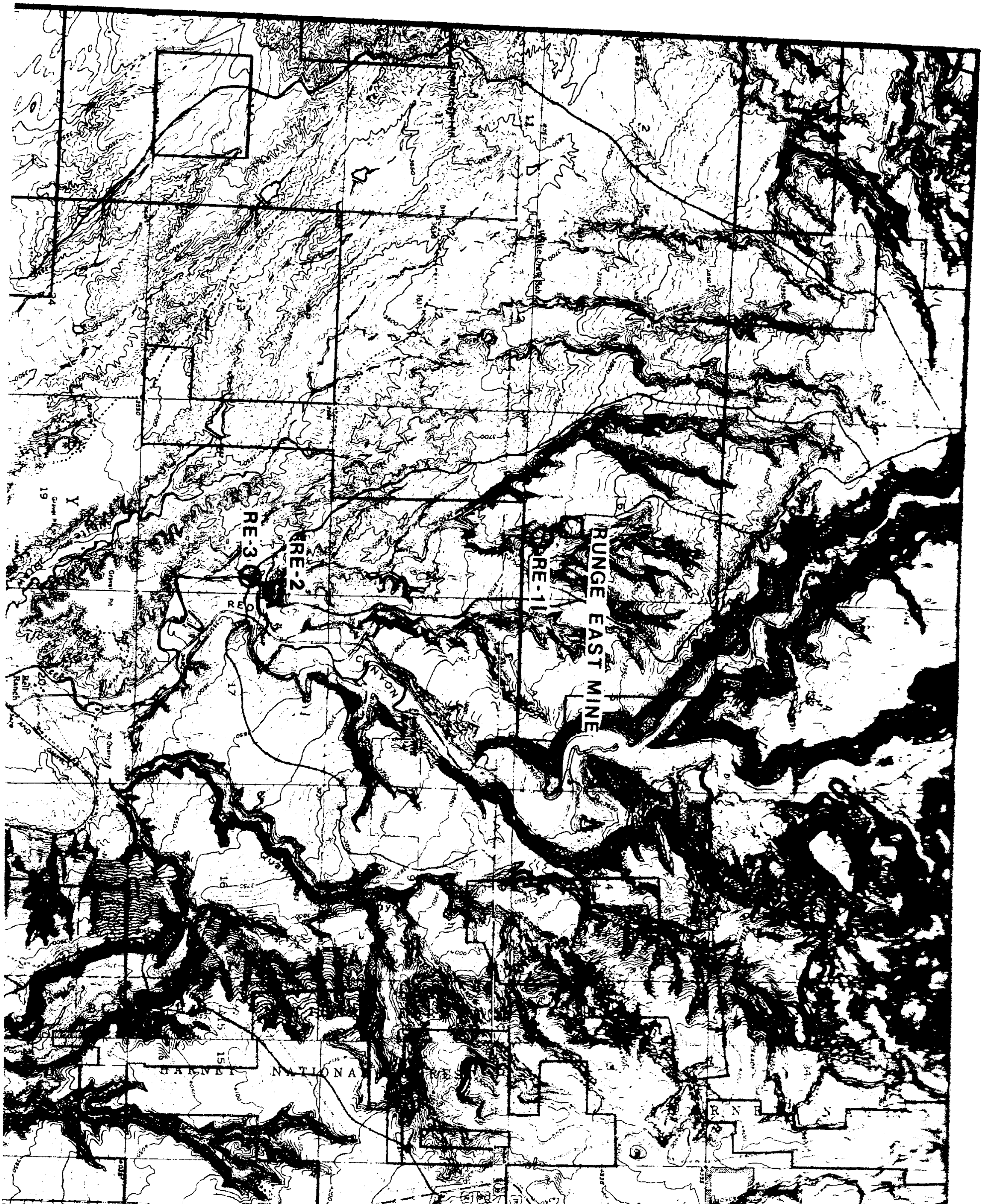


Figure 2.5.1-3 Streams and Subwatersheds - Edgemont Project Area


RUNGE EAST MINE
RE-1
RE-2
RE-3

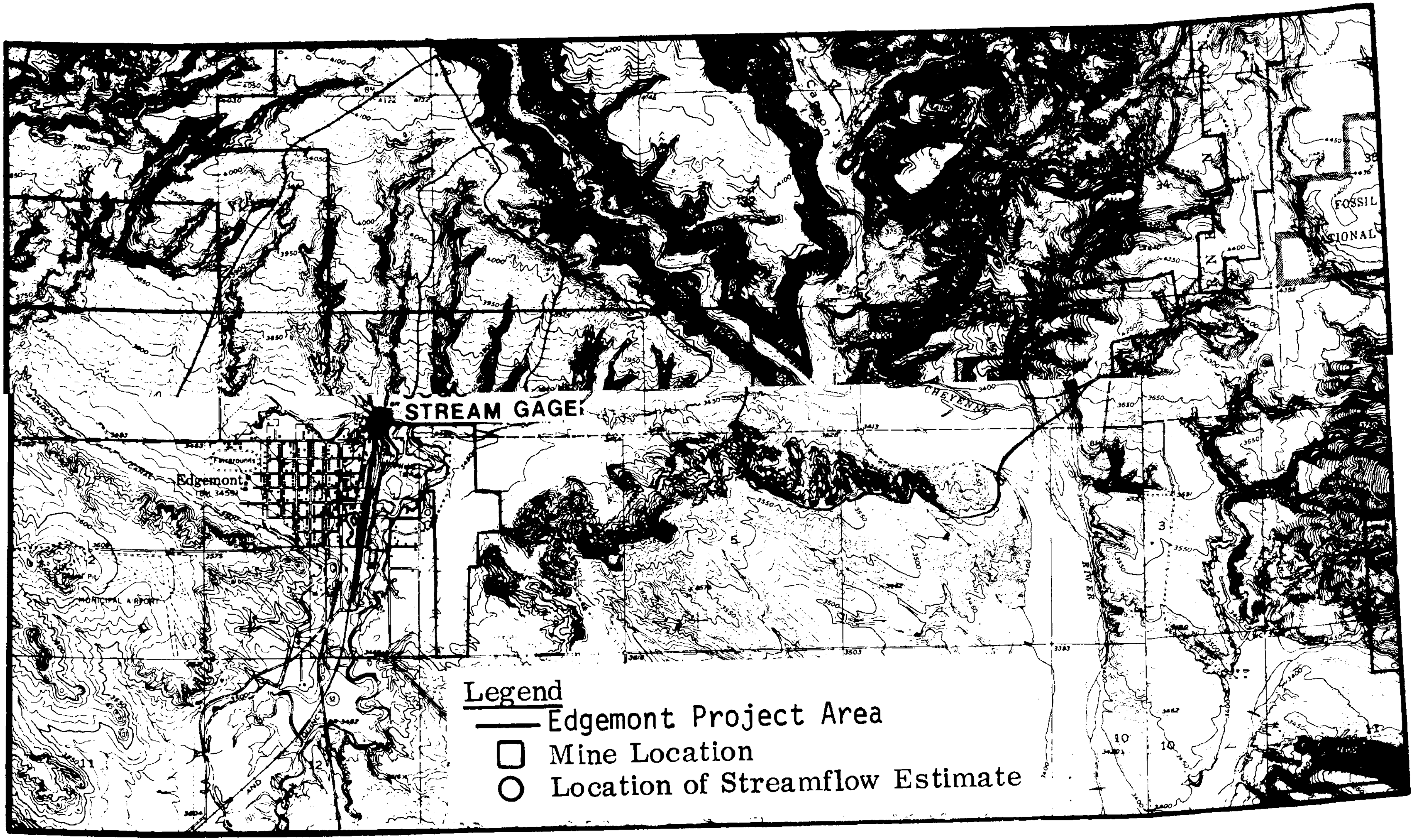


Figure 2.5.1-3 Streams and Subwatersheds - Edgemont Project Area

Burdock No. 1 Shaft - The location of the proposed shaft is shown on Figure 2.5.1-2. This site is drained by an intermittent, unnamed tributary of Beaver Creek. Elevations in the watershed of this tributary range up to 1,137 m (3,730 ft) on a hill north of the mine site and drop to about elevation 1,103 m (3,620 ft) near the shaft site.

A diversion system of two small dams and ditches has been constructed in the lower 1 km (0.6 mile) of the drainage course as shown on figure 2.5.1-2. Flow in the drainage course will be dispersed in the flood plain along Beaver Creek and the Cheyenne River. Elevations in this area are in the range of 1,076 to 1,079 m (3,530-3,540 ft). Runoff characteristics at selected sites on this tributary as well as other streams draining mine locations are presented in Tables 2.5.1-3 and 4. These include estimates of average annual runoff and peak discharges of floods with 2, 10, and 50-year recurrence intervals and of the maximum probable flood. These estimates, at selected locations near the mine sites and at downstream locations, are based on techniques developed by the Water Resources Division of the U.S. Geological Survey.[3,4] As indicated in Table 2.5.1-3 average annual runoff is only 1.80 cm (0.71 in) from an area of 0.88 km² (0.34 mi²) in the vicinity of Burdock No. 1 shaft (B1-1). More than half the runoff can be expected to occur during the months of May, June and July as the result of snowmelt and local, heavy rainfall. Average annual runoff from the larger watersheds above downstream locations (B1-2 and B1-3) is even less, in the order of 0.5 to 1.3 cm (0.2-0.5 in). Annual runoff may vary widely depending upon the occurrence of storm rainfall. Flood peak discharges are generally the result of heavy local thunderstorms. The estimates shown include the magnitude of these discharges which can be expected at or near the mine site. Flooding could occur along the drainage course in the vicinity of Burdock No. 1 shaft, but the shaft site would be located above or protected from anticipated flood levels.

Burdock No. 2 Shaft - This shaft site is drained by an unnamed intermittent tributary of the Cheyenne River. (See Figure 2.5.1-2.) The drainage area above the mine site is only 0.08 km² (0.03 mi²). Elevations in this area, as indicated on the topographic map of the area,[5] range from about 1,130 m (3,710 ft) at the mine site to about 1,146 m (3,760 ft) at the watershed divide. Downstream from the shaft site, the drainage course drops quite rapidly to an elevation of about 1,080 m (3,540 ft) where it flows into a small reservoir near the edge of the Cheyenne River flood plain. Overflow from the reservoir during periods of heavy runoff would either infiltrate into the flood plain along the Cheyenne River or eventually flow into the river. Average annual runoff on the unnamed tributary near the mine site (B2-1) and near its mouth (B2-2) is estimated to be 0.53 cm (0.21 in) as indicated in Table 2.5.1-3. Burdock No. 2 shaft site near the head of the unnamed tributary could be affected by heavy surface runoff depending upon the exact location of the site with respect to the drainage course. Some diversion of the surface runoff may be necessary.

Spencer-Richardson Mine - This existing open pit mine site is located near the top of a ridge; there is practically no drainage area above the mine site so flooding by surface runoff is not a consideration. (See Figure 2.5.1-2.) Drainage from the site is

Table 2.5.1-3

Estimates of Mean Annual Runoff - Drainage Basin Parameters[1] for Watersheds Above Selected Location in Vicinity of Proposed Mine Operations Edgemont Uranium Mining Project Wyoming and South Dakota

Mine and Selected Locations	Drainage Area(A) $mi^2(km^2)$	Forest Cover Percent(F) % +0.1	Maximum 24-Hour-2 Yr. Rainfall (I_{2-24}) in(cm)	Water Content of Snow Mar. 1-16, 25 Yr. Recurrence Interval-Sn_{25} in(cm)	Mean Annual Discharge QA cfs	m^3/sec	acre-ft	in
Burdock No. 1 Shaft								
B1-1	0.34(0.88)	24.1	1.9(4.8)	1.4(3.6)	0.018	0.0005	13	0.71
B1-2	1.48(3.83)	5.5	1.9(4.8)	1.4(3.6)	0.056	0.0016	40	0.51
B1-3	7,083(18,345)	Based on stream gage records at Edgemont (D.A. 7,143 mi^2 (18,500 km^2))			99	2.80	72,500	0.19
Burdock No. 2 Shaft								
B2-1	0.03(0.08)	0.1	1.9(4.8)	1.4(3.6)	0.0005	0.000013	0.3	0.21
B2-2	2.01(5.21)	0.1	1.9(4.8)	1.4(3.6)	0.031	0.0009	22	0.21
Spencer Richardson								
SR-1	0.18(0.47)	11.1	1.9(4.8)	1.4(3.6)	0.008	0.0002	6	0.60
SR-2	0.99(2.56)	12.1	1.9(4.8)	1.4(3.6)	0.045	0.0013	32	0.61
SR-3	3.25(8.42)	6.9	1.9(4.8)	1.4(3.6)	0.13	0.037	94	0.54
SR-4	8.93(23.13)	37.1	1.9(4.8)	1.4(3.6)	0.52	0.147	380	0.79
SR-5[2]	1,402(3,631)				36	1.02	26,500	0.35
Darrow Extensions								
DE-1	0.11(0.28)	27.1	1.9(4.8)	1.4(3.6)	0.006	0.00017	4.3	0.73
DE-2	1.87(4.84)	21.0	1.9(4.8)	1.4(3.6)	0.095	0.0027	69	0.69

Table 2.5.1-3 (Continued)

Mine and Selected Locations	Drainage Area(A) mi²(km²)	Forest Cover Percent(F) % +0.1	Maximum 24-Hour-2 Yr. Rainfall (I_{2-24}) in(cm)	Water Content of Snow Mar. 1-16, 25 Yr. Recurrence Interval-Sn_{25} in(cm)	Mean Annual Discharge QA cfs	m³/sec	acre-ft	in
Runge East								
RE-1	0.56(1.45)	18.1	1.9(4.8)	1.4(3.6)	0.028	0.0008	20	0.67
RE-2	2.29(5.93)	6.0	1.9(4.8)	1.4(3.6)	0.088	0.0025	64	0.52
RE-3	187(484)	64.1	1.9(4.8)	1.4(3.6)	12.4	0.35	8,960	0.90
RE-4	208(539)	58.1	1.9(4.8)	1.4(3.6)	13.5	0.38	9,750	0.88
RE-5[3]	7,502(19,430)				114	3.23	82,500	0.21

1. Significant parameters based on regression analysis as defined by Larimer[1/]
   Equation used for mean annual discharge:

   $$QA = 6.11 \times 10^{-3} A^{1.002} F^{0.224} I_{2,24}^{1.916} Sn_{25}^{0.624}$$

   A = drainage area in square miles
   F = Percent forest cover + 0.1
   I_{2-24} = Maximum 24-hour rainfall with 2-year recurrence interval as determined from U.S. Weather Bureau Technical Paper No. 40(1961)
   Sn_{25} = Water content of snow for the period March 1-16, having a recurrence interval of 25 years from U.S. Weather Bureau Technical Paper No. 50(1964)
2. Based on stream gage records at Beaver Creek at Newcastle.
3. RE-5 - Cheyenne River below Red Canyon Creek. Based on stream gage records at Edgemont plus local inflow estimates.

Table 2.5.1-4

Flood Peak Discharge Estimates at Selected Locations in Vicinity of Edgemont Uranium Mine Sites

Selected Locations*	Drainage Area	Discharge							
		2-Year		10-Year		50-Year		Max. Probable**	
	mi^2(km^2)	cfs	m^3/sec	cfs	m^3/sec	cfs	m^3/sec	cfs	m^3/sec
Burdock No. 1 Shaft									
B1-1	0.34(0.88)	15	0.42	110	3.1	340	9.6	4,600	130
B1-2	1.48(3.83)	30	0.85	230	6.5	670	19	9,000	255
Burdock No. 2 Shaft									
B2-1	0.03(0.08)	5	0.14	35	0.99	110	3.1	1,500	42
B2-2	2.01(5.21)	35	0.99	260	7.4	760	22	10,000	283
Spencer Richardson Mine									
SR-1	0.18(0.47)	10	0.28	80	2.3	240	6.8	3,500	99
SR-2	0.99(2.56)	25	0.71	180	5.1	540	15	7,500	212
SR-3	3.25(8.42)	45	1.3	330	9.4	940	27	13,000	368
SR-4	8.93(23.13)	80	2.3	530	15	1,480	42	20,000	566
Darrow Extension Mine									
DE-1	0.11(0.28)	5	0.14	60	1.7	190	5.4	2,700	76
DE-1	1.87(4.84)	35	0.99	250	7.1	720	20	10,000	283
Runge East Mine									
RE-1	0.56(1.45)	15	0.42	140	4.0	400	11	5,800	164
RE-2	2.29(5.93)	35	0.99	280	7.9	790	22	11,000	311
RE-3	187(484)	400	11.3	2,270	64	5,930	168	80,000	2,270
RE-4	208(539)	410	11.6	2,340	66	6,090	172	90,000	2,550

*Refer to location maps
**Reconnaissance-level estimates only

to the south and west into intermittent flowing, unnamed tributaries of Pass Creek, also an intermittent stream, which empties into Beaver Creek, a major tributary of the Cheyenne River. A small reservoir is located on one of the tributaries about a mile downstream from the mine site. The tributaries head on the ridge on which the mine site is located. Elevations along the ridge range up to 1,195 m (3,920 ft). The gradient of the tributary to the south of the mine is quite steep, dropping from about elevation 1,173 to about 1,125 m (3,850-3,690 ft) near the reservoir location.

Estimates of average annual runoff and flood peak discharges at selected sites near the mine and at downstream locations (SR-1 - SR-5) are shown in Table 2.5.1-3 and 4. Estimates of average annual runoff on the tributaries and Pass Creek range from 1.37 to 2.00 cm (0.54-0.79 in). Beaver Creek which drains an area of 3,631 km^2 (1,402 mi^2) at site SR-5 below the mouth of Pass Creek has an average annual runoff of 0.89 cm (0.35 in). All of the streams experience extended periods of no flow. Annual runoff varies widely. At the stream gage site on Beaver Creek near New Castle upstream from SR-5, average annual discharge varied from 3.68 m^3/s (130 ft^3/s) in 1962 (water year) to 0.14 m^3/s (5.1 ft^3/s) in 1961 (water year).

Darrow Extensions - The existing pits from which the underground extensions will be mined are located on a ridge which forms the divide between the unnamed tributaries which flow to the west and southwest into Pass Creek described in the preceding paragraphs, and another unnamed tributary which flows southward to the Cheyenne River. The latter tributary, another intermittent stream, drains an area of 0.28 km^2 (0.11 mi^2) at location DE-1 near the mine site. (See Figure 2.5.1-2.) Elevations on the watershed divide range up to about 1,195 m (3,920 ft). The tributary gradient is quite steep, dropping from an elevation of about 1,170 m (3,840 ft) at location DE-1 to 1,091 m (3,580 ft) at a small reservoir at location DE-2, 5.5 km (3.4 mi) downstream. At the reservoir, the topographic maps[5] indicates that part of the runoff may be diverted into Griffis Canal for irrigation purposes. The remainder flows out of the reservoir toward the Cheyenne River. The drainage course as defined on the topographic map[5] ends on the flat flood plain along the river. Estimates of average annual runoff and flood peak discharges at location DE-1 and DE-2 are shown in Tables 2.5.1-3 and 4. Average annual runoff is about 1.8 cm (0.7 in) at both locations. Since the mine site is on a ridge, flooding of the site is not a consideration.

Runge East Mine - The existing underground mine site is located in the drainage of an unnamed tributary of Red Canyon Creek. (See Figure 2.5.1-3.) The tributary, an intermittent stream, begins on the southern slopes of a steep ridge where elevations range up to 1,240 m (4,070 ft). The gradient of the tributary in the area above the mine location is very steep, dropping from an elevation of about 1,200 to 1,134 m (3,940-3,720 ft) in about 1.61 km (1 mi). The tributary drains an area of 1.45 km^2 (0.56 mi^2) at location RE-1 near the mine site. It empties into Red Canyon Creek at location RE-2 about 3.1 km (2 mi) to the south. Red Canyon Creek is a fairly large tributary of the Cheyenne River, draining an area of 539 km^2 (208 mi^2) most of which lies in the Black Hills National Forest. It empties

into the Cheyenne River about 3.1 km (2 mi) downstream from Edgemont.

Estimates of average annual discharge and flood peak discharges at selected locations on these streams are shown in Tables 2.5.1-3 and 4. Estimates of average annual runoff at the locations on the unnamed tributary (RE-1 and RE-2) are 1.70 and 1.34 cm (0.67 and 0.52 in) respectively. Red Canyon Creek also has extended periods of no flow. The higher annual runoff estimate, about 2.28 cm (0.90 in) is the result of its more forested drainage area and the slightly higher precipitation in the higher elevations of the Black Hills. The flood peak estimates indicate the magnitude of flood discharges which can be expected at the selected sites. Since the mine location is on a slope well above any drainage course, flooding is not a consideration. Minor diversion of local surface runoff may be necessary at the site.

Impacts - Mining plans[6] indicate that dikes and ditches will be used to divert local surface runoff away from mining operations and into existing drainage channels. Improvement of existing access roads may also include some ditching and culvert installations. On-site drainage will include ditches to collect runoff from ore and spoil piles and direct it to holding ponds. Such construction activities would alter local surface drainage patterns to some extent. Since reclamation plans will essentially restore or improve existing landforms and cover, both short-term and long-term effects of constructing mine facilities upon annual runoff volumes or flood peak discharges are considered to be insignificant. At the proposed Spencer-Richardson open pit operation, an area of about 8.1 ha (20 acre) will be mined initially. Because of the small areas involved, the effect of these mining operations upon annual runoff and flood peak discharges is considered to be insignificant.

Mine dewatering will be required at Burdock No. 1 shaft and possibly at Burdock No. 2 shaft. Very little or no dewatering is expected to be required at the Runge East or Darrow Extension underground mines and the Spencer-Richardson open pit mine is expected to be free of ground water. Any water from mine dewatering operations will be directed to retention ponds and treated as required, before release. A maximum rate of pumping of 42.5 l/s (675 gal/min) is anticipated at the Burdock No. 1 shaft. At present, it is anticipated that dewatering at Burdock No. 2 shaft may not be necessary since dewatering at Burdock No. 1 shaft will probably dewater the shaft site at Burdock No. 2 shaft also.

The water from the mining operations will be discharged into local drainages. This water discharge will comply with the effluent requirements of the permit obtained under the National Pollutant Discharge Elimination System as implemented by the South Dakota Environmental Protection Agency. The magnitude of such releases at the Burdock No. 1 shaft could be in the order of 42.6 l/s (675 gal/min). This discharge would be into the unnamed tributary west of the shaft site. Flow in this drainage course will be dispersed in the flood plain along Beaver Creek and the Cheyenne River. Releases at other underground mine sites are unknown but expected to be very small. Released water would in part evaporate or in part infiltrate into the ground and the dry

stream beds. These releases could stimulate the growth of natural vegetation along the drainage courses. Prolonged releases may cause some "soft" areas to develop in the drainage courses. Because of the small volumes of water to be released, no significant erosion of drainage courses is anticipated. Releases of treated water at Burdock No. 1 shaft will be dispersed over the flood plain of Beaver Creek and the Cheyenne River near the mouth of Beaver Creek by the existing small diversion system. Releases could eventually reach those streams. Since such releases would be treated as required to meet regulations governing such discharges, no harmful effects are anticipated. Since the quantity of such releases is small, they would have no significant effect upon flood peak discharges.

2.5.2 Ground Water

Regional - Western Fall River County is underlain by five principal aquifers: Quaternary alluvium; the Fall River Formation, 21 to 85 m (70-280 ft) thick, and the Lakota Formation, 43 to 67 m (140-220 ft) thick, both of Cretaceous age; the Sundance Formation, 21 to 137 m (70-450 ft) thick, of Jurassic age; and the Pahasapa Formation, 91 to 192 m (300-630 ft), of Mississippian age.[7] These formations crop out peripherally to the Black Hills, where they receive recharge from precipitation. Ground-water movement is in the direction of dip, radially from the central Black Hills. In most cases, the water is under artesian conditions away from the outcrop areas, and many wells in the region flow at the surface. The common practice for many years has been to allow wells to flow, which undoubtedly has resulted in declining regional potentiometric head.

Alluvium is used locally as a water source for domestic and stock water supplies.

The Fall River and Lakota Formations are the principal sources of water in the area. The Sundance Formation in Fall River County is used as an aquifer near its outcrop area in the central and northwestern parts of the county. The Pahasapa Formation, accessible in Fall River County only by very deep wells, is a source of water for Edgemont.[7]

The Fall River and Lakota Formations together form the Inyan Kara Group.[8] Water in the Fall River is separated from that in overlying formations by the Skull Creek Shale, which consists of 45 to 61 m (150-200 ft) of dark gray shale, and the Mowry Shale, which is up to 30 m (100 ft) of gray shale. Mudstone beds in the Fuson Member of the Lakota, 12 to 18 m (40-60 ft) thick,[8] generally separate water in the Fall River from that in the 30 to 45 m (100-150 ft) thick Chilson Member of the Lakota, which is the principal water-bearing unit of this formation. The Minnewaste Member of the Lakota, consisting of up to 8 m (25 ft) of limestone, lies below the Fuson Member and does not appear to be water bearing. The Lakota Formation is underlain by the Jurassic Morrison Formation, which consists mostly of shale and clay and is not considered to be an aquifer.[7]

Faults and fractures associated with the Dewey and Long Mountain structural zones, which trend southwesterly through northwestern Fall River County, are believed to affect ground-water movement and may be of considerable influence in future areal effects of drawdown caused by mining, but data are not yet available to quantify this.

According to Bowles[9,10], and Gott, Wolcott, and Bowles[11], large volumes of water may migrate upward from the Minnelusa Formation, along solution collapses and breccia pipes associated with fractures, to recharge the Inyan Kara Group near the margin of the Black Hills. This theory, which is supported by water quality data, is used to account for the source and deposition of uranium in the Inyan Kara Group.

In the Burdock project site area, it appears that little recharge to the Fall River Formation may come from the outcrop area, where open-pit mines are dry except for precipitation and inflow from surface water, with the exception of the existing Triangle mine, the mine farthest down-gradient. Also, the scarcity of water wells in the Fall River in this area suggests that the formation may not be saturated here. However, there is insufficient data to identify the source of recharge to the Inyan Kara Group at the project site.

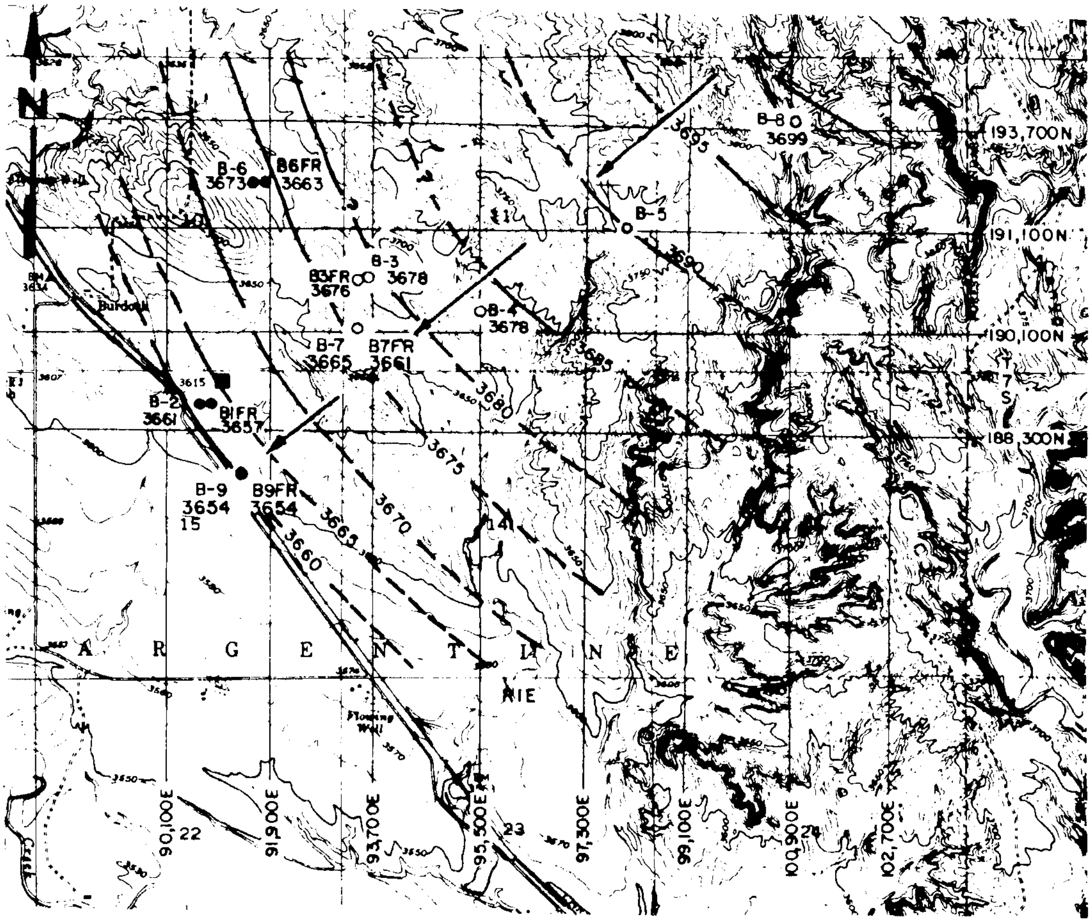
Local - The Fall River and Lakota Formations are the two aquifers of concern to the proposed mining operation at Burdock. The Fall River is the principal aquifer of western Fall River County, followed by the Lakota.[7] These aquifers are of similar thickness and hydrologic characteristics in the vicinity of the project site. At the proposed mine site, the Fall River, which is overlain by up to 61 m (200 ft) of Skull Creek Shale, consists of 23 to 38 m (75-125 ft) of fine-grained sandstone and interbedded carbonaceous shale. The top of the formation is at a depth of about 76 m (250 ft) at the shaft site. Within a 6.4 km (4 mi) radius of the shaft site, 26 wells are known to obtain water from this aquifer; many of these are flowing wells.

The Fuson Member of the Lakota, underlying the Fall River, varies in thickness, but generally is less than 15 m (50 ft) thick. It is expected to be an effective barrier to interaquifer water movement in most of the area. However, results of aquifer tests at the project site suggest that the Fuson Shale is not an effective barrier near and northeast of the shaft site. Interaquifer connection here could result from as-yet-unidentified structural features or old open exploration holes.

The Chilson Member of the Lakota is the ore-bearing and water-bearing unit. It consists of about 40 m (130 ft) of consolidated to semi-consolidated, fine-grained sandstone, the top of which is at a depth of about 134 m (440 ft) at the shaft site. The underlying Morrison Formation, at a depth of 174 m (570 ft), is shale and interbedded sandstone and probably is not water bearing. Within a 6.4 km (4 mi) radius, 23 wells are open to the Lakota, one of which flows an estimated 1.6 l/s (25 gal/min).

Figure 2.5.2-1 is a map showing the approximate potentiometric surface in the Lakota Formation in the vicinity of the project site, and showing the southwesterly gradient of about 9.8 m/km (20 ft/mi). A few water levels in the Fall River are shown, but there are insufficient data to allow contouring. Keene indicates a Fall River aquifer gradient of 9.8 m/km (20 ft/mi) near the project site.[7] Water levels were measured in January 1977, in observation wells installed for an on-site aquifer test. According to Keene[7], potentiometric levels in the Lakota in this area should be somewhat higher than those of the Fall River. This is consistent with data obtained at the project site, where the head in the Lakota is a few feet greater than in the Fall River.

Aquifer Test - A 169 m (555 ft) deep, rotary-drilled 25 cm diameter (10 in) steel cased test well near the proposed shaft site was completed in February 1977. The well is equipped with 17 m (55 ft) of 25 cm (10 in) diameter .030 slot size (0.76 mm)



SCALE:
0 ½ 1 mile
0 ½ 1 kilometer

EXPLANATION

3680 —?— Generalized water-level contour, Lakota Formation, in feet above sea level. Contour interval 5 feet. Dashed and queried where doubtful.

B-6 3673 — Flowing well -- number and head in feet above sea level.

B-3 3678 — Non-flowing well number and head in feet above sea level.

Proposed shaft site

Generalized direction of ground-water movement

B6FR — Water level in Fall River Formation (not contoured)

NOTE:
Topography taken from USGS 7.5' quadrangles. Contour interval 10 feet.

Figure 2.5.2-1 Water-Level Contour Map in the Area of the Proposed Burdock Mine

stainless steel wire-wound screen, gravel-packed, opposite the Fall River aquifer, [85-102 m (280-335 ft)] and 23 m (75 ft) of 20 cm (8 in) diameter screen, gravel packed, opposite the Lakota aquifer [146-169 m (480-555 ft)]. Upon completion, the well flowed about 3.2 l/s (50 gal/min).

A constant-discharge aquifer test began on February 11 and continued until February 25, 1977, at an average discharge of 16.5 l/s (261 gal/min). Discharge water was piped to a holding pond specially enlarged for the purpose. Water quality samples were obtained during the test.

Water-level responses were observed in nine piezometers, six of which were open to the Lakota and three to the Fall River. Locations of wells are shown on Figure 2.5.2-1.

A second aquifer test was run in November 1977, in which an inflatable packer was used to isolate the two aquifers, and the Lakota was pumped at an average rate of 12.2 l/s (194 gal/min) for 3.25 days. Analysis of results of this test indicates that the transmissivity of the Lakota is about 17.36 m^2 (1400 gal/day/ft) and the storativity is 2×10^{-4}. Significant drawdown was measured in the Fall River Formation in the vicinity of the pumped well and to the northeast of the site. The estimated hydraulic conductivity of the aquitard is about .13 m/da (3.4 gal/day/ft^2). The estimated transmissivity of the Fall River is about 9.9 m^2 (800 gal/day/ft). These values were used in calculations of projected drawdowns resulting from mine development and operation. Projections of impacts on potentiometric head are based on these aquifer properties.

Water Use - An inventory of water-supply wells within a 6.4 km (4 mi) radius of the proposed shaft site was made in August 1976, during which 61 wells were located, as shown on Figure 2.5.2-2 and summarized in Table 2.5.2-1. Of these, 57 furnish domestic or stock water and 4 are not used. Thirty-five wells were flowing at rates from less than 4 to an estimated 76 l/min (1-20 gal/min). Estimated total flow, almost entirely from the Inyan Kara Group, was about 655 m^3/d (173,000 gal/d), or 23.4 ha-m/yr (190 acre ft/yr). Figure 2.5.2-3 is a generalized water-level contour map showing the area of flowing wells within a 6.4 km (4 mi) radius of the mine site.

A 40 km (25 mi) radius well inventory was completed in 1978. This inventory included all known wells in the Inyan Kara Group. Within the area in South Dakota, 140 wells were visited, 55 of which are in the Lakota, 54 in the Fall River, and 31 for which the aquifer is not identified. Thirty-seven wells are reported to flow from the Lakota, 34 from the Fall River, and 16 from wells in unidentified aquifers.[12]

Impact Assessment - The potentiometric head in the Fall River Formation is expected to be affected by shaft construction, and during mine development and operation, by vertical leakage from the Fall River to the Lakota in those areas where such leakage occurs. Direct impacts on the Fall River Formation from shaft construction will be short-term. Shaft construction through the formation will require about 30 days. Cement or chemical grouting may be required to control water inflows to the shaft sinking operations during construction. An average inflow to the

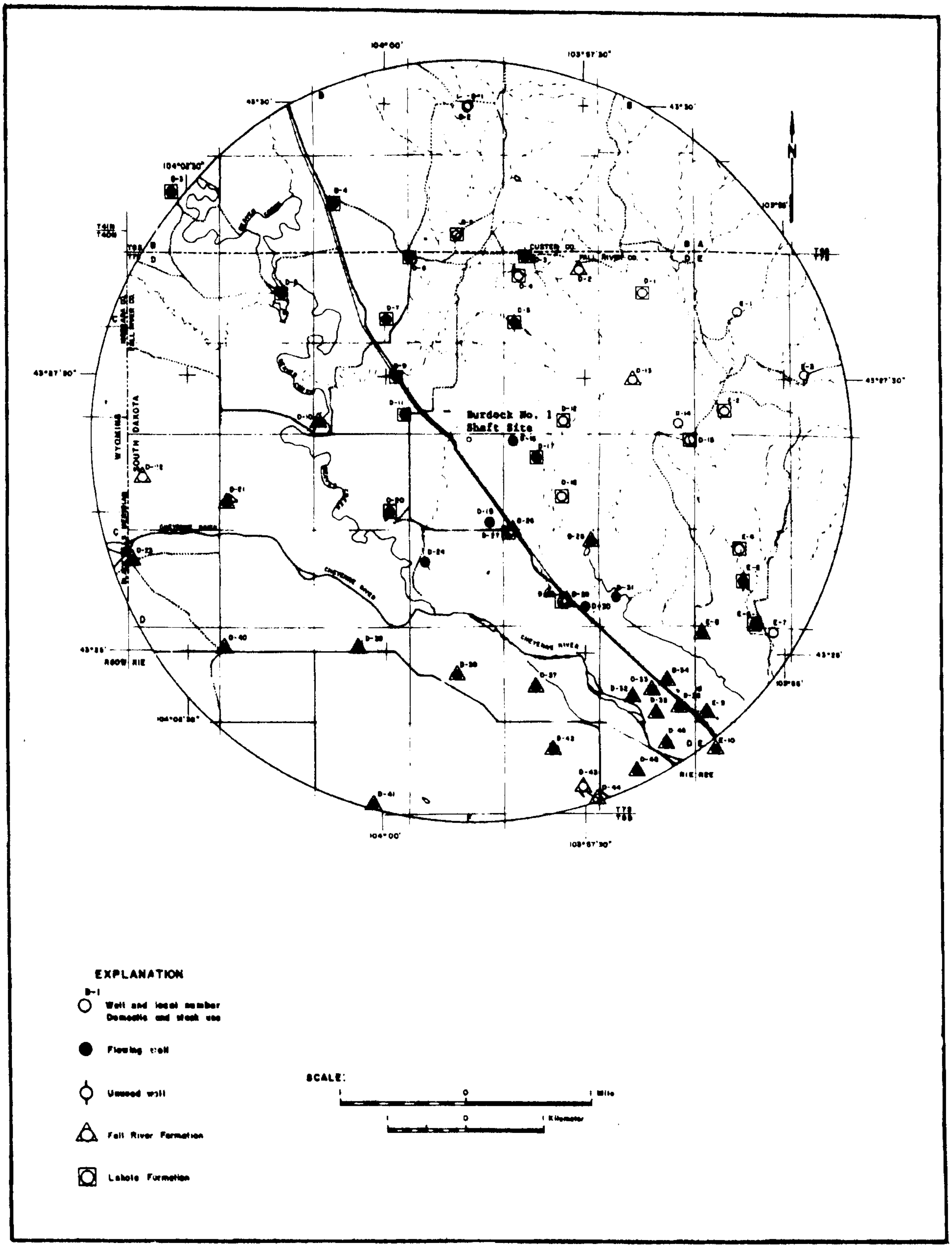


Figure 2.5.2-2 Location of Wells Within a 4-Mile (6.4 km.) Radius of the Proposed No. 1 Shaft Site

Table 2.5.2-1

Summary of Wells Within a Four-Mile (6.5 km.) Radius of the TVA Burdock, No. 1 Shaft Site

Well No.: Based on the Federal system of township and range. Each township within the project area is assigned a letter in consecutive order beginning with "A" in the northeast corner and ending with "F" in the southern part. Similarly, wells are numbered in consecutive order within a township--for example: B-1, B-2, etc. Location: Number based on township, range, section, 1/4 section, and 1/4 section. Aquifer: Qa, Quaternary alluvial deposits; Kf, Cretaceous, Fall River Formation; Kl, Cretaceous, Lakota Formation; Jm, Jurassic, Morrison Formation; Js, Jurassic, Sundance Formation; Trs, Triassic, Spearfish Formation; PmK, Permian, Minnekahta Limestone. Depth: Given in feet (ft.) and meters (m.) below land surface. Use Rate and Flow Rate: In gallons per minute (gpm) and liters per second (l/s). Elevation of Land Surface and Elevation of Water Surface: In feet (ft.) and meters (m.) above sea level. Superscript a indicates flow rate less than 1 gpm. Superscript b indicates estimated water surface elevations.

Well No.	Latitude	Longitude	Location	Aquifer	Depth (ft)	Depth (m)	Use Rate (gal/min)	Use Rate (l/s)	Flow Rate (gal/min)	Flow Rate (l/s)	Elevation Land Surf. (ft)	Elevation Land Surf. (m)	Elevation Water Surf. (ft)	Elevation Water Surf. (m)	Remarks
B-1	43°30'00"	103°58'57"	6-1-27Db	Qa	50	15	30	1.9	-	-	3715	1132	3700	1128	
B-2	43°29'58"	103°58'57"	6-1-27Db	Qa	46	14	30	1.9	-	-	3715	1132	3700	1128	
B-3	43°29'10"	104°02'43"	6-1-31Bd	-	-	-	-	-	12	.8	3605	1099	3610^b	1100	
B-4	43°29'09"	104°00'40"	6-1-33Bc	Kl	550	168	-	-	2	.1	3030	1106	3630^b	1106	
B-5	43°28'51"	103°59'06"	6-1-34Dc	Kl	350	107	-	-	-	-	3663	1116	-	-	Flowed until Triangle mine de-watered. 1/3 h.p. pump.
D-1	43°28'20"	103°56'47"	7-1-18d	Kl	330	101	-	-	-	-	3905	1190	3747	1146	
D-2	43°28'32"	103°57'34"	7-1-2Aa	Kf	180	55	10	.6	-	-	3749	1143	-	-	
D-3	43°28'39"	103°58'15"	7-1-2Bb	Kl	495	151	-	-	a	-	3705	1129	3705^b	1129	Water contains iron.
D-4	43°28'26"	103°58'20"	7-1-2Bc	Kl	280	85	5	.3	-	-	3698	1127	3674	1120	Unused.
D-5	43°28'01"	103°58'22"	7-1-2Cc	Kl	470	143	-	-	a	-	3679	1121	3689^b	1122	Water contains iron.
D-6	43°28'38"	103°59'42"	7-1-3Bb	Kl	500	152	-	-	2	.1	3660	1116	3661^b	1116	Unused.
D-7	43°28'02"	104°00'00"	7-1-4Dd	Kl	805	245	-	-	1	.06	3645	1111	3646^b	1111	A.E.C. water analysis.
D-8	43°28'17"	104°01'19"	7-1-5Ac	Kl	600	183	-	-	25	1.6	3600	1097	3610^b	1100	Flow rate in 1969, 30 gpm (1.9 l/s).
D-9	43°27'30"	103°59'52"	7-1-9Ad	Kl	550	168	-	-	16	1.0	3615	1102	3620^b	1103	Water contains iron & sulphur.
D-10	43°27'03"	104°00'54"	7-1-9Cc	Kf	527	161	-	-	8	.5	3700	1128	3701^b	1128	

TABLE 2.5.2-1 (continued)

Well No.	Latitude	Longitude	Location	Aquifer	Depth (ft.)	Depth (m)	Use Rate (gal/min)	Use Rate (l/s)	Flow Rate (gal/min)	Flow Rate (l/s)	Elevation Land Surf. (ft)	Elevation Land Surf. (m)	Elevation Water Surf. (ft)	Elevation Water Surf. (m)	Remarks
D-11	43°27'05"	103°59'46"	7-1-9Dd	Kl	600	183	-	-	1	.06	3624	1105	3631	1107	Water contains iron.
D-12	43°27'05"	103°57'47"	7-1-11Dc	Kl	525	160	-	-	-	-	3700	1128	-	-	A.E.C. water analysis.
D-13	43°28'29"	103°56'53"	7-1-12Bd	Kf	156	48	-	-	-	-	3750	1143	-	-	
D-14	43°27'04"	103°56'21"	7-1-12Dd	-	-	-	-	-	-	-	3830	1167	-	-	
D-15	43°26'55"	103°56'12"	7-1-13Aa	Kl	200	61	-	-	-	-	3740	1140	3662	1116	
D-16	43°26'54"	103°58'24"	7-1-14Bb	-	-	-	-	-	8	-	3675	1120	3675[b]	1120	
D-17	43°44'45"	103°58'25"	7-1-14Ba	Kl	850	259	-	-	7	.4	3630	1105	3634[b]	1108	Water contains iron.
D-18	43°26'23"	103°57'48"	7-1-14Db	Kl	280	85	1	.06	-	-	3610	1100	3598[b]	1097	
D-19	43°26'09"	103°58'43"	7-1-15Dd	-	2264	690	-	-	-	-	3576	1090	3580[b]	1091	
D-20	43°26'15"	103°59'58"	7-1-16Dd	Kl	640	195	-	-	15	.9	3555	1084	3560[b]	1085	A.E.C. water analysis.
D-21	43°26'16"	104°02'01"	7-1-17Cb	Kf	530	162	-	-	4	.3	3555	1084	3558[b]	1084	A.E.C. water analysis.
D-22	43°26'33"	104°03'06"	7-1-18Bc	Kf	740	226	-	-	-	-	3700	1128	-	-	
D-23	43°25'48"	104°03'12"	7-1-19Bc	Kf	910	277	-	-	15	.9	3590	1091	3585[b]	1093	
D-24	43°25'48"	103°59'31"	7-1-22Bc	-	2400	732	-	-	3	.2	3548	1081	3550[b]	1082	
D-25	43°25'59"	103°57'24"	7-1-23Aa	Kf	90	27	-	-	3	.2	3625	1105	3625[b]	1105	Flow rate 1969, 10 gpm (.6 l/s).
D-26	43°25'02"	103°58'26"	7-1-23Bb	Kl	500	152	-	-	5	.3	3574	1089	3574[b]	1089	
D-27	43°26'03"	103°58'29"	7-1-23Bb	Kf	200	61	3	.2	-	-	3574	1089	3561	1085	
D-28	43°25'26"	103°57'48"	7-1-23Dc	Kl	500	152	-	-	5	.3	3542	1080	3542[b]	1080	Casing perforated in 10 ft (3 m.) intervals below elevations 3222 (982 m.) and 3384 (1031 m.).
D-29	43°25'27"	103°57'44"	7-1-23Dc	Kf	240	73	-	-	1	.06	3542	1080	3542[b]	1080	
D-30	42°25'24"	103°57'30"	7-1-23Dd	Js-PmK	1470	448	-	-	5	.3	3550	1082	3550[b]	1082	
D-31	43°25'30"	103°57'07"	7-1-24Cb	Js-PmK	2480	756	-	-	6	.4	3577	1090	3578[b]	1091	
D-32	43°24'38"	103°55'58"	7-1-25Ca	Kl	375	114	-	-	2	.1	3508	1069	3508[b]	1069	
D-33	43°24'40"	103°56'37"	7-1-25Db	Kf	96	29	-	-	1	.06	3510	1070	3510[b]	1070	
D-34	43°24'46"	103°56'29"	7-1-25Db	Kf	90	28	-	-	1	.06	3528	1075	3528[b]	1075	

TABLE 2.5.2-1 (continued)

Well No.	Latitude	Longitude	Location	Aquifer	Depth (ft)	Depth (m)	Use Rate (gal/min)	Use Rate (l/s)	Flow Rate (gal/min)	Flow Rate (l/s)	Elevation Land Surf. (ft)	Elevation Land Surf. (m)	Elevation Water Surf. (ft)	Elevation Water Surf. (m)	Remarks
D-35	43°24'28"	103°55'38"	7-1-25Dc	Kf	130	40	-	-	1	.06	3510	1070	3510[b]	1070	
D-36	43°24'30"	103°56'20"	7-1-25Dd	Kf	450	137	-	-	3	.2	3508	1069	3508[b]	1069	
D-37	43°24'42"	103°57'53"	7-1-26Ca	Kl	260	79	-	-	2	.1	3530	1076	3530[b]	1076	
D-38	43°24'47"	103°59'07"	7-1-27Ac	Kf	350	107	-	-	-	-	3560	1085	3560[b]	1085	
D-39	43°25'01"	104°00'18"	7-1-28Da	Kf	600	183	-	-	-	-	3576	1090	3553[b]	1083	
D-40	43°25'01"	104°02'02"	7-1-29Bb	Kf	600	183	-	-	1	.06	3590	1094	3590[b]	1094	
D-41	43°23'30"	104°00'03"	7-1-33Dc	Kl	600	183	-	-	-	-	3670	1119	-	-	
D-42	43°24'05"	103°57'55"	7-1-35Ac	Kf	350	107	-	-	1	.06	3545	1081	3545[b]	1081	Slight flow in 1969; no flow in 1976.
D-43	43°23'44"	103°57'32"	7-1-35Da	Kf	320	98	-	-	-	-	3555	1084	3545	1031	1969 Flow, 15 gpm (.9 1/s); no flow in 1976.
D-44	43°23'37"	103°57'22"	7-1-35Dd	Kf	320	98	-	-	-	-	3555	1084	-	-	
D-45	43°23'10"	103°56'26"	7-1-36Aa	Kf	92	28	-	-	9	.6	3500	1067	3504[b]	1068	
D-46	43°23'55"	103°55'57"	7-1-36Ca	Kf	100	30	-	-	1.5	.2	3535	1077	3536[b]	1078	
E-1	43°28'08"	103°55'35"	7-2-6Ca	-	40	12	-	-	-	-	3860	1177	-	-	
E-2	43°27'11"	103°55'43"	7-2-7Cd	-	365	111	-	-	-	-	3755	1145	3475	1059	Unused.
E-3	43°27'32"	103°54'45"	7-2-8Bc	Js	470	143	-	-	-	-	3970	1210	-	-	
E-4	43°25'57"	103°55'33"	7-2-19Ba	Kl	145	44	-	-	-	-	3640	1109	-	-	Flow rate in 1969, 2 gpm (.1 1/s); no flow in 1976;unused.
E-5	43°25'38"	103°55'31"	7-2-19Ca	Kl	148	45	-	-	-	-	3620	1103	-	-	
E-6	43°25'15"	103°55'22"	7-2-19Dc	Kl	255	78	-	-	10	.6	3600	1097	3605[b]	1099	
E-7	43°25'11"	103°55'00"	7-2-30Aa	-	-	-	-	-	-	-	3600	1097	-	-	
E-8	43°25'13"	103°56'03"	7-2-30Bb	Kl	330	101	-	-	2	.1	3530	1076	3530[b]	1076	
E-9	43°24'27"	103°55'53"	7-2-30Cc	Kf	90	27	-	-	a	-	3522	1074	3522[b]	1074	
E-10	43°24'07"	103°55'52"	7-2-31Bc	Kf	104	32	-	-	1.3	.08	3495	1065	3500[b]	1067	

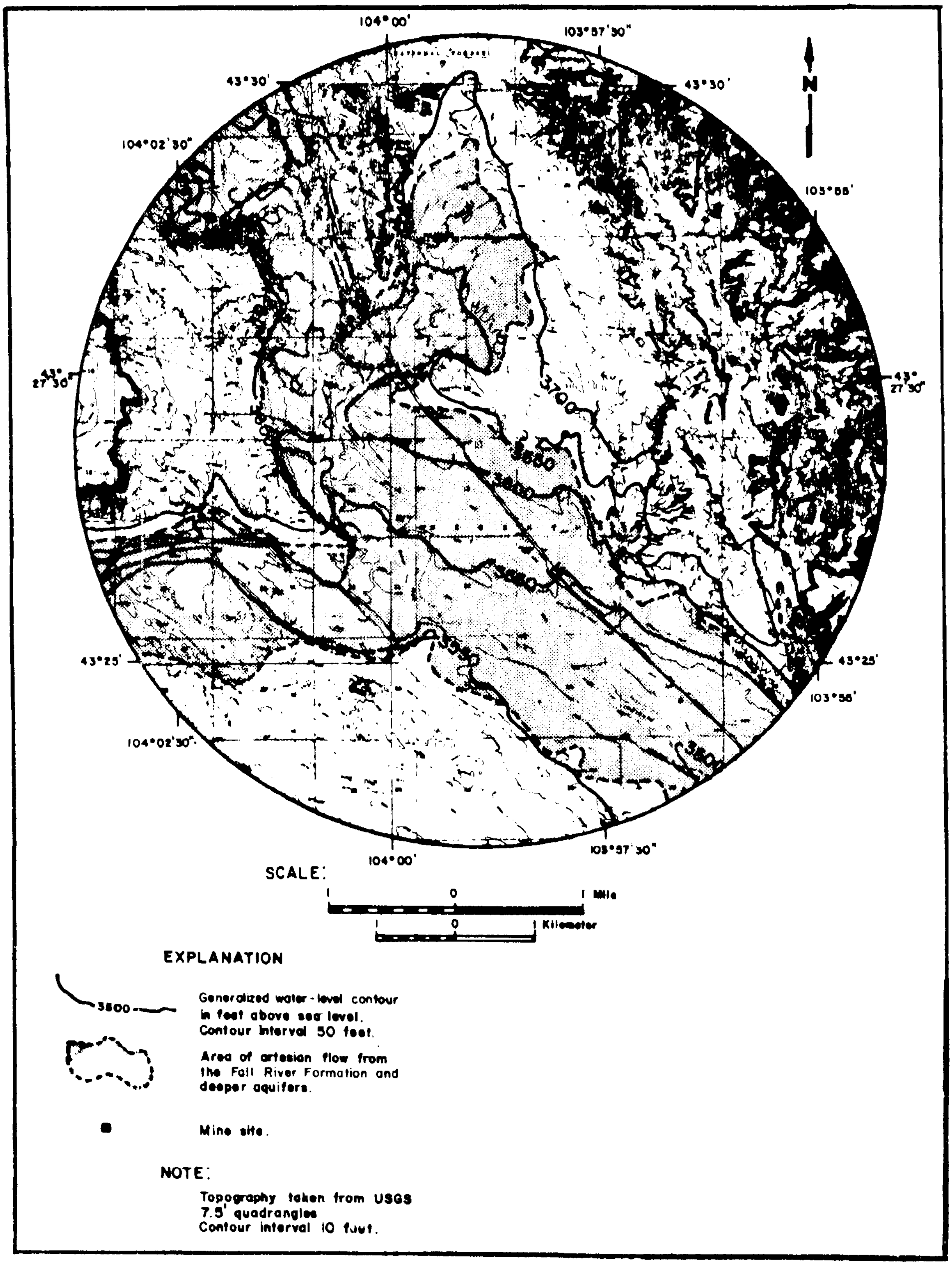


Figure 2.5.2-3 Generalized Water-Level Contour Map Within a 4-Mile Radius of the Proposed Mine Shaft Site

shaft of 12.6 l/s (200 gal/min) is expected during this time. The effects on the Fall River Formation resulting from leakage during mine development and operation will continue as long as water is removed from the lower aquifer. The rate of leakage will decrease with time and the magnitude of leakage will decrease with distance from the area in which leakage occurs. Water levels in wells in the Fall River Formation near the mine workings will be affected, but it is not anticipated that the aquifer will be dewatered.

It is possible that after mining, areal potentiometric heads will not recover to pre-mining levels within the affected area because of open flow from private wells. Discharge from flowing wells outside the radius of influence will continue, and may be sufficient to prevent complete recovery within the affected area.

The Lakota Formation will require depressurizing before it is entered by the shaft, since it is under at least 146 m (480 ft) of head, or more than 14.0 kg_f/cm^2 (200 lb_f/in^2). Two or more wells will be required, pumped at an estimated average total rate of 42.6 l/s (675 gal/min) for 180 days prior to entry into the aquifer by the shaft.

Inflow will increase as station and haulageway construction begin, then decrease gradually as the mine is developed and operated. If inflow averages 25.2 l/s (400 gal/min) over the 10-year expected life of the mine, the theoretical radius at which the potentiometric head will be reduced by 30 cm (1 ft) is about 105 km (65 mi), under the assumptions listed above. However, from experience in other mining areas, in rocks having similar hydrologic properties, lateral geologic changes should limit the growth of the cone of depression. The induced leakage from the Fall River may also limit the growth of the cone in the Lakota. The actual radius of effect is expected to be substantially less than the theoretical radius. The presence of the Long Mountain and Dewey structural zones is expected to constrain growth of the cone, but the extent of effect can not be quantified based on presently available information. Many wells that now flow within the area affected by decreased potentiometric head will cease to do so at some time after mining operations begin. The aquifers will remain saturated, however, and water will still be available by pumping except possibly in the immediate vicinity of the mine.

The planned expansion and deepening of the existing open-pit mine in the area should have little impact on the aquifer systems. The pit will be wholly within the unsaturated portion of the Fall River Formation. If the outcrop area is only a minor source of recharge, little effect on ground water flow should result. Any ground water entering the pits would come from the underlying Lakota Formation via structural features, which would result in local drawdown in the Lakota created by pit dewatering. Only one existing pit (the Triangle) contains ground water; some of the pits bottom near the Fuson Shale. Underground mining in the vicinity of an open pit will lower the potentiometric surface in the Lakota, reducing inflow, if any, to the pit.

Mitigation - Adverse effects on ground-water supplies attributable to the mining operation will be corrected in a manner acceptable to the owner of the supply. It is planned that such problems will be handled on a case-by-case basis. Possible

alternatives include installation of electric pumps where power is available; distribution of water by pipeline; construction of new wells into deeper aquifers; renovation of wells if cessation of flow causes well collapse; or reimbursing the landowner for the cost of repairing or replacing a water supply. Whatever action is taken, one main objective, in all cases, will be water conservation.

A comprehensive observation program in which pressure heads, flows, and water levels are measured periodically in selected wells has begun. This program will document premining conditions and changes in potentiometric head before and during mining, in both aquifers, and also will allow assessment of any post-mining impacts.

2.5 References

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2.6 Nonradiological Water Quality

2.6.1 Description of Existing Water Quality Environment - This section describes the non-radiological water quality characteristics in the region of the Edgemont Uranium mining project. (See Section 2.8, for a description of the radiological characteristics.)

2.6.1.1 Surface Water Quality - The Edgemont Uranium Mining Project area is drained by the Cheyenne River and several tributary streams. These streams including the Cheyenne River experience extended periods of no flow. The State of South Dakota[1] has classified the Cheyenne River in the project vicinity as being suitable for the following uses: (1) warm water semi-permanent fish life propagation, (2) limited contact recreation, (3) wildlife propagation and stock watering, and (4) irrigation. Beaver Creek (South Dakota) has been classified as being suitable for the same uses as the Cheyenne River except that this stream has been classified as being suitable for cold water marginal fish life propagation rather than warm water semi-permanent fish life propagation. The State of Wyoming[2] has classified Beaver Creek and Stockade Beaver Creek in the project vicinity as presently supporting game fish or having the hydrologic and natural water quality potential to support game fish. Beaver Creek has also been classified by Wyoming as a warm water fishery.

Surface water quality investigations were performed at the project during the period of December 1974 through September 1977. Additional water quality data from the USGS and the State of South Dakota were utilized in this assessment. A summary of results of water quality analyses of surface water samples obtained on and near the project site are listed in Tables 2.6.1.1-1 and 2. Their locations are shown in Figure 2.6.1.1-1. Table 2.6.1.1-3 provides various water quality standards and criteria for a comparison with the previously reported ranges of water quality parameters. Specific aspects of these data are discussed below.

The warmest water temperature [36.0°C (96.8°F)] within the Cheyenne River was observed at station S-5 in June 1974, which is upstream of Red Canyon Creek. The warmest temperature [31.0°C (87.8°F)] within Beaver Creek was observed at Station S-3, which is near the mouth of the creek. The South Dakota temperature standard for the Cheyenne River [32.2°C (90°F)] was exceeded in August 1973 and June 1974 at Station S-5, and the South Dakota temperature standard for Beaver Creek 23.9°C (75°F) was exceeded in July 1976 at Station S-3.

In the Cheyenne River and Beaver Creek, observed dissolved oxygen concentrations were normally well above State standards. The pH values were observed to be in the normal range of 6.5 to 9.0 Standard Units. Total alkalinity and hardness of the Cheyenne River averaged 156 mg/l (miligram/liter) and 1,390 mg/l, respectively, and Beaver Creek averaged 148 mg/l and 1,425 mg/l, respectively. Both waters are considered to be very hard. Dissolved solid concentrations for the Cheyenne River and Beaver Creek averaged 3,513 mg/l and 2,960 mg/l, respectively. The mean dissolved solids concentrations of the Cheyenne River exceed established criteria for livestock watering, and mean dissolved

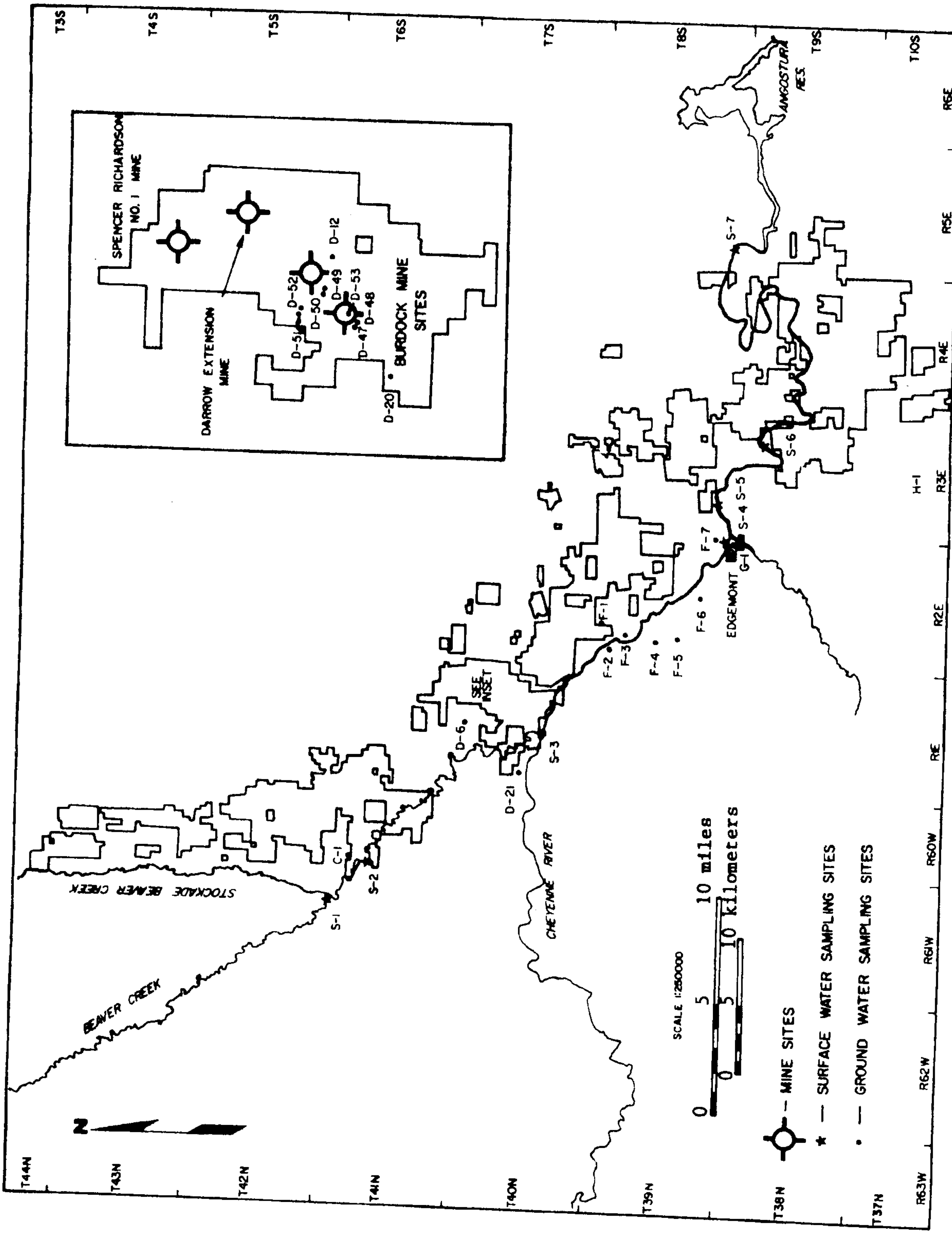

Figure 2.6.1.1-1 Water Quality Sampling Sites

Table 2.6.1.1-1

Summary of Physical and Bacteriological Surface Water Quality Data for the Cheyenne River and Beaver Creek in the Vicinity of the Edgemont Uranium Mining Project

Stream and Mileage		Water Temp. °C	Dissolved Oxygen mg/l	pH S.U.	Total Alkalinity as $CaCO_3$ mg/l	Hardness as $CaCO_3$ mg/l	True Color PCU	Apparent Color PCU	Turbidity JTU	Solids: Dissolved mg/l	Solids: Suspended mg/l	Coliform (No./100 ml.): Fecal	Fecal Streptococci	Total
Beaver Creek[1] (S-1)	Maximum	24.0		8.0	289	1933	95	2400	1100	5700	1300			
	Minimum	14.5		7.4	78	340	12	21	11	750	14			
	Mean	18.1		7.6	151	1343	36	620	300	4060	350			
	No. of Samples	4		4	3	4	4	4	4	4	4			
Beaver Creek[2] (S-2)	Maximum	25.5	10.8	8.2	273	3100	80	29000	11000	5300	19000			
	Minimum	0.0	-	6.5	56	300	6	18	64	630	22			
	Mean	9.8	-	7.7	150	1400	30	7280	2800	2980	4790			
	No. of Samples	68	1	50	68	69	4	4	4	27	4			
Beaver Creek[3] (S-3)	Maximum	31.0	9.7	7.9	130	1825	60	7400	3200	3200	4800			
	Minimum	13.3	-	7.6	96	390	7	70	22	600	70			
	Mean	19.4	-	7.7	100	1221	30	2040	860	1700	1310			
	No. of Samples	4	1	4	3	4	4	4	4	4	4			
Cheyenne River[4] (S-4)	Maximum	29.0	13.1	8.9	433	2770	100	6000	2700	7571	8593	4800	7500	5000
	Minimum	0.0	0.7	7.0	70	260	5	7	8.4	695	0	0	<4	0
	Mean	11.5	9.6	8.6	189	1390	30	1200	700	3526	692	480	620	1300
	No. of Samples	100	74	94	63	65	5	5	4	67	41	52	27	19
Cheyenne River[5] (S-5)	Maximum	36.0	13.7	8.4						4200	17			
	Minimum	0.0	8.3	6.9						3800	17			
	Mean	10.7	10.9	7.9						4000	17			
	No. of Samples	23	21	22						2	2			
Cheyenne River[6] (S-6)	Maximum	26.0	12.4	8.2	180	1900	90	6200	3200	6300	5500			
	Minimum	18.0	-	6.7	84	880	7	14	11	990	9			
	Mean	22.8	-	7.6	130	1400	30	1400	840	3560	960			
	No. of Samples	4	1	5	4	5	5	5	4	6	6			
Cheyenne River[7] (S-7)	Maximum	20	8.4	8.2	163	1692	10	210	68	2700	120			
	Minumum	-	-	8.1	160	1600	5	8	4.4	2500	21			
	Mean	-	-	8.2	162	1646	8	110	36	2600	70			
	No. of Samples	1	1	2	2	2	2	2	2	2	2			
South Dakota Water Quality Standards[8]		32.2 (23.9)	5	6.5 - 9.0 (6.5 - 8.8)	750				50	1500	90	1000		5000
Wyoming Water Quality Standards[9]		32.2	6	6.5 - 8.5					10 (Maximum increase)				1000	
EPA Drinking Water Standards[10]				6.5 - 8.5			15		5*	500		4*		
NAS-NAE Irrigation Water Criteria[11]				4.5 - 9.0										
NAS-NAE Livestock Watering Criteria[11]										3300				

1. Beaver Creek (S-1); 43°31'44", 104°09'16"; Upstream of mouth of Stockade Beaver Creek, Wyo; Data Source, TVA (9/75 through 9/77).
2. Beaver Creek (S-2); 43°32'07", 104°07'02"; Upstream of Old US 85 bridge, Wyo; Data Sources, TVA (9/75 through 9/77) and USGS (1/72 through 5/77).
3. Beaver Creek (S-3); 43°25'28", 103°59'30"; ~275 m. upstream of confluence with Cheyenne River, S.D.; Data Source, TVA (9/75 through 9/77).
4. Cheyenne River (S-4); 43°18'20", 103°49'17"; Upstream of US Hwy. 18 bridge at Edgemont, S.D.; Data Sources, TVA (12/74 through 9/77), USGS (1/72 through 9/76), and the State of South Dakota (11/72 through 5/77).
5. Cheyenne River (S-5); 43°18'49", 103°47'16"; ~2.5 km downstream of Edgemont, SD, above Red Canyon Creek; Data Sources, TVA (12/74 through 6/75) and USGS (7/73 through 6/74).
6. Cheyenne River (S-6); 43°17'07", 103°44'21"; ~10 km downstream of Edgemont, SD; Data Source, TVA (12/74 through 9/77).
7. Cheyenne River (S-7); 43°18'23", 103°33'43", Upstream of SR 71 bridge at Angostura Reservoir, SD; Data Source, TVA (6/77 through 9/77).
8. Standards for Beaver Creek are the same as the Cheyenne River with the exception of those more stringent standards in parenthesis which are for Beaver Creek. Reference number 1.
9. Reference number 2.
10. Standards marked with (*) are primary drinking water standards and unmarked standards are the proposed secondary drinking water standards. References numbers 3 and 4.
11. Reference number 5.

Table 2.6.1.1-2

Summary of Chemical Surface Water Quality for the Cheyenne River and Beaver Creek in the Vicinity of the Edgemont Uranium Mining Project*

Stream and Mileage

Parameter	Beaver Creek[1] (S-1) Observed Concentrations Maximum	Minimum	Mean	Number of Samples	Beaver Creek[2] (S-2) Observed Concentrations Maximum	Minimum	Mean	Number of Samples
Aluminum, µg/l	13000	<200	3500	4	8600	300	2400	4
Ammonia nitrogen, mg/l	0.02	0.01	0.02	2	0.19	<0.01	<0.10	2
Arsenic, µg/l	19	<2	9	4	85	<2	<25	4
Barium, µg/l	17000	<100	4400	4	16000	<100	4100	4
Beryllium, µg/l	<10	<10	<10	2	<10	<10	<10	2
Boron, µg/l	710	270	440	3	730	100	240	26
Cadmium, µg/l	3	<1	<2	4	180	<1	50	4
Calcium, mg/l	490	97	340	4	815	79	384	69
Chemical oxygen demand	61	38	50	2	140	11	75	2
Chloride, mg/l	1300	40	750	4	1400	32	504	69
Chromium (total), µg/l	13	<5	<7	4	10	<5	<6	4
Cobalt, µg/l	<5	<5	<5	2	18	<5	12	2
Conductivity, µmhos	7000	1380	5070	4	7910	1060	3800	50
Copper, µg/l	40	10	30	4	50	<10	40	4
Fluoride, mg/l	0.60	0.34	0.50	4	1.6	0.35	0.95	69
Iron (total), mg/l	2.60	0.20	1.00	4	4.6	0.0	0.38	27
Lead, µg/l	18	<10	<12	4	20	<10	12	4
Lithium, µg/l	160	80	120	2	160	70	120	2
Magnesium, mg/l	170	24	120	4	320	17	120	69
Manganese (total), µg/l	440	50	270	4	2800	30	770	4
Mercury, µg/l	0.6	<0.2	<0.3	4	0.7	<0.2	<0.4	4
Molybdenum, µg/l	<100	<100	<100	4	<100	<100	<100	4
Nickel, µg/l	<50	<50	<50	3	<50	<50	<50	3
Nitrate nitrogen, mg/l					5.6	0.0	0.3	55
Nitrate plus nitrite nitrogen, mg/l	0.28	<0.01	0.15	2	0.30	<0.01	0.17	3
Organic nitrogen, mg/l	0.92	0.37	0.65	2	1.6	0.28	0.90	2
Phosphorus (total), mg/l	0.97	0.02	0.50	2	1.6	0.0	0.1	44
Potassium, mg/l	7.9	6.8	7.4	2	10	2.3	6.2	67
SAR	-	-	9.1	4	-	-	5.2	69
Selenium, µg/l	3	<1	2	4	4	<1	2	4
Silica (total), mg/l	4.8	0.8	2.5	3	15	0.0	7	68
Silver, µg/l	<10	<10	<10	3	<10	<10	<10	3
Sodium, mg/l	1300	110	770	4	1300	96	460	69
Strontium, µg/l	3500	830	2160	2	4900	1100	3000	2
Sulfate, mg/l	2700	210	1280	4	3600	230	1510	69
Titanium, µg/l	<1000	<1000	<1000	2	<1000	<1000	<1000	2
Vanadium, µg/l	<100	<100	<100	4	<500	<100	<200	4
Zinc, µg/l	60	10	30	4	'30	10	40	4

Table 2.6.1.1-2 (continued)

Parameter	Beaver Creek[3] (S-3) Observed Concentrations Maximum	Minimum	Mean	Number of Samples	Cheyenne River[4] (S-4) Observed Concentrations Maximum	Minimum	Mean	Number of Samples
Aluminum, µg/l	7200	700	3200	4	400	<200	<300	3
Ammonia nitrogen, mg/l	0.03	0.01	0.02	2	0.35	<0.01	0.11	19
Arsenic, µg/l	15	<2	9	4	53	<2	<13	6
Barium, µg/l	19000	<100	4900	4	14000	<100	<2900	5
Beryllium, µg/l	<10	<10	<10	2	<10	<10	<10	2
Biochemical oxygen demand (5-day), mg/l					3.0	0.5	1.4	37
Boron, µg/l	560	140	360	3	1300	240	500	7
Cadmium, µg/l	5	<1	<3	4	8	0	2	7
Calcium, mg/l	530	110	340	4	650	67	370	61
Chemical oxygen demand, mg/l	170	18	94	2	150	16	83	2
Chloride, mg/l	940	55	410	4	1190	30	410	66
Chromium (total), µg/l	11	<5	<7	4	42	0	<9	10
Cobalt, µg/l	43	<5	<24	2	11	<5	<8	2
Conductivity, µmhos	5800	1200	3600	4	7690	590	3980	93
Copper, µg/l	50	<10	40	4	50	3	20	9
Fluoride, mg/l	0.66	0.41	0.51	4	0.8	0.2	0.6	31
Iron (total), mg/l	4.1	1.2	2.6	4	80	0.02	5.8	38
Lead, µg/l	23	<10	<13	4	27	0	11	9
Lithium, µg/l	120	110	120	2	280	120	210	3
Magnesium, mg/l	150	27	92	4	301	22	126	61
Manganese (total), µg/l	2000	130	620	4	4150	70	490	37
Mercury, µg/l	0.8	<0.2	<0.4	4	0.9	0.1	<0.3	7
Molybdenum, µg/l	<100	<100	<100	4	<100	2	<80	9
Nickel, µg/l	<50	<50	<50	3	80	5	<40	7
Nitrate plus nitrite nitrogen, mg/l	0.28	<0.01	0.15	2	0.64	<0.01	0.18	18
Organic nitrogen, mg/l	1.6	0.25	0.90	2	4.1	0.08	1.0	23
Phosphorus (total), mg/l	2.2	0.05	1.1	2	1.9	0.0	0.2	59
Potassium, mg/l	10	9.4	9.7	2	25	1.2	10	56
SAR	-	-	5.3	4	-	-	6.0	61
Selenium, µg/l	2	1	2	4	3	<1	<2	7
Silica (total), mg/l	5.1	1.8	3.6	3	12	3.9	8.4	25
Silver, µg/l	<10	<10	<10	3	10	0	6	5
Sodium, mg/l	850	100	430	4	1310	110	530	58
Strontium, µg/l	4900	1000	3000	2	4700	1600	3150	2
Sulfate, mg/l	1700	260	940	4	3720	350	1730	63
Tin, µg/l					<100	-	-	1
Titanium, µg/l	<1000	<1000	<1000	2	<1000	<1000	<1000	2
Vanadium, µg/l	<500	<100	<200	4	<500	3.3	<200	9
Zinc, µg/l	90	10	40	4	420	<10	80	9

Table 2.6.1.1-2 (continued)

Parameter	Stream and Mileage: Cheyenne River[5] (S-5) Observed Concentrations Maximum	Minimum	Mean	Number of Samples	Cheyenne River[6] (S-6) Observed Concentrations Maximum	Minimum	Mean	Number of Samples
Aluminum, μg/l					1100	200	700	3
Ammonia nitrogen, mg/l					0.05	0.01	0.03	2
Arsenic, μg/l	<5	-	-	1	90	<2	<20	5
Barium, μg/l					15000	<100	3100	5
Beryllium, μg/l					<10	<10	<10	2
Boron, μg/l					820	260	520	4
Cadmium, μg/l					4	<1	<2	5
Calcium, mg/l					490	220	340	5
Chemical oxygen demand					240	19	130	2
Chloride, mg/l					890	75	420	5
Chromium (total), μg/l	<5	<5	<5	2	18	<5	<7	6
Cobalt, μg/l					27	<5	<16	2
Conductivity, μmhos	5500	545	3925	22	6100	1490	3790	4
Copper, μg/l	70	<10	<40	2	50	<10	30	6
Fluoride, mg/l					0.61	0.43	0.52	5
Iron (total), mg/l	0.40	0.14	0.27	2	5.00	0.11	1.36	6
Lead, μg/l	13	<10	<12	2	21	<10	14	6
Lithium, μg/l					180	150	170	3
Magnesium, mg/l					190	69	130	5
Manganese (total), μg/l					3900	50	1100	5
Mercury, μg/l					<0.2	<0.2	<0.2	4
Molybdenum, μg/l	<100	<100	<100	2	<100	<100	<100	6
Nickel, μg/l	<50	<50	<50	2	100	<50	<60	4
Nitrate plus nitrite nitrogen, mg/l					0.56	0.10	0.33	2
Organic nitrogen, mg/l					3.60	0.31	2.00	2
Phosphorus (total), mg/l					2.80	0.07	1.40	2
Potassium, mg/l					25	9.6	18	3
SAR					-	-	6.6	6
Selenium, μg/l					4	<1	<2	5
Silica (total), mg/l					8.8	2.1	6.1	3
Silver, μg/l					10	<10	<10	3
Sodium, mg/l					910	170	560	5
Strontium, μg/l					4600	2000	3300	2
Sulfate, mg/l					2700	640	1590	5
Tin, μg/l	<100	-	-	1				
Titanium, μg/l					<1000	<1000	<1000	2
Vanadium, μg/l	<500	<500	<500	2	<500	<100	<200	6
Zinc, μg/l	60	10	40	2	100	<10	50	6

Table 2.6.1.1-2 (continued)

Stream and Mileage

Cheyenne River[7]
(S-7)

Parameter	Observed Concentrations Maximum	Minimum	Mean	Number of Samples
Aluminum, µg/l	1700	<200	1000	2
Ammonia nitrogen, mg/l	0.01	0.01	0.01	2
Arsenic, µg/l	4	<2	<3	2
Barium, µg/l	230	<100	<160	2
Boron, µg/l	140	-	-	1
Cadmium, µg/l	8	<1	<4	2
Calcium, mg/l	510	470	490	2
Chemical oxygen demand	19	5	12	2
Chloride, mg/l	160	150	160	2
Chromium (total), µg/l	<5	<5	<5	2
Cobalt, µg/l	<5	<5	<5	2
Conductivity, µmhos	3000	2770	2880	2
Copper, µg/l	40	20	30	2
Fluoride, mg/l	0.82	0.66	0.74	2
Iron (total), mg/l	0.65	0.14	0.40	2
Lead, µg/l	<10	<10	<10	2
Magnesium, mg/l	100	100	100	2
Manganese (total), µg/l	100	20	60	2
Mercury, µg/l	0.6	<0.2	<0.4	2
Molybdenum, µg/l	100	100	100	2
Nickel, µg/l	<50	-	-	1
Nitrate plus nitrite nitrogen, mg/l	1.60	0.17	0.89	2
Organic nitrogen, mg/l	0.55	0.03	0.29	2
Phosphorus (total), mg/l	0.29	0.01	0.15	2
SAR	-	-	2	2
Selenium, µg/l	2	2	2	2
Silica (total), mg/l	13	-	-	1
Silver, µg/l	<10	-	-	1
Sodium, mg/l	230	140	180	2
Strontium, µg/l	4900	4600	4750	2
Sulfate, mg/l	2200	1600	1900	2
Vanadium, µg/l	<100	<100	<100	2
Zinc, µg/l	30	10	20	2

Table 2.6.1.1-3

Water Quality Standards and Criteria for Comparison Purposes

Parameter	South Dakota Water Quality Standards[8]	EPA Drinking Water Standards[10]	NAS - NAE[11] Irrigation Water Criteria	NAS - NAE[11] Livestock Watering Criteria
Aluminum, μg/l			5000	5000
Ammonia nitrogen, mg/l	1.0			
Arsenic, μg/l		50*	100	200
Barium, μg/l		1000*		
Beryllium, μg/l			100	
Boron, μg/l			750	
Cadmium, μg/l		10*	10	50
Calcium, mg/l				
Chemical oxygen demand				
Chloride, mg/l		250		
Chromium (total), μg/l		50*	100	1000
Cobalt, μg/l			50	1000
Conductivity, μmhos	2500			
Copper, μg/l		1000	200	500
Fluoride, mg/l		1.4→2.4*	1.0	2.0
Iron (total), mg/l	0.2	0.3	5	
Lead, μg/l		50*	5000	100
Lithium, μg/l			2500	
Magnesium, mg/l				
Manganese (total), μg/l		50	200	
Mercury, μg/l		2*		10
Molybdenum, μg/l			10	
Nickel, μg/l			200	
Nitrate nitrogen, mg/l	50(as NO_3)	45(as NO_3)*		
Nitrate plus nitrite nitrogen, mg/l				100
Organic nitrogen, mg/l				
Phosphorus (total), mg/l				
Potassium, mg/l				
SAR	10			
Selenium, μg/l		10*	20	50
Silica (total), mg/l				
Silver, μg/l		50*		
Sodium, mg/l				
Strontium, μg/l				
Sulfate, mg/l		250		
Titanium, μg/l				
Vanadium, μg/l			100	100
Zinc, μg/l		5000	2000	25000

*Refer to Table 2.6.1.1-1 for footnotes.

solids concentrations for both streams exceed the State of South Dakota water quality standard.

Coliform bacteria data at Edgemont (S-4) showed that high concentrations of fecal, fecal streptococci, and total coliforms were present during various times of the year. The fecal to fecal streptococci ratios indicate the source of pollution to be animal feces.

The chemical water quality of the Cheyenne River and Beaver Creek was poor. Mean concentrations of barium and some arsenic measurements were above those concentrations identified by the EPA "National Interim Primary Drinking Water Standards"[3] for finished drinking water. Mean concentrations of cadmium above these standards were observed in Beaver Creek. Mean concentrations of chlorides, iron, manganese, and sulfates in both the Cheyenne River and Beaver Creek were above those concentrations identified by the EPA "Proposed Secondary Drinking Water Standards."[4] This data supports the fact that those streams are not classified for domestic water supply use. Concentrations of iron and conductivity levels in the Cheyenne River and Beaver Creek exceeded the State of South Dakota water quality standards. Based upon the "1972, NAS - NAE Water Quality Criteria,"[5] water from both the Cheyenne River and Beaver Creek is unsuitable for irrigation use (continuously on all soils). High concentrations of chemical oxygen demand were observed in both the Cheyenne River and Beaver Creek in the project vicinity.

Water quality data resulting from the surveys performed during the late summer and early fall months correlate closely with regional historical ground water quality data[6] from the upper Quaternary and Pierre Formations. This indicates that during this time of the year flow in Beaver Creek and the Cheyenne River are predominately composed of ground water base flows which enter the stream beds through seeps, springs, and flowing wells. Conversely, water quality data resulting from the surveys performed during the spring and early summer months show concentrations of those constituents characteristic of stormwater runoff and snow melt (increased concentrations of suspended solids, color, nutrients, iron, manganese, etc.).

<u>2.6.1.2 Ground Water Quality</u> - In the Edgemont project area the Fall River and Lakota Formations, which together form the Inyan Kara Group, are the principal sources of water for domestic water supplies, irrigation, and stock watering. Water in these formations is under artesian conditions. The Chilson Member of the Lakota Formation is the ore-bearing unit and is the main aquifer to be impacted by underground mining activities. Mining of ore at outcrop regions of the Fall River Formation will occur at surface mining sites.

Ground water quality investigations were conducted at the project during the period of November 1976 through November 1977. A summary of results of water quality analysis of ground water samples obtained on and near the project site are listed in Table 2.6.1.2-1. Their locations are shown on Figure 2.6.1.1-1. This table provides a comparison of reported ranges of water quality parameters with various water quality standards and criteria.

Table 2.6.1.2-1

Summary of Groundwater Quality Data in the Vicinity of the

Edgemont Project Area

Parameter	Burdock Mines Composite Groundwater Pump Test Results[1] Max	Min	Mean	Number of Observations	Burdock Mines Piezometers Lakota Formation[2] Max	Min	Mean	Number of Observations	Burdock Mines Piezometers Composite Groundwater[3] Max	Min	Mean	Number of Observations	Regional Data from the Lakota Formation[5] Max	Min	Mean	Number of Observations	Regional Data from the Fall River Formation[4] Max	Min	Mean	Number of Observations	EPA Drinking Water Standards[6]	NAS-NAE[7] Irrigation Water Criteria	NAS-NAE[7] Livestock Watering Criteria
Temperature, °C	14	13	13	3	14	6	11	7	13	5	10	7	14	-	-	1							
pH, S.U.	7.9	7.3	7.6	3	7.8	6.8	7.2	4	7.7	6.7	7.2	3	7.9	7.0	7.6	6	8.9	7.7	8.3	7	6.5-8.5	4.5-9.0	
Specific Conductance, µmhos	1675	1410	1580	3	1490	1050	1270	7	1850	1030	1320	7	2600	1098	1800	4	5100	1410	2850	4			
Alkalinity (as $CaCO_3$), mg/l	209	202	206	2	210	22	140	6	210	24	90	6	400	207	272	6	952	238	596	7			
Calcium, mg/l	170	150	160	3	150	7.3	80	7	92	8.1	47	7	260	62	109	6	104	2.8	26	8			
Chloride, mg/l	10	9	9	3	130	9	50	6	130	10	50	6	135	0.15	30	6	286	0.17	84	8	250		
COD, mg/l	10	6	8	3	-	-	-	-	140	56	98	2											
Fluoride, mg/l	0.26	0.24	0.25	3	0.64	0.17	0.40	5	0.80	0.32	0.56	6	0.95	0.10	0.50	6	2.6	0.6	1.5	7	1.4-2.4*	1.0	2.0
Hardness (as $CaCO_3$), mg/l	670	610	634	3	579	130	360	7	360	54	190	7	382	50	216	2	412	10	136	4			
Iron, mg/l	0.38	0.16	0.24	3	48	0.64	15	7	22	0.28	7.0	7	1.60	0.02	0.80	5	2.9	0.08	0.6	7	0.3	5	
Magnesium, mg/l	59	53	57	3	49	3.8	32	7	34	8.2	18	7	125	3.1	46	6	37	0.7	10	8			
Nitrogens																							
Ammonia, mg/l	0.11	0.10	0.10	3	0.37	0.03	0.18	3	0.37	0.08	0.18	3											
Organic, mg/l	0.02	<0.01	0.01	3	1.20	0.12	0.55	3	0.63	0.29	0.38	3											
Nitrite plus Nitrate, mg/l	<0.01	<0.01	<0.01	3	0.26	0.08	0.14	3	0.17	0.07	0.10	3	0.1(NO_3)	-	-	1						45(NO_3)*	100
Phosphorus, mg/l	0.02	0.01	0.01	3	0.33	0.01	0.12	3	0.10	0.03	0.06	3											
Potassium, mg/l	7.5	7.3	7.4	3	210	14	90	6	140	9	50	6	23	-	-	1							
Silica, mg/l					8.1	0.09	3.9	3	1.4	0.02	0.50	3	10	8.4	9.7	5	17	5.4	12	7			
Sodium, mg/l	120	120	120	3	250	110	150	7	270	110	200	7	390	107	236	6	1064	167	470	8			
Solids (dissolved), mg/l	1000	1000	1000	3	1200	680	940	6	1300	480	870	[illegible]	2091	829	1358	6	3189	1010	1689	8	500		
Sulfate, mg/l	580	540	560	3	690	230	510	6	900	180	520	6	1102	246	679	6	1790	8	533	8	250		3300
Aluminum, µg/l	<200	<200	<200	3	520	<200	300	7	500	<200	<270	7										5000	5000
Arsenic, µg/l	2.8	1.6	2.4	3	6	<2	2	7	<2	<2	<2	7									50*		
Barium, µg/l	<100	<100	<100	3	200	<100	<110	7	<100	<100	<100	7									1000*		
Beryllium, µg/l					<10	<10	<10	3	<10	<10	<10	3										100	
Boron, µg/l	120	50	80	3	440	140	240	6	580	160	270	6	70	-	-	1						750	
Cadmium, µg/l	<1	<1	<1	3	2	<1	<1	7	2	<1	<1	7									10*	10	50
Chromium, µg/l	<5	<5	<5	3	<5	<5	<5	7	<5	<5	<5	7									50*	100	1000
Colbalt, µg/l	<5	<5	<5	3	<5	3	<5	7	8	<5	7	7										50	1000
Copper, µg/l	20	10	20	3	140	<10	50	7	160	<10	<30	7									1000	200	500
Lead, µg/l	20	<10	<10	3	1600	<10	360	7	380	<10	80	7									50*	5000	100
Lithium, µg/l					110	40	80	4	90	50	70	4										2500	
Manganese, µg/l	240	230	240	3	530	140	270	7	390	30	180	7									50	200	
Mercury, µg/l					0.5	<0.2	<0.3	5	0.4	<0.2	<0.3	5									2*		10
Molybdenum, µg/l	<100	<100	<100	3	<100	<100	<100	6	<100	<100	<100	6										10	
Nickel, µg/l	<50	<50	<50	3	<50	<50	<50	6	<50	<50	<50	6										200	
Selenium, µg/l	<1	<1	<1	3	2	<1	<1	6	1	<1	<1	6									10*	20	50
Silver, µg/l	<10	<10	<10	3	<10	<10	<10	6	<10	<10	<10	6									50*		
Strontium, µg/l	3700	3400	3600	3	2100	1300	1670	6	2200	370	1130	6											
Vanadium, µg/l	<100	<100	<100	3	<100	<100	<100	7	<100	<100	<100	4										100	100
Zinc, µg/l	290	100	180	3	7700	<10	2250	6	210	40	140	7									5000	2000	25,000
Hydrogen Sulfide, mg/l													2	0.1	1	3	5+	5	5+	3			
SAR	-	-	2.1	3	-	-	3.6	7	-	-	6.2	7	-	-	4.9	4	-	-	20	8			

1. Groundwater samples were obtained during a pump test of well D-53, and represents a composite of water from the Lakota and Fall River Formations (see section 2.5.2). Data Source: TVA, 11/14-17/77.
2. Groundwater samples were from flowing (F) and nonflowing (NF) piezometers D-47 (F), D-49 (NF), and D-51 (F). Data Source: TVA, 1976-1977.
3. Groundwater samples were from flowing (F) and nonflowing (NF) piezometers D-48 (F), D-50 (NF), and D-52 (F). Samples represent a composite of water from the Lakota and Fall River Formations (see section 2.5.2). Data Source: TVA, 1976-1977.
4. Samples were obtained from wells D-6, D-12, D-20, F-1, and G-1 (Data Source: Reference No. 6) and Well G-1 (Data Source: USGS, 1972).
5. Samples were obtained from wells D-21, F-2, F-3, F-4, F-5, F-6, F-7, and H-1 (Data Source: Reference No. 6).
6. Standards marked with (*) are primary drinking water standards and unmarked are the proposed secondary drinking water standards. Reference numbers 3 and 4.
7. Reference number 5.

Hydrologic studies at the Burdock mine sites were conducted utilizing well D-53 and site piezometers during the period of November 14-17, 1977. The results of this study revealed that in the vicinity of the Burdock mines, waters from the Lakota and Fall River Formations intermix and water samples from this well represent a composite of water from these two aquifers (section 2.5.2).

Well D-53 may be utilized as a depressuring well for the Burdock underground mine. Evaluation of water quality data from this pumped well show its physical-chemical quality to be fair. Concentrations of dissolved solids averaged 1,000 mg/l and the ground water is considered to be very hard. The principal cations were calcium and sodium, and the principal anions were sulfate and bicarbonate. Concentrations of analyzed primary (health) trace metals were less than those specified by the EPA for finished drinking water.[4] Mean concentrations of dissolved solids, sulfates, and manganese were greater than those concentrations specified by the proposed EPA secondary (aesthetically undesirable) standards for finished drinking water.[4] Using the USDA[7] diagram for evaluating ground water for irrigation purposes, the ground water is unsuitable for irrigation purposes because of its high salinity hazard.

When depressuring of the Lakota Formation is not in progress, water from the Lakota Formation enters the Fall River Formation because of its greater piezometric head. Piezometers D-47, D-49, and D-51 are screened in the Lakota Formation only thus permitting evaluation of the quality of water in the aquifier. Evaluation of the water quality data from the Lakota Formation, in advance of any hydrologic studies, shows its physical-chemical quality to be poorer than the intermixed ground water obtained during the hydrologic studies. Concentrations of nutrients and most metals were greater than those concentrations observed at well D-53. Nevertheless, except for lead, concentrations of analyzed primary trace metals were less than those specified by the EPA primary standards. An excessively high concentration of lead (1,600 g/l) was observed in a grab sample from piezometer D-49, which is non-flowing. Lower concentrations were observed in D-51 and on a different occasion in D-49, but the observed concentrations still exceeded the EPA standard of 50 g/l for finished drinking water. Mean concentrations of iron, dissolved solids, sulfates, and manganese exceeded those concentrations specified by the proposed EPA secondary standards. The water is considered to be very hard, the principal cations were sodium and calcium, and the principal anions were sulfate and bicarbonate. Based upon the 1972 NAS - NAE criteria[5] the ground water is unsuitable for irrigation and livestock watering purposes and based upon USDA criteria, the salinity hazard for irrigation is high.

Water quality samples were also obtained prior to the hydrologic studies at piezometers (D-48, D-50, and D-52) screened in the Fall River Formation. Based upon hydrologic studies, this ground water also represents a composite of the Lakota and Fall River Formations. An evaluation of the water quality data from samples obtained from these piezometers showed its physical-chemical quality to be better than that of the Lakota Formation. Concentrations of dissolved solids averaged 870 mg/l. The water is considered to be moderately hard, the principal cations were

sodium and calcium and the principal anions were sulfate and bicarbonate. Although lower concentrations were observed at these piezometers, the mean concentration of lead, iron, dissolved solids, and manganese exceeded the EPA standards. The highest concentrations of Chemical Oxygen Demand and sulfates were reported in samples from these piezometers. A higher mean Sodium Adsorption Ratio was calculated and based upon USDA criteria the salinity hazards for irrigation is high.

A comparison of the water quality of composite ground water obtained at the piezometers screened in the Fall River Formation and the pumped depressuring well reveals that the pumped depressuring well provides water of better quality containing smaller concentrations of most metals and nutrients. Conversely concentrations of minerals, especially hardness causing minerals, and dissolved solids measured in the piezometer samples were less than the concentrations observed in samples from the pumped well.

Based upon this evaluation, it can be concluded that (1) the water quality of the Fall River Formation is better than the water quality of the Lakota Formation, (2) the pumped depressuring well provides the best source of raw water for various uses, and (3) during depressuring the inflow of water from the Fall River Formation to the Lakota Formation will not degrade water quality, but instead enhance water quality in local private wells which tap the Lakota Formation.

Summaries of historical water quality data from the USGS, the Atomic Energy Commission (replaced by NRC), and the South Dakota School of Mines are also listed in Table 2.6.1.2-1. Evaluation of this data would lead to the conclusion that the water quality of the Fall River Formation is poorer than that of the Lakota Formation. The discrepancy between the historical data and the data obtained on the project site may be explained by several reasons: (1) changes in aquifer water quality with time, (2) well locations in the ground water basin, (3) well design, (4) sampling techniques, and (5) laboratory accuracies.

<u>2.6.2 Water Quality Impact Assessment</u> - Impacts to surface and/or ground water quality potentially can be caused by several activities connected with uranium mining. These activities and proposed mitigative measures will be discussed individually for underground and surface mining. A discussion of liquid wastes, their treatment, discharge, and the impact of this discharge is presented under Section 2.12.1.

2.6.2.1 Underground Mining

<u>2.6.2.1.1 Ground Water Depressuring and Quality Protection Measures</u> - Depressuring of the Lakota Formation at the Burdock Mine will be accomplished by pumped wells and subsurface drainage systems. Depressuring will contribute to the drawdown of the piezometric surface of the Lakota Formation, thus permitting waters from the overlying Fall River Formation to enter the Lakota Formation and form a composite of water from the two aquifers. No significant adverse impact to the water quality of the Fall River and Lakota Formations during mining is anticipated since the depressuring operation will always cause the mine to act as a sink for any potentially contaminated water

rather than a source. Some local change in the water quality of the Lakota Formation will occur but this should represent an improvement over existing conditions (see Section 2.6.1.2). Depressuring will not be conducted at the Darrow Extensions and Runge East Mines since mining will be within unsaturated portions of the Fall River Formation.

Protection of ground water quality in the vicinity of underground mines will be accomplished by (1) the sealing of all ponds which will receive contaminated mine water, (2) the sealing of ore storage pads and the dikes providing containment of runoff in the ore storage area, and (3) the immediate cleanup following accidental spills of fuel and oils.

2.6.2.1.2 Nonpoint Source Runoff - No significant degradation of the area's water resources is expected from nonpoint source discharges at the underground mines since (1) runoff will be limited due to the semiarid climate, (2) existing drainage patterns will be designed to allow runoff outside the boundary of the mining operations to be diverted around the areas disturbed by mining, (3) runoff from overburden storage, topsoil storage, revegetated areas, and other disturbed areas will be controlled as necessary by a system of dikes, trenches, ponds, or other appropriate measures including routing to the lagoon-treatment system, (4) runoff from ore storage areas will be controlled by diking around the impervious ore pad, (5) erosion of haul roads will be minimal because all roads currently exist, drainage ditches will be constructed alongside the roads, and the roads will be well maintained.

2.6.2.1.3 Spill Control - Areas will be designated for the storage of fuel and oil. These materials will be stored within diked areas of sufficient capacity to retain 110 percent of the total volume contained. In the event of an accidental spill within a diked area, the spilled material will be contained and disposed of in an environmentally acceptable manner. Substantial quantitites of other potentially hazardous or toxic materials are not anticipated to be stored at the underground mining sites.

2.6.2.1.4 Post Mining - After operations cease, waste piles, mine water holding ponds, ore storage areas, disturbed areas, and other surface facilities will be stabilized and/or reclaimed to minimize adverse impacts to ground or surface water quality that might result from rainfall or snowmelt runoff, or ground water contacting these areas. Along with this site stabilization, each shaft will be covered with a concrete slab. Requirements applicable at the time of stabilization of these areas, in addition to those described in the reclamation program, will be met. Upon abandonment of a mine shaft, depressuring operations will cease and natural hydraulic gradients in the Lakota and Fall River Formations will likely recover to approach pre-mining conditions. Some deterioration of ground water quality in the Lakota Formation could occur in the immediate vicinity of the mine. This would be a result of oxidation and other chemical reactions within the abandoned mine. At this time, the potential impact on these aquifers is judged to be insignificant because during aquifer gradient restoration the flow will be towards the mine site, thus confining any potentially contaminated ground water to the immediate area. A

return to the chemically reduced state will eventually occur due to the natural geochemical reactions in the formations and the reducing characteristics of the natural ground water. Thus, metals associated with the ore body should be converted from a soluble to an insoluble phase; and precipitate in the mine site area. After the restoration period, any dispersion of the soluble form of these metals should be minimal.

2.6.2.2 Surface Mining

2.6.2.2.1 Ground Water Inflows, Overburden Leachates, and Ground Water Quality Protection Measures - Only one surface mine has been planned to date, the Spencer Richardson Mine. Significant volumes of ground water are not expected to be encountered in surface mines because all surface mining should be in unsaturated portions of the Fall River Formation. Runoff from the overburden spoil piles, ground water seepage, rainfall, and/or snowmelt that does enter the mining pit will be handled as specified in Section 2.12.1.

A portion of the rainfall, snowmelt, and ground water inflows, if any, to the open pit will infiltrate the bottom of the pit. When the surface mine is reclaimed, rainwater and snowmelt will infiltrate the implaced overburden. Rainwater has a pH of less than neutral and therefore is capable of leaching minerals and metals from the overburden matrix. The impact of this leaching on the water quality of the Fall River Formation is judged to be insignificant because all surface mining is proposed in aquifer outcrop areas which normally permit the infiltration of rainwater.

If, in the future, mining is proposed for non-outcrop sections of the Fall River Formation, the impact of leaching on groundwater quality should also be insignificant because of several factors: (1) leaching should be short-termed because a hardpan condition is likely to occur on newly disturbed overburden piles after the first few rainfalls, thus reducing the infiltration rates, (2) the low average rainfall quantities expected at the site, 30 to 40 cm/yr, (13 to 16 in/yr) should reduce the time the rainwater is in contact with the overburden, (3) most of the rain expected at the site is of short duration and high intensity thus resulting in greater volumes of runoff and lesser volumes of water infiltrating the overburden surface, (4) the volume of the portion of the aquifer to be mined is insignificant when compared to its total volume, and (5) the attenuation capabilities of the aquifer should decrease leached metal concentrations within a short distance of the mining zone. Only minor post-mining overburden leaching is expected since the same overburden will have been used in the reclamation program.

Protection of ground water quality in the vicinity of the surface mine sites shall be accomplished as discussed in underground mining (Section 2.6.2.1.1, second paragraph).

2.6.2.2.2 Nonpoint Source Impacts - No significant degradation of the area's water resources is expected from nonpoint source discharges at surface mining areas. Drainage and control systems will be built and maintained to control runoff as discussed in underground mining (Section 2.6.2.1.2).

2.6.2.2.3 Spill Control - Fuels and oils will be handled as discussed in underground mining (Section 2.6.2.1.3). Substantial quantities of other potentially hazardous or toxic materials are not anticipated to be stored at the surface mining sites.

2.6.3 Water Quality Monitoring

2.6.3.1 Surface Water Quality Monitoring - Mining wastewaters will be fed to mine water holding ponds where they will be treated and discharged in compliance with applicable requirements which will be identified in the NPDES permit. Site runoff will be controlled as necessary by a system of dikes, trenches, ponds, or other appropriate measures. Monitoring will be carried out in accordance with the discharge permit requirements.

2.6.3.2 Ground Water Quality Monitoring - At the Burdock underground mining area, the Lakota Formation will be depressurized by a series of wells located around the periphery of each mine shaft. This ground water, which represents a composite of the Lakota and Fall River Formations, will be monitored for various parameters at least once annually to detect changes, if any, as a result of the continued leakage of the Fall River Formation into the Lakota Formation. In addition, selected private water wells will be monitored once annually for a limited period to verify the analysis contained in Section 2.6.1.2.

At the Burdock area, mine water holding ponds will be located on top of the Skull Creek Shale Formation, and the pond bottom and dike walls will be sealed to prevent any seepage. If any seepage were to occur, it would be through a dike and appear on the land surface. Therefore, shallow ground water monitoring will not be conducted at the Burdock mining area.

At the Spencer Richardson mine, Darrow Extensions, and Runge East Mines, mining will occur in unsaturated outcrop regions of the Fall River Formation. Significant volumes of ground water are not expected to be encountered at these sites, but water removed from the mine shafts, open pits, and runoff will be routed to sealed mine water holding ponds. To adequately monitor the integrity of the sealed ponds and ensure that they are efficiently retaining waste waters, shallow ground water quality monitoring will be conducted. Wells will be provided in the saturated portion of the Fall River Formation both upgradient and downgradient to the ponds. Sampling will begin prior to mining activities on a quarterly frequency. Samples will be analyzed for various physical and chemical water quality constituents.

Results of the ground water quality monitoring program will be evaluated on a routine frequency to ensure that water quality conditions are not significantly impacted by the mining activity. At the end of one full year of ore production, the program will be reevaluated to ensure that the objectives of the program are being satisfied and appropriate changes will be made as necessary, consistent with these objectives. Additional program evaluations will be conducted as necessary.

2.6 References

1. State of South Dakota. Department of Environmental Protection. Surface Water Quality Standards. Chapter 34:04:02, and Uses Assigned to Streams. Chapter 34:04:04, SDCL 46-25-107.

2. State of Wyoming Department of Environmental Quality. Water Quality Standards for Wyoming. Dated August 8, 1974, and Stream Classifications in Wyoming Oct. 1, 1977; 1973 CS, 35-502.19 and 1973 SI, 35-487-19.

3. U.S. Environmental Protection Agency. National Interim Primary Drinking Water Regulations. CFR. Title 40. Part 141. V. 40, No. 248. December 1975.

4. U.S. Environmental Protection Agency. Proposed National Secondary Drinking Water Regulations CFR. Title 40. Part 143 V. 42, No. 62. March 1977.

5. National Academy of Sciences and National Academy of Engineering. Water Quality Criteria 1972. USEPA R3 73 033. March 1973.

6. Keene, Jack R. Ground-Water Resources of the Western Half of Fall River County, S.D.; South Dakota Geological Survey Rept. of Inv. No. 109. 1973.

7. United States Department of Agriculture. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook No. 60. 1954.

2.7 Climatology and Air Quality

2.7.1 Physical Environment

2.7.1.1 General Climate - The project area is located in extreme southwestern South Dakota and extreme east-central Wyoming, adjacent to the southwestern extension of the Black Hills. The project area is characterized by low precipitation, high evaporation rates, abundant sunshine, low relative humidities, and moderate temperatures with large diurnal and annual variations.[1,2] The general climate of the project area may be considered as semi-arid continental or steppe with a dry winter season.[3,4]

Migratory storm systems originating in the Pacific Ocean generally release most of their moisture over the Coastal and Cascade Range and Rocky Mountains, thus arriving in the Black Hills area relatively dry, and generally producing only light precipitation. Heavier precipitation normally occurs when these systems reintensify east of the Rocky Mountains and interact with moist air that is either already present or advected into the area from the southeast. Isolated summertime convective storms may also produce heavy localized precipitation, primarily over and adjacent to the Black Hills.

Topography on the lease properties does not vary substantially and therefore should not influence synoptic-scale air flow to any great extent. The adjacent Black Hills, however, are a major barrier to air flow and may cause some variation in the airflow in the general region.

2.7.1.2 Temperature - Temperatures in the project vicinity are reasonably represented by data from nearby Ardmore, South Dakota located approximately 35 km (22 mi) south-southeast of the Edgemont properties . Table 2.7.1.2-1 presents mean monthly and annual mean daily maximum and minimum temperatures for the Ardmore station for 42 years of record.

Temperatures greater than or equal to 32° C (90° F) are estimated to occur on an average of 60 days per year in the project area.[2] The extreme maximum temperature reported for Ardmore is 46° C (114° F).[2] Migrating high pressure systems moving southward out of Canada frequently influence the site area. This fact, combined with elevations of about 3,500 to 3,800 feet MSL (Mean Sea Level), a northern continental location, and infrequent cloud cover, contributes to an average of 198 days per year in the project area recording temperatures less than or equal to 0° C (32° F). The lowest temperature on record for Ardmore is -38° C (-37° F).[2]

Freezing temperatures generally do not occur in the project area after mid-May or before the last of September.[1] However, there are large variations in freeze dates from year to year.

2.7.1.3 Precipitation and Relative Humidity - Maximum precipitation amounts in the project area occur during late spring and early summer, primarily as a result of moist air from the Gulf of Mexico interacting with frontal systems moving across

Table 2.7.1.2-1

Monthly and Annual Mean and Mean Daily Maximum and Minimum

Temperatures in Degrees Centigrade (Fahrenheit)

For Ardmore, South Dakota (1919-1960)[2]

Month	Mean	Mean Daily Maximum	Mean Daily Minimum
January	-6.8 (20)	0.9 (34)	-14.4 (6)
February	-4.1 (25)	3.8 (39)	-11.6 (11)
March	0.8 (33)	8.3 (47)	-7.1 (19)
April	7.0 (45)	14.9 (59)	-0.8 (30)
May	12.9 (55)	20.7 (69)	5.2 (41)
June	18.6 (65)	26.6 (80)	10.4 (5[illegible])
July	23.3 (74)	32.4 (90)	14.3 (58)
August	22.1 (72)	31.3 (88)	12.7 (55)
September	15.9 (61)	25.6 (78)	6.6 (44)
October	8.8 (48)	18.0 (64)	-0.1 (32)
November	1.1 (34)	9.1 (48)	-6.8 (20)
December	-4.8 (23)	2.8 (37)	-12.2 (10)
Annual	7.9 (46)	16.2 (61)	-0.3 (31)

the region. Summertime convective thunderstorm activity also contributes substantially to the precipitation totals during the summer months. Monthly and annual precipitation data from Edgemont, South Dakota (Table 2.7.1.3-1), indicate that approximately one-half of the annual precipitation falls during the months of May, June, and July. Most of the winter precipitation can be expected as snow. Based on snowfall records for Ardmore over a 9 year period of record, the annual average snowfall for the project area is estimated to be approximately 94 cm (37 in).[2]

Based on records from the NWS (National Weather Service) station at Rapid City, South Dakota, located about 105 km (65 mi) northeast of the site, it is estimated that precipitation of 0.25 mm (0.01 in) or more occurs on an average of 90 days per year in the project area.[5,6,7]

The mean annual relative humidity for the project area is estimated to be about 52 percent.[5,7] However, afternoon humidities in the warmer months are often lower than 30 percent.

<u>2.7.1.4 Wind Speed and Direction</u> - Long-term wind information is not available for the immediate project area. The nearest NWS stations with such data are at Rapid City, South Dakota, and Scottsbluff, Nebraska, which are more than 105 km (65 mi) northeast and 160 km (100 mi) south of the site, respectively. Table 2.7.1.4-1 presents monthly and annual mean wind speeds and directions for these two stations. Limited site-specific information for the period March 24, 1977, through March 23, 1978, is presented in Table 2.7.1.4-2.

The NWS data indicate that the general air flow in the region is most frequently from a northwesterly direction with a secondary maximum from a southeasterly direction. Wind speeds are relatively high, generally averaging over 4.5 m/s (10 mi/h). The site specific wind data is reasonably consistent with the NWS information. However, in the site specific data, the wind direction distribution is shifted slightly to a more west-northwest and east-southeast orientation, and the average wind speed during the one year measurement period is lower than that observed over the longer-term NWS period.

<u>2.7.1.5 Severe Weather</u> - Tornadoes are infrequent in western South Dakota and eastern Wyoming. Of those reported, most occurred in the afternoon and early evening hours during the summertime thunderstorm season. Only nine tornadoes were reported within the one-degree (of latitude and longitude) square that includes the project area during the period from 1955 through 1967.[10] Thus, the estimated probability of a tornado striking a point within the project area in any given year is 0.0006.[10,11] In other words, the estimated mean recurrence interval for a tornado occurrence at any point within the project area is about 1,650 years.

Thunderstorms are relatively frequent in southwestern South Dakota and east-central Wyoming during the summer months, occurring on the average of 40 to 45 days per year.[7,12] Hail in

Table 2.7.1.3-1

Mean Monthly and Annual

Precipitation for Edgemont, South Dakota (1949-1957)[2]

Month	Amount (Millimeters)	Amount (Inches)	Years of Record
January	9	.3	9
February	11	.5	9
March	23	.9	9
April	30	1.2	9
May	73	2.9	9
June	67	2.6	9
July	48	1.9	8
August	29	1.1	8
September	28	1.1	8
October	19	.7	8
November	10	.4	9
December	9	.3	9
Annual	356	14.0	

Table 2.7.1.4-1

Monthly and Annual Mean Wind Speeds and Predominant Wind Directions

At Scottsbluff, Nebraska, and Rapid City, South Dakota[7,8,9]

	Scottsbluff, Nebraska		Rapid City, South Dakota	
Month	Mean Speed, m/s (mi/h)[a]	Direction[a]	Mean Speed, m/s (mi/h)[a]	Direction[b]
January	4.7 (10.6)	WNW	4.7 (10.5)	NNW
February	5.1 (11.5)	WNW	4.8 (10.8)	NNW
March	5.5 (12.3)	WNW	5.6 (12.5)	NNW
April	5.8 (12.9)	NW	5.9 (13.2)	NNW
May	5.4 (12.1)	ESE	5.5 (12.4)	NNW
June	4.7 (10.6)	ESE	4.8 (10.7)	NNW
July	4.2 (9.4)	ESE	4.4 (9.9)	NNW
August	4.1 (9.2)	ESE	4.6 (10.2)	NNW
September	4.2 (9.5)	ESE	4.9 (11.0)	NNW
October	4.4 (9.8)	NW	5.0 (11.1)	NNW
November	4.6 (10.4)	NW	4.9 (10.9)	NNW
December	4.8 (10.7)	WNW	4.6 (10.4)	NNW
Annual	4.8 (10.7)	ESE	5.0 (11.1)	NNW

a. Based on 24 years of record.

b. Based on 13 years of record.

TABLE 2.7.1.4-2

JOINT PERCENTAGE FREQUENCIES OF WIND SPEED BY DIRECTION

DISREGARDING STABILITY CLASS

EDGEMONT MILL METEOROLOGICAL FACILITY

MAR 24, 77 - MAR 23, 78

WIND DIRECTION	WIND SPEED (Mi/h) 0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	>=24.5	TOTAL
N	0.12	0.65	0.50	0.38	0.35	0.16	0.0	0.0	2.16
NNE	0.07	0.69	0.41	0.12	0.10	0.0	0.0	0.0	1.39
NE	0.16	0.87	0.44	0.15	0.20	0.06	0.0	0.01	1.89
ENE	0.09	0.96	0.62	0.40	0.66	0.44	0.07	0.0	3.24
E	0.13	1.30	1.50	1.43	4.13	2.52	0.13	0.0	11.14
ESE	0.09	0.54	1.01	1.32	5.10	2.97	0.20	0.0	11.23
SE	0.06	0.56	0.66	0.87	2.63	0.85	0.15	0.02	5.80
SSE	0.17	1.04	1.04	1.22	1.17	0.50	0.10	0.01	5.25
S	0.32	3.89	1.80	0.78	0.55	0.12	0.0	0.01	7.47
SSW	0.26	1.63	0.99	0.41	0.37	0.07	0.01	0.0	3.74
SW	0.09	0.83	0.33	0.30	0.33	0.02	0.01	0.0	1.91
WSW	0.09	1.27	0.45	0.24	0.29	0.09	0.0	0.0	2.43
W	0.38	4.72	3.32	1.41	1.57	0.66	0.24	0.0	12.30
WNW	0.10	2.44	2.90	1.85	3.08	2.29	1.02	0.21	13.89
NW	0.15	1.57	1.83	1.43	2.36	1.82	0.77	0.39	10.32
NNW	0.07	1.26	1.24	0.66	1.49	0.59	0.11	0.16	5.58
SUBTOTAL	2.35	24.22	19.04	12.97	24.38	13.16	2.81	0.81	99.74

Total hours of valid wind observations	8204
Total hours of observations	8747
Recoveability percentage	93.8
Total hours calm	2?

All columns and calm total 100 percent of joint valid observations

Meteorological Facility: Wind speed and direction measured at the 33.00 foot level

Mean wind speed = 7.2 Mi/h

association with these thunderstorms is generally reported on an average of 4 to 6 days per year.[12]

Extreme winds of short duration in this area are generally associated with thunderstorms. Table 2.7.1.5-1 presents estimated maximum (fastest mile) wind speeds at 9.1 m (30 ft) above the ground for various recurrence intervals.

Maximum short-duration rainfalls are generally associated with intense thunderstorms. Table 2.7.1.5-2 presents estimated maximum precipitation at any point in the project area for various durations and recurrence intervals.

2.7.1.6 Atmospheric Stability - Based on the input parameters of solar altitude, cloud cover, ceiling height and wind speed, atmospheric stability can be classified into several categories. The closest NWS stations with available long-term atmospheric records from which stability conditions can be estimated are Scottsbluff and Chadron, [located about 85 km (53 mi) southeast of the site], Nebraska, and Rapid City, South Dakota. The percent frequencies of the various stability conditions for these three locations are presented in Table 2.7.1.6-1. The data indicate that stability conditions contributing to good dispersion conditions (generally Pasquill classes A through D) occur more than 65 percent of the time at all three stations.

2.7.2 Existing Air Quality

2.7.2.1 Air Quality Standards - The project area is located in the Black Hills-Rapid City and the Wyoming Intrastate AQCR's (Air Quality Control Regions). Both of these AQCR's are classified as Priority III for sulfur dioxide, nitrogen dioxide, carbon monoxide, photochemical oxidants, hydrocarbons, and particulate matter.[17] This means that existing pollutant levels within these AQCR's are currently below Federal secondary standards for these six criteria pollutants. Federal ambient air quality standards are presented in Table 2.7.2.1-1, South Dakota and Wyoming ambient standards in Tables 2.7.2.1-2 and 2.7.2.1-3, respectively.

In addition to ambient standards, Federal laws on the PSD (Prevention of Significant Deterioration) establish ambient increments (Table 2.7.2.1-4) to protect areas with air quality cleaner than minimum national standards.[18] The project area is presently designated as Class II with respect to significant deterioration. These laws specify both conditions under which major new sources or major source modifications must undergo a PSD preconstruction review and those pollutants for which the source is subject to meeting best available control technology. Because of the uncertainties presently associated with the Environmental Protection Agency's implementation of these laws, it has not been determined whether the Edgemont project will be required to undergo a PSD preconstruction review.

Table 2.7.1.5-1

Annual Extreme - Estimated Fastest Mile Wind Speeds

9.1 Meters (30 Feet) Above Ground Level

For the Edgemont Area[13]

Recurrence Interval (Years)	Wind Speed (m/s)	Wind Speed (mi/h)
2	26.8	60
10	32.6	73
25	35.8	80
50	38.4	86
100	41.1	92

Table 2.7.1.5-2

Estimated Maximum Point Precipitation in Millimeters (Inches)

For Selected Durations and Recurrence Intervals

For the Edgemont Area[14,15]

Duration	2 Years	10 Years	25 Years	50 Years	100 Years
1 hour	25 (1.0)	43 (1.7)	50 (2.0)	58 (2.3)	66 (2.6)
12 hours	40 (1.6)	68 (2.7)	78 (3.1)	88 (3.5)	101 (4.0)
24 hours	48 (1.9)	76 (3.0)	88 (3.5)	101 (4.0)	114 (4.5)
2 days	53 (2.1)	83 (3.3)	99 (3.9)	114 (4.5)	124 (4.9)
7 days	71 (2.8)	109 (4.3)	127 (5.0)	149 (5.9)	162 (6.4)
10 days	81 (3.2)	119 (4.7)	142 (5.6)	152 (6.0)	177 (7.0)

Table 2.7.1.6-1

Percent Frequency Distributions of Pasquill Stability Classes

For Rapid City, South Dakota, and Scottsbluff and Chadron, Nebraska[8,9,16]

Stability Class	Percent Rapid City (1959-1968)	 Scottsbluff (1948-1975)	 Chadron (1948-1954)
A (extremely unstable)	0.3	0.9	0.5
B (unstable)	4.1	5.4	5.1
C (slightly unstable)	9.7	9.9	9.7
D (neutral)	54.8	52.9	55.1
E (slightly stable)	14.7	15.4	11.6
F (stable)	11.7	11.1	10.1
G (extremely stable)	4.6	4.4	7.1

Table 2.7.2.1-1

Federal Ambient Air Quality Standards[19]

Standard	Carbon Monoxide ($\mu g/m^3$)	Oxidants ($\mu g/m^3$)	Nitrogen Dioxide ($\mu g/m^3$)	Suspended Particulates ($\mu g/m^3$)	Sulfur Dioxide ($\mu g/m^3$)
Primary					
1-hour	40,000	160			
8-hour	10,000				
24-hour				260	365
Annual			100	75[a]	80
Secondary					
1-hour	40,000	160			
3-hour					1,300
8-hour	10,000				
24-hour				150	
Annual			100	60[a]	

a. Annual geometric mean.

Table 2.7.2.1-2

South Dakota Ambient Air Quality Standards[20]

Duration	Carbon Monoxide (ppm)	Photochemical Oxidants (ppm)	Nitrogen Dioxide (ppm)	Soiling Index (COHs/1000 ft)	Suspended Particulates ($\mu g/m^3$)
1-hour	35	0.08	-	-	-
3-hour	-	-	-	-	-
8-hour	9	-	-	-	-
24-hour	-	-	0.10	-	150
7-day	-	-	-	-	-
30-day	-	-	-	-	-
Annual	-	-	0.05	0.2	60[a]

Duration	Hydrocarbons (ppm)	Sulfur Dioxide (ppm)
1-hour	-	-
3-hour	0.24[b]	0.50
8-hour	-	-
24-hour	-	0.14
7-day	-	-
30-day	-	-
Annual	-	0.03

a. Annual geometric mean.

b. Maximum 3-hour concentration.

Table 2.7.2.1-3

Wyoming Ambient Air Quality Standards[21]

Duration	Carbon Monoxide (ppm)	Photochemical Oxidants (ppm)	Nitrogen Dioxide (ppm)	Soiling Index (COHs/1000 ft)	Suspended Particulates ($\mu g/m^3$)	Total Settleable Particulates (g/m^2-month)
1-hour	35	0.08	-	-	-	-
3-hour	-	-	-	-	-	-
8-hour	9	-	-	-	-	-
24-hour	-	-	0.10	-	150	-
7-day	-	-	-	-	-	-
30-day	-	-	-	-	-	5-10[a]
Annual	-	-	0.05	0.4	60[b]	-

Duration	Hydrocarbons (ppm)	Fluorides (ppb)	Sulfur Dioxide (ppm)	Hydrogen Sulfide (ppm)	Total Suspended Sulfate (mg/100 cm^2-day)
1/2-hour	-	-	-	0.05[d]	-
3-hour	0.24[c]	-	0.50	-	-
8-hour	-	1.0	-	-	-
24-hour	-	-	0.10	-	0.5[e]
7-day	-	-	-	-	-
30-day	-	-	-	-	-
Annual	-	-	0.02	-	0.25[e]

a. Includes 1.7 g/m^2 background concentration. The 5 g/m^2-month standard applies to a residential area, the 10 g/m^2-month standard to an industrial area.
b. Annual geometric mean.
c. Maximum 3-hour concentration, 6-9 a.m.
d. To be exceeded only twice per year. A standard of 0.03 ppm is not to be exceeded more than twice within 5 consecutive days.
e. Measured as the sulfation rate by the lead peroxide method.

Table 2.7.2.1-4

Federal Prevention of Significant Deterioration (PSD) Increments[18]

Pollutant	Allowable Increases in Pollutant Concentrations (μg/m³) Over Baseline					
	Class I PSD Increment	Class I PSD Increment Subparagraph C[a] Variance[b]	Class I PSD Increment Subparagraph D[a] Variance[c] Terrain Areas[d] Low	Class I PSD Increment Subparagraph D[a] Variance[c] Terrain Areas[d] High	Class II PSD Increment	Class III PSD Increment
Particulates						
Annual geometric mean	5	19	e	e	19	37
24-hour maximum	10	37	e	e	37	75
Sulfur Dioxide						
Annual arithmetic mean	2	20	2	2	20	40
24-hour maximum	5	91	36	62	91	182
3-hour maximum	25	325	130	221	512	700

a. Conditions for receiving variance specified under Clean Air Act Amendments, 1977.

b. Variance must be approved by Federal land manager.

c. Concentrations up to limits of variance permitted only on 18 days/year. Variance must be approved by governor and Federal land manager or President.

d. The division between high and low terrain is 900 feet above the stack.

e. Not applicable for particulates.

2.7.2.2 Existing Air Quality - There are no existing air quality data available for the immediate project area. However, official monitoring station data on total suspended particulates are available for communities in the general region (Table 2.7.2.2-1). The data show a wide range of concentrations for the different locations and, in some cases, for different years at each location, e.g., a high annual geometric mean of 88 μg/m³ at Gillette during 1972, a low annual geometric mean of 31 μg/m³ at Gillette during 1974. Background particulate levels in the region are highly variable and depend on a large number of factors, such as wind speed, amount of vegetation, soil type, topsoil moisture, and the number and type of anthropogenic sources. The higher concentrations reported at stations like Gillette, Douglas, and Hot Springs may be due to some extent to differences in anthropogenic source activities, such as transportation, construction, and energy production. Background concentrations of other criteria pollutants (sulfur dioxide, hydrocarbons, hydrogen sulfide, total reduced sulfur, photochemical oxidants, nitrogen dioxide, and carbon monoxide) are all expected to be very low in the project area because of the low population density and lack of industrial development.

2.7.3 Air Quality Impacts

2.7.3.1 Sources of Air Pollution - Nonradiological gaseous emissions will result from the combustion of fossil fuels by mining equipment and support vehicles used in the surface and underground mining operations. Lists of the number, type, and probable operation schedules of major fossil-fueled equipment that could be used for this project are presented in Tables 1.1.2.1-1 and 1.1.2.2-1. The estimated total fuel consumption by these vehicles is approximately 7,840 l (2,070 gal) of No. 2 diesel fuel per day. Of this total, 2,540 l (670 gal) per day will be used by the underground equipment and 3,090 l (815 gal) per day will be used by the surface support equipment associated with the initial shaft at the Burdock underground mine: The remaining 2,220 l (585 gal) per day will be used in the various surface mining operations. On-highway support equipment (approximately 40 vehicles) are expected to consume approximately 325 l/day (85 gal/day) of gasoline. Additional fuels will be consumed for building, office, and shaft heating. These heaters will only be operated in the colder months, as weather conditions require.

Because of the limited operation of shop and office heaters, their dispersed locations, and their small fuel consumption rates, the nonradiological air quality impact from their operation obviously will be small. Operation of shaft heaters will result in the emission of nonradiological pollutants into the mine ventilation air. These emissions, when added to other underground nonradiological pollutant emissions, must comply with Federal Mine Safety and Health Administration (MSHA) regulations. Maximum MSHA Air Contaminant Standards are presented in Table 2.7.3.1-1.

Emission rates for nonradiological pollutants resulting from the underground and surface mining operations were

Table 2.7.2.2-1

Measured Particulate Concentrations

(Annual Geometric Mean-µg/m^{3})[22,23]

Station Name	1972	1973	1974	1975	1976
South Dakota					
Hot Springs	-	-	-	-	54
Spearfish	-	-	-	23	32
Wyoming					
Douglas	-	59	55	33	-
Gillette	88[a]	36	31	56[b]	-
Irene Ranch	-	-	-	23[c]	-
Moorcroft	-	-	-	51	-
Stoddard Ranch	-	-	-	16[d]	-
Torrington	-	20[e]	27	24	-

a. Only data from the last 6 months of 1972 are included.
b. Only data from the first 9 months of 1975 are included.
c. Only data from the first 8 months of 1975 are included.
d. Only 6 months of data are included.
e. Only data from the last 4 months of 1973 are included.

Table 2.7.3.1-1

MSHA Air Contaminant Standards[25]

Pollutant	8-Hour Time-Weighted Averages[a]
Nuisance Particulates	10 mg/m^3
Sulfur Oxides	13 mg/m^3
Carbon Monoxide	55 mg/m^3
Nitrogen Oxides	9 mg/m^3

a. These concentrations represent the maximum allowable 8-hour time-weighted average airborne concentrations to which workers can be exposed. These standards consist of the threshold limit values (TLV's) established for chemical substances in workroom air, adopted by the American Conference of Governmental Industrial Hygienists in 1973.

calculated for the equipment listed in Tables 1.1.2.1-1 and 1.1.2.2-1. These emission rates were calculated using emission factors developed by the EPA (Environmental Protection Agency)[24] and by considering the anticipated schedules of operation. The estimated emissions are presented in Table 2.7.3.1-2.

The material mined and the interior surfaces of the Burdock underground mine are expected to be wet. Therefore, particulates emitted from this mine are likely to consist primarily of particulates produced from operation of the underground equipment and intermittent operation of the shaft heater(s). The interior surfaces of the Runge East underground mine, however, will be drier and will be watered to reduce particulate releases to the atmosphere.

Fugitive dust will result from surface activities (construction and ore and waste handling and storage) in support of the underground mining operations. Fugitive dust will also be released from travel on roads, development and production of the Spencer-Richardson mine and to a limited extent from the mining of adits in the Darrow pits.

2.7.3.2 Nonradiological Air Quality Impacts

Underground Mining Operations - Information concerning the actual concentrations of nonradiological pollutants in air vented from the mine is limited at this time. Emission estimates have therefore been made based on MSHA air contaminant standards.[25] Table 2.7.3.1-1 presents the maximum allowable 8-hour-time-weighted averages of pertinent nonradiological contaminant concentrations in underground mine air. It can be reasonably assumed that these will be the upper limits of average concentrations in the mine ventilation air at the surface.

Mine ventilation air is expected to be exhausted through the production shafts. Estimated maximum average emission rates for Burdock from each shaft were calculated (for those pollutants listed in Table 2.7.3.1-1) by multiplying the indicated concentrations by the maximum expected flow rate per shaft of 56.6 m^3/s (120,000 ft^3/min). For hydrocarbons, the emission estimate shown in Table 2.7.3.2-1 was used to estimate ambient hydrocarbon concentrations. This is the maximum flow rate anticipated for each shaft at the Burdock underground mine. The Runge East underground mine will be much smaller in size and will have lower release rates. Nonradiological emission rates from the Runge East mine vents, and resulting ambient pollution contributions, should therefore be much smaller than those from the Burdock operation. The underground mining in the existing Darrow Pits will be limited to adits along ore trends at the bottom of the pits. Nonradiological emission rates from this mining, and resulting ambient pollution contributions, should also be much smaller than those from the Burdock operations. Therefore, only impacts from the Burdock operation are assessed in any further detail. Estimated maximum emission rates of nonradiological pollutants from the Burdock underground mine are presented in Table 2.7.3.2-1.

Table 2.7.3.1-2

Estimated Vehicular Emissions[24] From Mining Equipment[a]

Pollutant	Emissions					
	Burdock Underground Mine (Initial Shaft)				Spencer-Richardson Surface Mine[b]	
	Underground Equipment[b]		Surface Support Equipment[b]			
Particulates	.12 g/s	2.0 tons/yr	.15 g/s	1.2 tons/yr	.27 g/s	2.1 tons/yr
Sulfur Oxides	.17 g/s	2.8 tons/yr	.21 g/s	1.7 tons/yr	.29 g/s	2.2 tons/yr
Carbon Monoxide	.49 g/s	8.1 tons/yr	.63 g/s	10.4 tons/yr	1.0 g/s	7.7 tons/yr
Nitrogen Oxides	2.55 g/s	42.1 tons/yr	3.23 g/s	53.3 tons/yr	4.0 g/s	31.3 tons/yr
Hydrocarbons	.17 g/s	2.8 tons/yr	.20 g/s	1.6 tons/yr	.37 g/s	2.9 tons/yr

a. Emissions due to diesel fuel consumption.

b. Emissions given in grams per second are for those periods when vehicles are operating. The tons-per-year figures reflect the schedule of operations for the year.

Table 2.7.3.2-1

Estimated Maximum Average Nonradioactive Burdock Production Shaft Emission Rates[a]

Pollutant	Emission Rate Each Vent
Particulates	.56 g/s
Sulfur Oxides	.72 g/s
Carbon Monoxide	3.10 g/s
Nitrogen Oxides	.51 g/s
Hydrocarbons	.17 g/s

a. During operation of fossil-fueled equipment.

Estimates of maximum short-term nonradiological ambient contributions at selected distances from each underground mine shaft release were determined by assuming various combinations of conservative meteorological circumstances. Consideration was given to equipment operating schedules (16 hours per day, 5 days per week) in selecting appropriate atmospheric stabilities for the 8-hour and 24-hour averaging periods.

The estimated maximum shaft emission rates (Table 2.7.3.2-1) were used as input to a standard short-term diffusion equation.* Calculations were made for selected distances from each shaft and for conservative meteorological conditions in accordance with the preceding paragraph. Resultant concentrations (above background levels) were compared with the most stringent Federal and state short-term ambient standards (Table 2.7.3.2-2). These comparisons show that the maximum short-term concentrations at each selected distance should be much less than short term standards.

At project boundaries and beyond, ambient nonradiological contributions due to shaft emissions are expected to be less than allowable Class II significant deterioration increments.

Annual average ambient concentrations were estimated for nonradiological shaft emissions (Table 2.7.3.2-1) using a sector average straight-line model.[26] The onsite meteorological information shown in Table 2.7.1.4-2 combined with D stability, was used to estimate annual average nonradiological ambient pollutant concentrations. The ambient annual average concentration estimates shown in Table 2.7.3.2-2 represent, for selected distances, the maximum concentration values expected to result from production shaft releases. These results indicate that annual average concentrations can be expected to stay well below Federal and state annual ambient standards (see Table 2.7.3.2-3).

Ambient concentrations resulting from the combustion of fuel from the underground mine surface support equipment were not estimated because of the limited number of vehicles operating above ground, their dispersed locations while in operation, and their less frequent operation. Because of these factors, the degradation of the ambient air quality resulting from the combustion of fossil fuel by the surface equipment will be so small that further discussion of their impact is not considered warranted.

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*Turner's equation 3.1[26] is used for short-term estimations of ambient concentrations (1-, 3-, 8-, and 24-hour averaging periods). A sector averaging diffusion equation was used to estimate 24 hour ambient concentrations.[26]

Table 2.7.3.2-2

Calculated Maximum Short-Term Ambient Contributions of Nonradiological Pollutants At Select Distances Downwind From Each Production Shaft[a]

Pollutant	Maximum Contribution ($\mu g/m^3$) at Select Downwind Distances From Shaft Release				Most Stringent Short-Term Ambient Standards		Short-Term Significant Deterioration Increment[b]
	1000 m	2000 m	3000 m	5000 m	Federal $\mu g/m^3$	State[c] $\mu g/m^3$	$\mu g/m^3$
Particulates							
(24-hour average)	29	9.3	4.8	2.2	150	150	37
Sulfur Dioxide							
(3-hour average)	251	85	48	23	1,300	1,300	512
(24-hour average)	27	12	6.2	2.8	365	365	91
Carbon Monoxide							
(1-hour average)	1,278	443	243	117	40,000	40,000	None
(8-hour average)	985	342	187	91	10,000	10,000	None
Nitrogen Dioxide							
(24-hour average)	26	8.3	4.3	2.0		250	None
Hydrocarbons							
(3-hour average)	59	20	12	5.4		160	

a. For 1-, 3-, and 8-hour concentration calculations, emissions from the mine shafts were assumed to diffuse according to Turner's equation 3.1.[26] Estimates of 24-hour average ambient pollutant concentrations are based on application of a standard sector-averaged diffusion equation.[26] Emissions were assumed to occur at ground level.

b. Allowable increase over baseline for Class II areas.

c. South Dakota standards (table 2.7.2-2).

Table 2.7.3.2-3

Calculated Maximum Annual Average Ambient Contributions of Nonradiological Pollutants At Select Distances Downwind From Each Underground Mine Production Shaft[a]

Pollutant	Maximum Contribution ($\mu g/m^3$) at Select Downwind Distances From Shaft Release[c]				Standards		Significant Deterioration Increments[b]
	1000 m	2000 m	3000 m	5000 m	Federal $\mu g/m^3$	State $\mu g/m^3$	$\mu g/m^3$
SO_2	5.9	4.5	2.1	1.1	80	80	20
NO_2	4.3	3.2	1.6	0.8	100	100	None
Particulates[a]	4.5	3.5	1.6	0.8	60[a]	60[a]	19[a]
CO					No annual standards		
Hydrocarbons					No annual standards		

a. Particulate concentrations were calculated as annual arithmetic means. Federal and state ambient particulate standards are listed as annual geometric means. The annual arithmetic mean will always be larger than or equal to the annual geometric mean.

b. Allowable increase over baseline for Class II areas.

c. The indicated pollutant concentrations represent the average concentration values expected to result from production shaft releases. These concentration estimates are based on 1 year of onsite meteorological measurement, and an assumed E stability.

fugitive dust releases from surface activities around the underground mines are discussed later in this subsection.

Surface Mining Operations - The largest nonradiological air quality impacts expected from surface operations will be at the Spencer-Richardson mine, the only proposed surface mine. However, these impacts will be limited to only about a 6-month period of mining activity. Consequently, air quality impacts from this operation will be of short duration. Estimations of maximum nonradiological air quality impacts at select distances for surface mining are conservatively based on emissions from the limited Spencer-Richardson operation.

In determining emission rates from the Spencer-Richardson mining operation, consideration was given to emissions from the fossil-fueled surface mining equipment (Table 2.7.3.1-2). For calculational purposes, it was assumed that all of the equipment anticipated for all of the surface mining operations will be used in the Spencer-Richardson operation. Fugitive dust was not considered in the source term for particulates in the impact calculation because of the difficulty in obtaining a quantitative release rate with the presently limited preoperational information. However, potential fugitive dust sources will be monitored and controlled as necessary to minimize any impact. A discussion of potential fugitive dust sources is presented in the latter part of this subsection.

The estimated maximum emission rates for this surface mining operation (Table 2.7.3.1-2) were used as input to a standard short-term area source dispersion equation.[26] From preoperational information, it was estimated that most of the emissions would emanate from an area about 300 m (984 ft) on a side. Calculations were made for the meteorological conditions specified in the succeeding paragraph, and resulting concentrations compared with Federal and state air quality standards and PSD standards (Tables 2.7.3.2-4 and 2.7.3.2-5).

It is anticipated that surface mining activities at the Spencer-Richardson mine will be conducted 8 hours per day, 5 days per week over a 6-month period. This operating schedule was assumed in determining the conservative meteorological conditions to use in the nonradiological ambient impact calculations. Since all of the surface mining is during daylight hours, a D-stability was chosen for short-term and annual average ambient impact calculations. For comparison with 1-, 3-, 8-, and 24-hour standards, D-stability was combined with a wind speed of 1 m/s (2.2 mi/h), and a persistent wind direction for ambient contribution estimates at selected distances from the area source. For comparison with annual standards, D-stability and the onsite wind information shown in Table 2.7.1.4-2 was used to estimate annual ambient concentrations for selected downwind distances. All nonradiological releases from surface mining operations were assumed to be ground-level.

The estimated short-term and annual-average ambient contributions presented in Table 2.7.3.2-4 and Table 2.7.3.2-5, respectively, indicate that ambient pollutant concentrations can

Table 2.7.3.2-4

Calculated Maximum Short-Term Contributions of Air Pollutants At Select Distances Downwind From the Spencer-Richardson Surface Mining Operation[a]

Pollutant	Maximum Contribution ($\mu g/m^3$) at Select Downwind Distances From Surface Mine 1000 m	2000 m	3000 m	5000 m	Most Stringent Short-Term Ambient Standards Federal $\mu g/m^3$	State[c] $\mu g/m^3$	Short-Term Significant Deterioration Increment[b] $\mu g/m^3$
Particulates							
(24-hour average)	1.5	.8	.5	.3	150	150	37
Sulfur Dioxide							
(3-hour average)	7.4	4.0	2.7	1.4	1,300	1,300	512
(24-hour average)	1.8	1.0	.6	.3	365	365	91
Carbon Monoxide							
(1-hour average)	30.7	15.9	10.8	5.8	40,000	40,000	None
(8-hour average)	21.2	11.7	7.5	4.0	10,000	10,000	None
Nitrogen Dioxide							
(24-hour average)	24.9	13.5	8.7	4.8		250	None
Hydrocarbons	8.9	4.8	3.2	1.7		160	None

a. Emissions from the surface mine were treated as an area source. The dimensions of this area source were defined and a virtual point source determined using methods recommended by Turner.[26] Emissions were assumed to occur at ground level.

b. Allowable increase over baseline for Class II areas.

c. South Dakota standards (table 2.7.2-2).

Table 2.7.3.2-5

Calculated Maximum Annual Average Contributions of Air Pollutants At Select Distances Downwind From the Spencer-Richardson Surface Mining Operation

Pollutant	Maximum Contribution (ug/m^3) at Select Downwind Distances From Surface Release[c]				Standards		Significant Deterioration Increments[b]
	1000 m	2000 m	3000 m	5000 m	Federal $\mu g/m^3$	State $\mu g/m^3$	$\mu g/m^3$
SO_2	0.4	0.2	0.1	.07	80	80	20
NO_2	6.0	3.1	1.9	1.0	100	100	None
Particulates[a]	0.4	0.2	0.1	.07	60[a]	60[a]	19[a]
CO					No annual standard		None
Hydrocarbons					No annual standard		None

a. Particulate concentrations were calculated as annual arithmetic means. Federal and state ambient particulate standards are listed as annual geometric means. The annual arithmetic mean is normally larger than the annual geometric mean.

b. Allowable increase over baseline for Class II areas.

c. The indicated pollutant concentrations represent **average** concentration values expected to result from production shaft releases. These concentration estimates are based on 1 year of onsite meteorological measurement, and an assumed D stability.

be expected to stay far below Federal and state ambient standards. The data presented in these tables also indicate that ambient contributions from the surface mining activities can be expected to be much less than the allowable Class II significant deterioration increments.

Annual-average meteorological conditions were also used in estimating radiological impacts from surface mining operations (Section 2.8.2). Annual-average meteorological assumptions used in radiological impact assessment of underground mine shaft releases are identified in the subsection on underground mining. The meteorology used in the radiological impact estimation consisted of an assumed E stability and the onsite wind information presented in Table 2.7.1.4-2.

<u>Fugitive Dust</u> - Preoperational information on fugitive dust from the planned mining operation is limited. Fugitive dust is expected from four major sources: (1) construction, (2) ore and waste rock storage, (3) vehicular travel on roads, and (4) surface mining.

<u>Construction</u> - Fugitive dust during the project construction phase will be associated with land clearing, ground excavation, cut and fill operations, and equipment traffic over access roads. The EPA has presented an emission factor of 2.7 t/ha/month (1.2 ton/acre/month) for fugitive dust during moderate construction activity.[24] This emission factor was developed from data collected around construction sites in Las Vegas, Nevada, and Maricopa County, Arizona, and is applied to particles less than about 30 μm in diameter.[24] Particles of this size have the potential for remaining airborne beyond project boundaries.

Surface construction activities for this project are expected to be less extensive than those for which this emission factor was developed and to be of short duration (about 6-9 months). In addition, overburden removal activities which have a potential to release substantial amounts of fugitive dust are already 70 percent complete at the Spencer-Richardson mine. The total anticipated surface disturbance for all new mine sites over the life of the mining operation will be about 35 ha (90 acre). An effective mitigation program is estimated to reduce construction-related fugitive dust by up to 50 percent.

<u>Unpaved Roads</u> - On the average, fugitive dust from unpaved roads with no mitigation applied have the following particulate size characteristics:

Particle Size Diameter	Weight Percent
$<$ 30 μm	60
$\geq$ 30 μm but $<$ 100 μm	40

Particles larger than 100 μm are not considered in fugitive dust estimations from unpaved roads. Studies indicate that with mean wind speeds of 4.4 m/s (10 mi/h) or less, [24] these particles are likely to settle out within 6 to 9 m (20-30 ft) from the edge of the road. Particles with diameters in the 30 to 100 μm range are likely to settle out within a few hundred feet

of the road depending on atmospheric turbulence. Thus, only about 60 percent of the fugitive dust from uncontrolled roads has a potential of remaining suspended. The fugitive dust will be carried away and dispersed by turbulent mixing. Resultant impacts are expected to be relatively minor and localized.

Based on EPA-recommended procedures for estimating fugitive dust from unpaved roads,[24] the estimated emission factor for vehicle travel on unpaved roads in the project area is about 3.30 kg/vehicle-km (11.72 lb/vehicle-mi). Approximately 1.98 kg/vehicle-km (7.03 lb/vehicle-mi) is expected to remain suspended.

It is estimated that chemical treatment or frequent watering of unpaved roadways can reduce fugitive dust by up to 50 percent.[24] Continuous watering of frequently traveled roads will be performed as ground and weather conditions require. Thus, the expected fugitive dust emission rates presented in the preceding paragraph will be substantially reduced, and resultant impacts should not be significant.

Ore and Waste Rock Storage - Fugitive dust associated with ore and waste rock storage piles can be divided into the contributions of several distinct source activities: (1) loading onto storage piles, (2) equipment traffic in storage areas, (3) wind erosion, and (4) loadout of ore and waste rock for processing or transportation. Approximate percentages of the total ore and waste rock storage dust emissions for each of these four activities are 12, 40, 33, and 15 percent, respectively.[24] Using EPA recommended procedures, an emission factor for fugitive dust of 0.66 kg/t (1.63 lb/ton) of ore and waste rock placed in storage was estimated for the project area.

Topsoil storage piles associated with the project will be seeded to prevent wind erosion (see Section 3.5). Initially, mined ore for the most part will be moist, so dust control during loading operations should not be necessary. However, sprinkling will be provided to prevent dust releases from ore and waste rock storage piles, if conditions warrant such action. The potential for dust in the storage areas from equipment traffic will be controlled by watering as ground and weather conditions require.

2.7.3.3 Air Pollution Control - Control methods for nonradiological air pollutants applicable to this project will depend primarily on the types or combinations of mining methods chosen. The primary pollutant caused by surface activity is likely to be fugitive dust. This problem will be mitigated to a large extent by revegetation of waste dumps, stockpiles and other disturbed areas and by watering of haulage roads as weather and ground conditions require. Combustion emissions from above-ground vehicles are regulated by EPA. Applicable emission standards depend on the year of vehicle manufacture.

Emissions from diesel engines used in underground mining and the operation of shaft heaters will be controlled in order to maintain underground pollutant concentrations below applicable MSHA standards (Table 2.7.3.1-1). The amount of fugitive dust

generated by underground operations depends to a large extent on the moisture content of the material to be mined. High moisture contents are expected in the Burdock mine, so fugitive dust amounts released from underground shafts should be small. As previously mentioned, lower moisture contents are expected in the Runge East underground mine, so some fugitive dust may be released through its mine shafts. However, these amounts should also be small because of the limited nature of the Runge East operation.

2.7.3.4 Cumulative Project Air Quality Impacts - Nonradiological air quality impacts from simultaneous operation of the underground and surface projects will primarily result from fugitive dust attributed to surface mining, vehicular travel on largely unpaved roads, and wind erosion of stockpiles, waste piles, and disturbed lands. With the planned mitigation, fugitive dust impacts can be held to a minimum and should only result in a small impact on the project area's air quality. Nonradiological air emissions from fossil-fuel combustion will also result in some degradation of the local air quality. However, cumulative concentrations from all mining operations should stay well within Federal and state ambient air quality standards because the sources are small, will be widely dispersed, and will have different release characteristics. Increased turbulence associated with the intervening topography is also expected to reduce additive concentrations.

2.7.4 - Nonradiological Air Quality Monitoring - An air quality monitoring program will be performed at the mining site to conform with the requirements of the appropriate regulatory agencies. What is considered to be an adequate monitoring program is described below. However, the actual program would differ somewhat based upon the requirements of the regulatory agencies. Additional monitoring will be carried out as necessary.

At least one year prior to ore production, air quality monitoring will commence to establish background concentrations for particulates. The monitoring station will be maintained by the mine operator and will consist of a high-volume sampler collecting 24-hour samples once every 6 days. A site-specific meteorological facility, located at the old mill site in Edgemont, is presently collecting wind speed, wind direction, temperature, relative humidity, and precipitation information. The air quality monitoring station will be located in such a manner as to preclude significant interference from mine development activities.

Operational air quality monitoring will be conducted at locations where the maximum particulate impact from the mining project is expected. The preproduction information will be analyzed to determine the number of monitoring stations required for the operational program.

Samples from the high-volume monitors will be analyzed for particulate mass. Analysis for radionuclide concentrations are discussed in Section 2.8.3.

Results of the operational monitoring program will be evaluated periodically to determine if changes in the program are appropriate.

2.7 References

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2.8 Radiological

2.8.1 Description of the Existing Environment - Sampling of environmental media for background radioactivity levels was begun in July 1975. Samples of surface and ground waters, sediment, soil, and vegetation have been taken in various seasons of the year and returned to TVA's Radioanalytical Laboratory for analysis. These data establish a baseline on the distribution of background radioactivity in the environment within the project area and may be used in determining the impact of mining operations on the environment. The results from samples collected to date are listed in Tables 2.8.1-1 through 2.8.1-5.

Uranium concentrations were determined by fluorimetry and thorium concentrations (reported as thorium-230) were determined by chemical separation of thorium followed by alpha counting. Beginning in May 1976, radium-226 concentrations were determined by the radon emanation technique.

The available results for bismuth-214 and those results for radium-226 obtained through the use of gamma spectroscopy must be viewed and used with caution. These results were determined by use of gamma scans using lithium-drifted germanium detector systems. The interpretation of a gamma spectrum from such a gamma scan, to identify and quantify some of the uranium isotopes and their progeny, is extremely difficult because of the presence of overlapping peaks. To obtain the reported values, radium-226 was considered to be in equilibrium with bismuth-214 when each of the spectra was interpreted. Consideration also must be given to potential contributions by background and other radionuclides to the reported radium and bismuth concentrations.

2.8.2 Radiological Impacts - Atmosphere - Small amounts of radioactive materials will be released to the atmosphere as a result of mining operations. These releases will result in small exposures to man and other biota from both external and internal sources. Doses from external sources include doses from submersion in gaseous effluent and doses from exposure to soil on which very small amounts of radioactive material have been deposited. Doses to area organisms from radionuclides deposited internally are believed to be larger than the doses from external sources of radiation. These internal exposures result primarily from radionuclides ingested with food and from the inhalation of airborne radioactivity. Taking into consideration the land use characteristics in the project area and the belief that radionuclides such as radium and lead do not concentrate in plants, doses from the inhalation of airborne radioactivity are likely to be the highest doses which organisms in the area will receive.

Underground mining in the saturation zone will be performed at the Burdock mine; therefore, a high water content in the mined material may be expected. This high moisture content is likely to result in minimal particulate generation. Consequently, effluent releases of radioactive materials associated with particulates from the mining operation may be expected to be very small. However, even if appreciable quantities of particulates were generated, dilution of the original concentrations by the large volume of ventilating air and by natural dispersion in the atmosphere would be expected to result in concentrations at the

Table 2.8.1-1

Radioactivity Levels - Edgemont Project Area

Ground Water (Dissolved Activity)

Sampling Location	Date Collected	Gross α pCi/ℓ	Gross β pCi/ℓ	Natural U μg/ℓ	^{230}Th pCi/ℓ	^{226}Ra Dissolved pCi/ℓ	^{226}Ra Suspended pCi/ℓ	^{210}Pb pCi/ℓ	^{210}Po pCi/ℓ
Francis Peterson Ranch Well	8/16/76	-	-	2.29	0.02 ± 0.07[a]	2.55 ± 0.03			
Burdock Site (Lakota)	8/16/76	-	-	1.12	0.84 ± 0.16	1.55 ± 0.02			
Burdock Well B-1	11/12/76	-	-	0.87	1.1 ± 0.2	0.55 ± 0.03			
(Fall River)	4/27/77	-	-	0.25	0.04 ± 0.07	0.43 ± 0.03		b	b
	7/21/77	-	-	0.25	0.3 ± 0.2	0.91 ± 0.04			
	11/15/77	-	-	0.41	0.4 ± 0.1	0.35 ± 0.03			
Burdock Well B-2	11/12/76	-	-	9.49	0.5 ± 0.1	133.2 ± 0.4			
(Lakota)	4/27/77	-	-	0.32	0.06 ± 0.07	80.6 ± 0.3			
	7/21/77	-	-	0.19	0.05 ± 0.10	33.2 ± 0.2		c	33.2 ± 0.2
Burdock Well # 1	2/08/77 (Start of Pump Test)	89.9 ± 8.7	75.7 ± 4.7	6.39	0.2 ± 0.08	111.4 ± 0.4			
	2/21/77 (During Pump Test)	169.9 ± 14.9	94.0 ± 9.6	8.20	0.2 ± 0.09	222.4 ± 0.5			
	2/25/77 (end)	113.8 ± 8.9	84.5 ± 4.9	7.29	0.2 ± 0.09	226.6 ± 0.6			
	4/27/77	76.7 ± 5.9	54.9 ± 2.8	0.51	-0.04 ± 0.04[d]	159.3 ± 0.4		b	b
	7/21/77	-	-	0.10	0.1 ± 0.1	230.1 ± 0.6			
	11/14/77 (Start of Pump Test)	178.9 ± 9.7	133.6 ± 4.1	7.49	0.2 ± 0.1	189.8 ± 0.5	0.64 ± 0.004		
	11/14/77 (3 Hours After Start)	204.0 ± 10.3	154.8 ± 4.5	9.50	0.02 ± 0.06	204.6 ± 0.5	0.70 ± 0.004		
	11/17/77 (End of Pump Test)	377.2 ± 14.8	56.7 ± 3.6	5.85	0.9 ± 0.2	183.0 ± 0.5	0.56 ± 0.004		
Holding Pond for Burdock	4/27/77	10.6 ± 2.5	26.2 ± 1.8	5.46	0.4 ± 0.1	29.95 ± 0.20			
Well # 1	7/21/77	-	-	5.00	0.04 ± 0.06	4.31 ± 0.08		b	b
	11/17/77 (After Pump Test)	141.8 ± 9.0	49.0 ± 3.0	4.66	1.15 ± 0.17	83.7 ± 0.3	30.0 ± 0.2		
Miles Spencer Ranch Well	4/27/77	-	-	0.08	0.04 ± 0.07	1.87 ± 0.05			
Preston Richardson Ranch Well	4/27/77	-	-	0.16	0.01 ± 0.07	4.42 ± 0.08			
Wayne Peterson Ranch Well	4/27/77	-	-	1.00	-0.01 ± 0.06[d]	2.97 ± 0.06			
Glen Peterson Ranch, Well D-27	4/27/77	-	-	0.48	0.13 ± 0.08	10.36 ± 0.12			
(Lakota)	11/15/77	-	-	0.43	0.10 ± 0.08	9.61 ± 0.11			
Glen Peterson Ranch, Well D-26 (Fall River)	4/27/77	-	-	0.06	0.11 ± 0.08	1.08 ± 0.04			
	11/15/77	-	-	0.11	0.70 ± 0.14	2.95 ± 0.07			
Well D-11	11/15/77	-	-	0.32	0.23 ± 0.09	1.37 ± 0.04			
Well D-17	11/15/77	-	-	1.83	0.28 ± 0.10	2.08 ± 0.05			
Well D-19	11/15/77	-	-	4.00	0.22 ± 0.09	1.73 ± 0.05			
Darrow Well	11/15/77	-	-	5.68	0.28 ± 0.10	97.25 ± 0.35			

a - The error reported is the 1-sigma counting error.
b - Insufficient sample.
c - Sample lost during analysis.
d - Negative value is an artifact of counting statistics and does not infer a negative activity.

Table 2.8.1-2

Radioactivity Levels - Edgemont Project Area - Soil[a]

Sampling Location	Date Collected	Gross α pCi/g	Gross β pCi/g	Natural U μg/g	^{230}Th pCi/g	^{226}Ra pCi/g	^{214}Bi[c] pCi/g	^{137}Cs[c] pCi/g	^{210}Pb pCi/g	^{210}Po pCi/g
Burdock, Southeast; East Central Section 11	7/31/75	0.6 ± 0.1[b]	5.2 ± 0.2	-	-	1.11 ± 0.04[c]	1.0 ± 0.04	0.1 ± 0.01	-	-
	5/5/76	6.9 ± 0.8	-	2.98	3.6 ± 0.4	0.74 ± 0.02	1.3 ± 0.07	0.9 ± 0.03	-	-
	8/25/76	-	-	1.73	2.3 ± 0.2	0.91 ± 0.03	-	-	-	-
	11/12/76	-	-	2.07	2.9 ± 0.3	1.11 ± 0.03	-	-	-	-
	4/27/77	14.6 ± 1.7	-	2.26	1.8 ± 0.2	1.10 ± 0.03	-	-	-	-
	7/21/77	-	-	6.33	1.1 ± 0.2	1.30 ± 0.03	-	-	5.2 ± 0.4	2.9 ± 0.3
	11/15/77	-	-	4.08	0.08 ± 0.08	1.35 ± 0.03	-	-	10.8 ± 0.6	5.2 ± 0.4
Burdock, West; North Central Section 15	5/5/76	7.3 ± 0.8	-	2.67	0.6 ± 0.2	0.85 ± 0.03	0.9 ± 0.03	0.3 ± 0.01	-	-
	8/25/76	-	-	4.42	3.8 ± 0.3	1.36 ± 0.03	-	-	-	-
	11/12/76	-	-	1.82	2.0 ± 0.2	1.09 ± 0.03	-	-	-	-
	4/27/77	10.9 ± 1.5	-	2.07	0.8 ± 0.2	1.03 ± 0.03	-	-	-	-
	7/21/77	-	-	2.34	0.0 ± 0.06	1.35 ± 0.03	-	-	6.7 ± 0.4	4.0 ± 0.3
	11/15/77	-	-	2.40	0.2 ± 0.1	0.71 ± 0.02	-	-	5.6 ± 0.5	5.6 ± 0.3
Pit # 6 Area; Northeast Section 2	5/5/76	8.1 ± 0.9	-	4.78	2.3 ± 0.3	2.15 ± 0.04	1.8 ± 0.07	0.9 ± 0.03	-	-
	8/25/76	-	-	0.64	2.3 ± 0.2	1.08 ± 0.03	-	-	-	-
	11/12/76	-	-	1.50	1.9 ± 0.2	1.07 ± 0.03	-	-	-	-
	4/27/77	24.6 ± 2.1	-	2.35	3.0 ± 0.3	3.20 ± 0.05	-	-	-	-
	7/21/77	-	-	5.36	2.3 ± 0.3	2.07 ± 0.04	-	-	56.7 ± 2.9	14.9 ± 2.7
	11/15/77	-	-	4.37	0.2 ± 0.1	1.81 ± 0.04	-	-	8.9 ± 0.6	10.5 ± 0.4
Runge, East; Central Section 31	5/5/76	4.9 ± 0.7	-	2.94	0.1 ± 0.1	0.97 ± 0.03	1.4 ± 0.05	1.2 ± 0.03	-	-
	8/25/76	-	-	2.70	0.4 ± 0.1	1.55 ± 0.03	-	-	-	-
	11/12/76	-	-	1.86	1.6 ± 0.2	1.38 ± 0.03	-	-	-	-
	4/27/77	9.5 ± 1.4	-	2.28	2.1 ± 0.2	1.97 ± 0.04	-	-	-	-
	7/21/77	-	-	3.11	1.4 ± 0.2	1.37 ± 0.03	-	-	14.1 ± 0.7	11.3 ± 1.2
	11/15/77	-	-	2.46	0.05 ± 0.08	1.30 ± 0.03	-	-	4.7 ± 0.5	3.5 ± 1.2
Burdock Mill # 1 (West)	11/15/77	-	-	2.41	0.03 ± 0.08	0.74 ± 0.02	-	-	4.7 ± 0.5	4.8 ± 0.2
Burdock Mill # 2 (North)	11/15/77	-	-	1.13	-0.02 ± 0.06[d]	1.00 ± 0.03	-	-	7.4 ± 0.6	6.3 ± 0.3
Burdock Mill # 3 (East)	11/15/77	-	-	3.76	0.11 ± 0.09	1.32 ± 0.03	-	-	4.8 ± 0.5	5.0 ± 0.3
Burdock Mill # 4 (South)	11/15/77	-	-	1.32	0.08 ± 0.08	0.82 ± 0.03	-	-	4.6 ± 0.4	4.9 ± 0.3

a - All results reported on a dry weight basis.
b - The error reported is the 1-sigma counting error.
c - Results obtained by gamma spectroscopy using a Ge(Li) detection system. Analysis for Ra-226 and Bi-214 using this method may produce results which are of questionable reliability.
d - Negative value is an artifact of counting statistics and does not infer a negative activity

Table 2.8.1-3

Radioactivity Levels - Edgemont Project Area
Vegetation[a]

Sampling Location	Date Collected	Gross α pCi/g	Gross β pCi/g	Natural U μg/g	^{230}Th pCi/g	^{226}Ra pCi/g	^{214}Bi[c] pCi/g	^{137}Cs[c] pCi/g
Burdock, Southeast; East Central Section 11	7/31/75	0.01 ± 0.01[b]	10.1 ± 0.1	-	-	0.30 ± 0.05[c]	0.30 ± 0.05	d
	5/5/76	0.5 ± 0.2	-	0.14	0.17 ± 0.02	0.11 ± 0.01	d	0.2 ± 0.03
	8/25/76	-	-	0.22	0.19 ± 0.03	0.28 ± 0.01	-	-
	11/12/76	-	-	e	e	0.08 ± 0.004	-	-
	4/27/77	-	-	0.14	0.19 ± 0.03	0.12 ± 0.01	-	-
	7/21/77	-	-	0.12	0.00 ± 0.01	0.17 ± 0.02	-	-
	11/15/77	-	-	0.15	-0.002 ± 0.004[f]	0.10 ± 0.001	-	-
Burdock, West; North Central Section 15	5/5/76	0.3 ± 0.2	-	0.07	0.13 ± 0.02	0.19 ± 0.01	d	0.2 ± 0.02
	8/25/76	-	-	0.21	0.19 ± 0.03	0.46 ± 0.02	-	-
	11/12/76	-	-	0.05	0.03 ± 0.01	0.15 ± 0.006	-	-
	4/27/77	-	-	0.17	0.01 ± 0.02	0.11 ± 0.01	-	-
	7/21/77	-	-	0.13	0.01 ± 0.01	1.01 ± 0.04	-	-
	11/15/77	-	-	0.13	0.03 ± 0.02	0.05 ± 0.001	-	-
Pit #6 Area; Northeast Section 2	5/5/76	0.9 ± 0.2	-	0.04	0.03 ± 0.01	0.15 ± 0.01	0.6 ± 0.07	0.2 ± 0.02
	8/25/76	-	-	0.03	0.10 ± 0.01	0.65 ± 0.01	-	-
	11/12/76	-	-	e	e	0.14 ± 0.007	-	-
	4/27/77	-	-	0.24	0.05 ± 0.14	0.17 ± 0.01	-	-
	7/21/77	-	-	0.21	0.01 ± 0.01	0.16 ± 0.02	-	-
	11/15/77	-	-	0.17	0.01 ± 0.02	0.22 ± 0.001	-	-

a - All results reported on a dry weight basis.
b - The error reported is the 1-sigma counting error.
c - Results obtained by gamma spectroscopy using a Ge(Li) detection system. Analysis for Ra-226 and Bi-214 using this method may produce results which are of questionable reliability.
d - None detected.
e - Insufficient sample.
f - Negative value is an artifact of counting statistics and does not infer a negative activity.

Table 2.8.1-3 (Continued)

Radioactivity Levels - Edgemont Project Area
Vegetation[a]

Sampling Location	Date Collected	Gross α ρCi/g	Gross β ρCi/g	Natural U μg/g	^{230}Th ρCi/g	^{226}Ra ρCi/g	^{214}Bi[c] ρCi/g	^{137}Cs[c] ρCi/g
Runge, East; Central Section 31	5/5/76	1.0 ± 0.2	-	0.22	0.14 ± 0.02	0.26 ± 0.01	0.8 ± 0.1	0.4 ± 0.04
	8/25/76	-	-	0.02	0.01 ± 0.01	0.07 ± 0.004	-	-
	11/12/76	-	-	e	e	0.10 ± 0.007	-	-
	4/27/77	-	-	0.90	0.15 ± 0.03	0.34 ± 0.01	-	-
	7/21/77	-	-	0.42	0.01 ± 0.01	0.31 ± 0.02	-	-
	11/15/77	-	-	0.54	0.03 ± 0.01	0.24 ± 0.001	-	-
Burdock Mill #1, West	11/15/77	-	-	0.45	0.01 ± 0.01	0.25 ± 0.001	-	g
Burdock Mill #2, North	11/15/77	-	-	0.13	0.03 ± 0.01	0.08 ± 0.001	-	g
Burdock Mill #3, East	11/15/77	-	-	0.31	0.03 ± 0.01	0.10 ± 0.001	-	g
Burdock Mill #4, South	11/15/77	-	-	0.26	0.03 ± 0.01	0.11 ± 0.001	-	g

a - All results reported on a dry weight basis.
c - Results obtained by gamma spectroscopy using a Ge(Li) detection system. **Analysis for Ra-226 and Bi-214 using this method** may produce results which are of questionable reliability.
e - Insufficient sample.
g - Analysis not complete.

Table 2.8.1-4

Radioactivity Levels - Beaver Creek Surface Water (Dissolved Activity)

Sampling Location	Date Collected	Gross Alpha pCi/ℓ	Gross Beta pCi/ℓ	Natural U μg/ℓ	^{230}Th pCi/ℓ	^{226}Ra pCi/ℓ
Beaver Creek at Hwy. 85 Bridge	7-31-75	1.1 ± 1.1[a]	5.5 ± 2.5	-	-	-
	5-5-76	-	-	9.8	0.09 ± 0.15	1.11
	8-25-76	-	-	4.0	0.27 ± 0.11	0.17 ± 0.02
	11-12-76	-	-	8.6	0.05 ± 0.05	0.15 ± 0.02
	4-27-77	-	-	5.4	0.17 ± 0.09	0.20 ± 0.02
	7-21-77	-	-	9.7	0.14 ± 0.08	1.09 ± 0.04
	11-15-77	-	-	5.4	0.17 ± 0.09	0.38 ± 0.03
Beaver Creek at Mouth	5-5-76	-	-	10.5	0.24 ± 0.20	0.05
	8-25-76[b]	-	-	-	-	-
	11-12-76	-	-	9.6	0.63 ± 0.13	0.08 ± 0.02
	4-27-77	-	-	6.1	0.17 ± 0.09	0.36 ± 0.03
	7-21-77	0.3 ± 2.0	40.4 ± 3.8	16.5	0.17 ± 0.09	0.25 ± 0.02
	11-15-77	-	-	4.6	0.12 ± 0.08	0.20 ± 0.02
Beaver Creek Control (Upstream)	5-5-76	-	-	11.3	0.16 ± 0.16	0.08
	8-25-76	-	-	5.1	0.97 ± 0.30	0.20 ± 0.02
	11-12-76	-	-	9.7	1.08 ± 0.17	0.10 ± 0.02
	4-27-77	-	-	7.4	0.24 ± 0.10	0.22 ± 0.02
	7-21-77	-	-	10.9	0.29 ± 0.10	0.31 ± 0.03

a - The error reported is the 1-sigma counting error.

b - Sample lost in transit.

Table 2.8.1-5

Radioactivity Levels - Beaver Creek Bottom Sediment[a]

Sampling Location	Date Collected	Gross Alpha pCi/g	Gross Beta pCi/g	Natural U µg/g	^{230}Th pCi/g	^{226}Ra pCi/g	^{214}Bi[b] pCi/g	^{137}Cs[b] pCi/g	^{210}Pb pCi/g	^{210}Po pCi/g
Beaver Creek at Old Hwy 85 Bridge	7/31/75	0.7 ± 0.1[c]	5.3 ± 0.2	-	-	1.06 ± 0.04[b]	0.93 ± 0.04	1.7 ± 0.01	-	-
	5/5/76	5.4 ± 0.7	-	2.57	0.3 ± 0.2	1.29 ± 0.03	0.75 ± 0.05	0.1 ± 0.02	-	-
	8/25/76	-	-	1.48	1.5 ± 0.2	1.06 ± 0.03	-	-	-	-
	11/12/76	-	-	1.12	2.1 ± 0.2	0.98 ± 0.03	-	-	-	-
	4/27/77	-	-	1.42	0.3 ± 0.1	1.15 ± 0.03	-	-	-	-
	7/21/77	-	-	3.4	-0.05 ± 0.07[d]	0.91 ± 0.03	-	-	-	-
	11/15/77	-	-	0.02	0.8 ± 0.2	0.44 ± 0.02	-	-	3.3 ± 0.4	1.5 ± 0.2
Beaver Creek at Mouth	5/5/76	8.0 ± 0.9	-	2.65	0.06 ± 0.2	1.25 ± 0.03	1.3 ± 0.7	0.6 ± 0.03	-	-
	8/25/76	-	-	2.23	0.4 ± 0.1	1.71 ± 0.04	-	-	-	-
	11/12/76	-	-	0.86	2.6 ± 0.3	0.84 ± 0.03	-	-	-	-
	4/27/77	-	-	0.87	0.2 ± 0.1	1.31 ± 0.03	-	-	-	-
	7/21/77	-	-	4.1	0.5 ± 0.2	2.45 ± 0.05	-	-	-	-
	11/15/77	-	-	0.72	0.2 ± 0.1	0.83 ± 0.02	-	-	5.5 ± 0.5	4.8 ± 0.4
Beaver Creek, Upstream	5/5/76	5.54	-	4.37	0.4 ± 0.3	1.03 ± 0.03	1.4 ± 0.07	0.2 ± 0.03	-	-
	8/25/76	-	-	3.01	0.9 ± 0.2	1.23 ± 0.03	-	-	-	-
	11/12/76	-	-	1.50	2.9 ± 0.3	1.01 ± 0.03	-	-	-	-
	4/27/77	-	-	0.89	0.02 ± 0.07	1.34 ± 0 03	-	-	-	-
	7/21/77	-	-	3.7	0.02 ± 0.08	1.41 ± 0.04	-	-	-	-

a - All results reported on a dry weight basis.
b - Results obtained by gamma spectrometry using a Ge(Li) detection system. Analysis for Ra-226 and Bi-214 using this method may produce results which are of questionable reliability.
c - The error reported is the 1-sigma counting error.
d - Negative value is an artifact of counting statistics and does not infer a negative activity.

project boundary which are insignificant. Because sprinkling will be used as necessary to reduce the potential for dust generation along the main ore transport routes, that potential exposure pathway also should lead to insignificant exposure.

The principal gaseous effluent will be radon-222, resulting from the decay of radium-226, which is an established component of uranium ore. For purposes of calculation, radon-222 and its progeny will be assumed to be vented to the atmosphere from the underground mine exhausts such that the short-lived decay products of radon-222 are present in the following concentrations: ^{218}Po(RaA), 2.0 Bq/l (Becquerel/liter) (5.4×10^{-8} μCi/cm^3); ^{214}Pb(RaB), 1.1 Bq/l (3.0×10^{-8} μ Ci/cm^3); ^{214}Bi(RaC) and ^{214}Po(RaC'), each at 0.78 Bq/l (2.1×10^{-8} μ Ci/cm^3). These decay products are assumed to be released at an approximate composite 50 percent of the secular equilibrium level and are present at a concentration of 0.3 working levels (WL). In this regard one working level may be defined as any combination of short-lived decay products of radon-222 in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of $1.3 \times 10^{+5}$ MeV of alpha-particle energy. The radon-222 concentration in the shaft exhaust then is assumed to be approximately 2.2 Bq/l (6.0×10^{-8} μ Ci/cm^3).

Ventilation characteristics have not been finalized. In accordance with preliminary plans, releases are assumed to be exhausted vertically at a ventilation flow rate of 56.6 m^3/s (2,000 ft^3/s) through each of the first two production shafts (see Figure 1.1.2.1-2). The flow is expected to be continuous (24 hours per day 7 days per week). The total estimated radon-222 emission rate is then approximately 2.5×10^5 Bq/s (6.8 Ci/s) or 2.2×10^{10} Bq/d (0.59 Ci/d).

Two ore stockpiles are expected to be established in the vicinity of each production shaft. Secular equilibrium through radium-226 is assumed for the ore, as is radon-222 flux (Bq/m^2.s) equal to 0.893 times the radium-226 concentration (Bq/g).[4] For purposes of calculation, one ore pile with an average U_3O_8 grade of 0.11 percent and an area of 8640 m^2 is assumed to exist near each production shaft, leading to a conservatively estimated total release from the ore piles of 1.6×10^{10} Bq/d (0.42 Ci/d) of radon-222. This release is assumed to be initially free of the short-lived decay products of radon-222.

Concentrations above background of radon-222 and its short-lived decay products are calculated using the emission information listed above and estimated annual average meteorological conditions (see Section 2.7.3) for the project area of interest in conjunction with a point-source, Gaussian plume model[5] for calculating dispersion of effluents.

Buildup of the short-lived decay products of radon-222 in transit is considered; however, processes for removal of the decay products from the atmosphere are not fully considered. Secular equilibirum values would therefore be calculated at large downwind distances. Such values in composite would probably exceed realistic composite values by a factor ranging from 2 to 5.

Concentrations at specified points of interest near the mining operation at the Burdock mine are presented in Table 2.8.2-1. These locations are generally locations where it is believed that the human occupancy factor is greater than zero; for example, residences. For such locations, indoor concentrations (in WL) and doses are calculated from the listed outdoor concentrations by assuming a ventilation rate of one air change per hour for each residence. Removal processes such as plateout of decay products on furniture are not considered. The calculated disequilibrium conditions (approximately 71 to 96 percent of secular equilibrum values) are therefore expected to exceed realistic disequilibrum conditions (believed to be in the 20 to 50 percent range) by factors ranging from approximately 1.5 to 4.5. The production shaft was used as the reference point for determination of distance and compass sector.

The highest annual average above-background concentration calculated at a known residence is approximately 2.7 x 10^{-4} Bq/l (7.3 x 10^{-12} μCi/cm^3) of radon-222 or approximately 5.6 x 10^{-5} WL of the short-lived decay products. This concentration is less than 1 percent of the maximum permissible concentration (MPC) for radon-222 or is less than 1 percent of MPC for the short-lived decay products of radon-222, as these MPC's are listed in the Code of Federal Regulations, Title 10, Part 20 (10CFR20) for release to unrestricted areas. These MPC's are used here as guidelines in the absence of applicable regulatory limits.

At a project boundary location, the maximum radon concentrations is 1.0 x 10^{-3} Bq/l (2.7 x 10^{-11} μCi/cm^3) or is 1.1 x 10^{-4} WL of the short-lived decay products.

These calculated concentrations can be compared roughly to the approximate average 5.5 x 10^{-3} Bq/l (1.5 x 10^{-10} μCi/cm^3) background concentration for radon-222 or the approximate average 1.0 x 10^{-3} WL background concentration for the short-lived decay products of radon-222.[6] In areas where radon exhalation is naturally high, background concentrations of radon-222 and its short-lived decay products may be significantly in excess of the above figures. The Edgemont area is very likely to be an area with high natural exhalation, and therefore high background concentrations.

Limited data collected for TVA to date suggest that background in the Edgemont, South Dakota, area may be in the range of 1.1 to 3.0 x 10^{-2} Bq/l (3 to 8 x 10^{-10} μCi/cm^3) for radon-222 and 3 to 6 x 10^{-3} WL (outdoors) for the short-lived radon progeny.[7] Limited data collected for the Nuclear Regulatory Commission suggest that appropriate background values for radon-222 may be in the range of 3.0 to 4.4 x 10^{-2} Bq/l (8 to 12 x 10^{-10} μCi/cm^3).[8]

Annual doses to the lungs (segmental bronchi) of adults residing in the project area from the inhalation of radon-222 and its short-lived decay products may be estimated by multiplying the appropriate decay product concentrations by the following dose conversion factors: ^{218}Po (RaA), 16 ram•l/y•Bq (0.6 x 10^9 rem•cm^3/y• μCi); ^{214}Pb(RaB), 27 rem•l/y•Bq (1.0 x 10^9 rem•cm^3/y Ci); and ^{214}Bi(RaC), 46 rem•l/y•Bq (1.7 x 10^3 rem•cm^3/y μCi). The dose conversion factor for ^{214}Po(RaC') is very small in comparison with the above factors. Use of these dose conversion

TABLE 2.8.2-1

RADIONUCLIDE CONCENTRATIONS AND ANNUAL INHALATION DOSES TO BRONCHIAL EPITHELIUM OF LUNGS OF AREA RESIDENTS

Location No.	Distance(m) and Direction[a]		Outdoor Concentrations: Rn-222 Conc. (Bq/l)	Po-218 Conc. (Bq/l)	Pb-214 Conc. (Bq/l)	Bi-214 Conc. (Bq/l)	Rn-222 Decay Product Conc. (WL)[b]	Annual Dose (rem)[c]
1	3,660	N	1.9 (-4)	1.9 (-4)	1.5 (-4)	1.1 (-4)	4.5 (-5)	.015
2[e]	21,300	SE	1.2 (-5)	1.2 (-5)	1.2 (-5)	1.1 (-5)	3.1 (-6)	.001
3	1,770	SSE	2.3 (-4)	2.2 (-4)	1.3 (-4)	8.3 (-5)	4.8 (-5)	.016
4	3,220	SSE	1.1 (-4)	1.0 (-4)	7.3 (-5)	5.2 (-5)	2.4 (-5)	.008
5	1,910	SW	1.3 (-4)	1.3 (-4)	9.3 (-5)	6.6 (-5)	3.0 (-5)	.010
6	3,760	SSW	4.4 (-5)	4.4 (-5)	3.7 (-5)	3.0 (-5)	1.1 (-5)	.004
7[f]	4,180	WSW	5.4 (-5)	5.4 (-5)	4.3 (-5)	3.4 (-5)	1.3 (-5)	.004
8[g]	890	W	1.0 (-3)	9.0 (-4)	4.3 (-4)	2.7 (-4)	1.1 (-4)	.038
9	960	W	8.8 (-4)	7.9 (-4)	3.8 (-4)	2.4 (-4)	1.7 (-4)	.057
10	2,420	W	2.7 (-4)	2.6 (-4)	1.6 (-4)	1.1 (-4)	5.6 (-5)	.019
11	3,960	NW	9.1 (-5)	9.1 (-5)	5.9 (-5)	4.1 (-5)	2.0 (-5)	.007
12	3,360	NNW	1.2 (-4)	1.2 (-4)	7.9 (-5)	5.6 (-5)	2.6 (-5)	.009

Note: (1) Releases from shafts 1 and 2 and the associated ore piles are considered.
(2) 1 Curie (Ci) = 3.7×10^{10} Becquerel (Bq).

a. The reference point used for determining location distances and directions is production shaft number 1.
b. "WL" is working level (see text).
c. Doses to area residents are calculated using radon decay product disequilibrium assumptions which are conservative (see text).
d. 1.9 (-4) = 1.9×10^{-4}
e. City of Edgemont.
f. Lease boundary location; occupancy factor near zero.
g. Burdock School; no longer in use.

factors is believed to result in conservative (e.g., by an order of magnitude) estimates of the inhalation dose rates to the lung. Using these factors, the maximum annual average dose, is approximately 0.019 rem to the lung of an individual continuously occupying the "worst" known residence. The population dose to the lung for the city of Edgemont, with an assumed population of 2000 is estimated to be 2 person-rem. Doses due to natural background concentrations of the radionuclides of interest are likely to be in the range of hundreds of millirem per year and are here assumed to be approximately 0.35 rem/y per individual. The subsequent natural background population dose to the lung for Edgemont is therefore approximately 700 person-rem. The estimated population dose due to mining operations is therefore approximately 0.3 percent of the background lung dose for the nearest population center. If, as previously suggested, the background dose is higher than that estimated, the impact from mining operations would of course be reduced below the 0.3 percent increment.

Note should be made that a significant discrepancy exists between the doses implied by the figures on percentage of maximum permissible concentration and the doses calculated herein. The implied difference is believed to be primarily attributable to the anatomic lung model and the method of lung dosimetry used by the Nuclear Regulatory Commission (NRC) in determining the MPC for radon-222, as compared to the lung model and dosimetry used herein. In general, radon dosimetry is a very complex problem, and presentation of the many factors involved in radon dosimetry is beyond the scope of this statement. However, use of apparent NRC models would reduce the highest calculated doses by approximately a factor of 5.

Calculated concentrations for radon-222 and its short-lived decay products are much less than the maximum permissible concentrations used herein as guidelines. Also, the calculated annual average concentrations are significantly less than the assumed background concentration. The small number of persons continually occupying known residences in the immediate vicinity of the shafts may receive doses which range up to 5 percent of the assumed background dose.

A third production shaft may be sunk at the Burdock mine at some time subsequent to the sinking of the initial production shaft. The postulated location of this third shaft is 760 m (2500 ft) E of the second shaft. Because the location has not been finally determined, an accurate assessment of potential radiological impacts due to mining operations at this shaft site is not possible. However, an assessment was performed, considering releases from the postulated shaft and an adjacent ore pile, with doses determined at the same residence locations previously considered. Source terms for the shaft and ore pile are assumed to be the same as those used for each of the initial production shafts. Results of the calculations are presented in Table 2.8.2-2.

In addition to the Burdock mine, other mining operations are planned for the Edgemont area. Two "underground" mines are the Darrow and Runge East mines, located approximately 4,000 m (13,120 ft) NE and 16.4 km (10.2 mi) ESE of the Burdock No. 1 shaft, respectively. Assuming the same configuration, source

TABLE 2.8.2-2

RADIONUCLIDE CONCENTRATIONS AND ANNUAL INHALATION DOSES TO BRONCHIAL EPITHELIUM OF LUNGS OF AREA

RESIDENTS - POSTULATED RELEASES FROM SHAFT NO. 3

Location No.	Distance(m) and Direction[a]		Outdoor Concentrations: Rn-222 Conc. (Bq/l)	Po-218 Conc. (Bq/l)	Pb-214 Conc. (Bq/l)	Bi-214 Conc. (Bq/l)	Rn-222 Decay Product Conc. (WL)[b]	Annual Dose (rem)[c]
1	3,660	N	4.5 (-5)[d]	4.4 (-5)	2.8 (-5)	2.0 (-5)	9.7 (-6)	.003
2	21,300	SE	4.9 (-6)	4.9 (-6)	4.7 (-6)	4.6 (-6)	1.3 (-6)	.0004
3	1,770	SSE	4.0 (-5)	4.0 (-5)	2.9 (-5)	2.0 (-5)	9.1 (-6)	.003
4	3,220	SSE	3.4 (-5)	3.4 (-5)	2.6 (-5)	1.9 (-5)	7.9 (-6)	.003
5	1,910	SW	3.5 (-5)	3.5 (-5)	2.7 (-5)	2.0 (-5)	8.1 (-6)	.003
6	3,760	SSW	1.8 (-5)	1.8 (-5)	1.6 (-5)	1.4 (-5)	4.5 (-6)	.002
7[f]	4,180	WSW	1.8 (-5)	1.8 (-5)	1.5 (-5)	1.3 (-5)	4.3 (-6)	.001
8[f]	890	W	5.1 (-5)	5.1 (-5)	3.6 (-5)	2.6 (-5)	8.9 (-6)	.003
9[g]	960	W	5.0 (-5)	4.9 (-5)	3.5 (-5)	2.5 (-5)	1.1 (-5)	.004
10	2,420	W	6.7 (-5)	6.7 (-5)	4.7 (-5)	3.4 (-5)	1.5 (-5)	.005
11	3,960	NW	4.1 (-5)	4.1 (-5)	2.8 (-5)	1.9 (-5)	9.1 (-6)	.003
12	3,360	NNW	4.2 (-5)	4.1 (-5)	2.7 (-5)	1.9 (-5)	9.1 (-6)	.003

Note: (1) Release of radon-222 from the assumed ore pile adjacent to shaft No. 3 is also considered.
(2) 1 Curie (Ci) = 3.7×10^{10} Becquerel (Bq).

a. The reference point used for determining location distances and directions is production shaft number 1.
b. "WL" is working level (see text).
c. Doses to area residents are calculated using radon decay product disequilibrium assumptions which are conservative (see text).
d. 4.5 (-5) = 4.5×10^{-5}
e. City of Edgemont.
f. Lease boundary location; occupancy factor near zero.
g. Burdock School; no longer in use.

terms (hence, neglecting particulate generation underground), and meteorology as assumed for one shaft at the Burdock No. 1 mine, potential lung doses incurred by residents due to these mining operations are not expected to exceed 0.007 rem annually. A site identified for surface mining is the Spencer-Richardson site located approximately 4,330 m (14,200 ft) NNE of the Burdock No. 1 mine. No occupied residences have been identified within a 2,000 m (6,560 ft) radius of this site. Doses to occupants of the "worst" known residence near this operation are not expected to exceed approximately 0.008 rem to the lungs, based on release and dispersion characteristics the same as for one shaft at the Burdock No. 1 mine. The lung dose to the population of Edgemont due to all of the additional mining operations is conservatively estimated to be 2.8 person-rem per year; that is, the dose from these operations is likely to be approximately 0.4 percent of the assumed background dose. Based on present estimates of ore reserves, the additional operations are likely to be of short duration; therefore, the estimated dose rates will be applicable only for a short period of time (e.g., less than one year).

Concentrations of radon-222 at receptor locations, resulting from such subsequent underground operations as may be scheduled, would not be expected to exceed those concentrations calculated for the first operation, assuming that effluent concentrations do not exceed the concentrations assumed herein and that venting configurations would be similar.

> Note: Preliminary calculations were made to estimate doses from ingestion of beef and vegetables contaminated with the daughter products of radon-222. For the locations previously considered, the highest doses were found at the unoccupied project boundary location. These hypothetical doses were 0.0026 rem/y to bone and 0.0025 rem/y to kidney via the ingestion pathway. Doses to other organs were smaller than the above numbers. Considering the magnitude of these doses in comparison to the doses to the bronchial epithelium, no further discussion of the ingestion pathway was considered warranted.

Water - Small amounts of radioactive materials are contained in water produced during mining operations. Releases of such water could potentially result in small exposures to man and other biota, principally from the ingestion of waters in which there exist small, above-background concentrations of radionuclides.

No water quality changes are expected to be induced below ground during operations at the Burdock mine because net flow will be toward the mine and its depressuring wells. Depressuring operations will result in a quantity of ground water which will be stored in retention lagoons. Any deliberate discharge from the lagoons or any use of the water as drinking water would be permitted only if the proposed effluent or drinking water, respectively, meets applicable standards (see Table 2.6.1.1-3). The water would be treated, as necessary, to assure compliance with those standards. Periodic monitoring of soils and shallow ground water in any effluent discharge area may need to be conducted, depending on conditions of operation.

Proper design and operation of the rentention (of precipitation, drainage, etc.) lagoons, pipelines, and ore and waste storage pads at all of the mining sites will assure that (a) any effluent released in a planned operation would meet applicable standards, (b) any water to be used as drinking water would meet applicable standards, and (c) inadvertent releases of radionuclides will occur at minimal frequency and that any such release will be of minimal quantity. Appropriate radiological monitoring of area surface and ground waters would be conducted following any inadvertent release of sufficient quantities of radioactive materials to affect significantly radionuclide concentrations in those waters.

After cessation of mining operations at the Burdock mine, the reestablished hydraulic gradient will approach premining conditions. There may be some water quality changes down-gradient from the disrupted ore zone. This would be a result of oxidation and other chemical reactions that could change the solubility of salts and chemicals within an abandoned mine. (See Section 2.6.2.1.) Monitoring of the host aquifer could be continued into the post-mining stage to determine whether a study of ground-water quality in and near the abandoned mine area is necessary.

Considering the water use characteristics in the site areas, no significant exposure from ingestion of water containing above-background concentrations of radioactive materials is expected, due to the mining operations. Radiological surveillance programs will be designed to detect significant changes in radionuclide concentrations in the project areas. Mitigating measures would be instituted and implemented if water supplies are found to contain concentrations of radionuclides which are significantly increased due to project operations.

<u>2.8.3 Radiological Monitoring</u> - Waters generated during the mining operations will be treated, monitored, and discharged in compliance with applicable requirements. The actual effluent monitoring program will be designed by the mine operator to conform with the requirements of the appropriate regulatory agencies. It is anticipated that the program will include monthly sampling of the effluent, with analyses being performed to determine uranium and radium-226 contents. The environmental radiological monitoring program is designed to determine the radiological impact of mining operations on the environment. During the life of the facility, increases in radionuclide concentrations in the environment should exist in no more than trace amounts, with very minor or no impact on the environment. Operational monitoring program details (i.e., sampling locations, equipment, frequencies, etc.) will be determined through evaluation of site topography, meteorology, the preoperational monitoring program, and the requirements of appropriate regulatory agencies.

Preoperational sampling is conducted to establish a baseline of data on the distribution of background radioactivity in the environment. Efforts are made to begin this sampling at least one year prior to operation of the facility, with samples being collected in the various seasons of the year. Results available to date are presented in Section 2.8.1.

The operational-phase monitoring program presently envisioned is described in the paragraphs below.

Ground Water - Samples of ground water will be collected quarterly from at least two locations in the vicinity of the Burdock mining operations. Initial operational monitoring will include analyses for uranium and radium-226 content, and possibly for gross alpha content. Analyses for thorium-230, lead-210, or polonium-210 content may be conducted periodically, and these or other analyses will be conducted as required.

Surface Water and Sediment - Samples of surface water and bottom sediment will be taken quarterly from at least two locations in Beaver Creek. Water will be monitored for uranium and radium-226 content and sediment will be monitored for uranium, thorium-230, and radium-226. Gross alpha analysis may be performed on some samples. Any other analyses required by applicable regulations will also be performed.

Soil and Vegetation - Soil sampling will be conducted at least semi-annually at a minimum of one control and one indicator ("downwind") location around each mine. Uranium, thorium-230, and radium-226 analyses will be performed on all samples, while lead-210 or polonium-210 analyses will be performed on selected samples.

Vegetation will be sampled at least one time per year at a minimum of one control and one indicator ("downwind") location around each mine. Normally, samples will be taken during the growing season. Uranium, thorium-230, and radium-226 analyses will be performed on all samples while lead-210 or polonium-210 analyses will be performed on selected samples.

Air - Samples from the high-volume monitors discussed in Section 2.7.4 will be composited for quarterly analyses for uranium, thorium-230, radium-226, and lead-210 content. Plans are not finalized regarding the collection of samples for determination of radon-222 or radon-222 progeny concentrations. However, it is anticipated that either radon or radon progeny will be determined on a continuous basis for one week each month. Sampling locations for radon or its progeny are expected to be the same as those used for the high-volume sampling. Any sampling and analyses required by applicable regulations would be performed.

Results of the monitoring program will be evaluated periodically and appropriate changes in the program will be made. Such changes may include increasing or decreasing the frequency of sampling or the number of sampling locations, relocating some sampling locations, or discontinuing some sections of the monitoring program if measurements are consistently negligible. Sampling and analyses required by applicable regulations would in any case be performed.

2.8 References

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3. Brenchley, D. L., et al. Environmental Assessment Methodology for the Nuclear Fuel Cycle. BNWL-2219. Battelle Pacific Northwest Laboratories. Richland, Washington. July 1977.

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6. "Natural Background Radiation in the United States." NCRP Report No. 45. National Council on Radiation Protection and Measurements. Washington, DC. November 1975.

7. Environmental Information Report - Edgemont, South Dakota, Uranium Mill; Tennessee Valley Authority; January 1976. Also, Semiannual Effluent Release Reports Nos. 2 and 4 for the Edgemont, South Dakota, Uranium Mill; Tennessee Valley Authority; August 1976 and August 1977.

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2.9 Flora and Fauna

2.9.1 Vegetation

2.9.1.1 Description - Surveys to document major vegetation types and floristic elements on the Edgemont project area were conducted for TVA during the period from fall 1975-fall 1976[1]. Three major vegetation regions are transected by the project area: grassland, ponderosa pine, and desert shrub.[2] Grassland vegetation communities are dominated by buffalo grass (*Buchloe dactyloides* (Nutt.) Engelm.), blue grama (*Bouteloua gracilis* (HBK) lag.), western wheatgrass (*Agropyron smithii* Rydb.), Sandberg bluegrass (*Poa secunda* Presl.) and little bluestem (*Andropogon scoparius* (Michx.) Nash). The ponderosa pine (*Pinus ponderosa* Lawson) region extends out of the Black Hills to include a large portion of the project area in both South Dakota and Wyoming. Major species within this zone are ponderosa pine, Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) and sedge (*Carex* spp.). Big sagebrush (*Artemisia tridentata* Nutt.) and black greasewood (*Sarcobatus vermiculatus* Hood. Emory) communities, part of the desert shrub region, cover a major portion of the project area, especially dominating the western half and extending westward into the Powder River basin.

Vegetation on the project area has not extensively deteriorated from livestock use, but intensive overgrazing occurs in some areas (particularly near water). Overgrazed areas can also be found where sheep are being pastured. Although sheep grazing is important in portions of the project area in Wyoming, rangeland use is predominantly by cattle. Other domestic animals on or adjacent to the project area are horses, pigs, and goats. Generally, 2.7 to 3.9 ha (6.6 to 9.5 acre) are required to support one animal unit (a 1,000-pound cow and calf, five sheep or the equivalent) for one year on and near the project area.[3]

Crop production is generally limited to dry land hay or grain. Native hay crops usually yield less than 3,360 kg/ha (1.5 ton/acre). Wheat yields vary, but are generally below 3 m^3/ha (35 bu/acre). Other crops occasionally grown on the project area include dry land corn, barley and oats.

Fourteen major vegetation types were identified on the project areas: (1) abandoned--invaded (orphan mine lands), (2) silver sagebrush, (3) silver sagebrush--big sagebrush, (4) big sagebrush--medium stand, (5) big sagebrush--heavy stand, (6) sand sagebrush, (7) grassland, (8) little bluestem grassland, (9) prairie dog town, (10) rough breaks, (11) black greasewood-- big sagebrush, (12) black greasewood, (13) cottonwood bottom, and (14) ponderosa pine. Variations in species composition occur within most vegetation types as a result of such factors as microclimatic differences, slope aspect, gradient (angle), and length, grazing pressure, and moisture availability.

Of the major communities, those covering the greatest portion of the project area are: (1) sagebrush, (2) ponderosa pine, (3) rough breaks, and (4) grassland, (Table 2.9.1.1-1). In the big sagebrush, medium stand type, vegetative ground cover averaged 23 percent (76 percent of the surface area is litter, rocks and bare ground), of which grasses comprise approximately

two-thirds. In the ponderosa pine, understory species average 8 percent ground cover. Grasses, the major life form on the rough breaks, comprise nearly half the total cover of 14 percent. Grassland averages 17 percent ground cover and is dominated by grasses with 12 percent cover. The ten remaining communities range from an average total percent ground cover of 16 percent on little bluestem grassland to 30 percent on silver sagebrush--big sagebrush.

Shrubs, a major portion of the ground cover in three communities (silver sagebrush, big sagebrush, heavy stand and black greasewood), comprise between one-third and one-half of total cover. Shrub density ranges from 50 plants/ha (20/acre) on the grassland to 14,602 plants/ha (5,912/acre) on big sagebrush, heavy stand. Other vegetation types with high shrub densities are black greasewood--big sagebrush, sand sagebrush, and silver sagebrush--big sagebrush. Of the plant species recorded for the project area, approximately 60 percent are forbs, 20 percent grasses, 10 percent shrubs, and 5 percent grasslike species. Trees, half-shrubs and succulents comprise the remaining 5 percent. Table 2.9.1.1-2 summarizes the 14 plant communities. In the Edgemont area, ponderosa pine stands have increased and encroachment into surrounding grasslands has occurred in the past 50 to 100 years.[4] Fire has occasionally been used to limit seedling invasion into adjacent little bluestem grasslands found along the margins of pine stands.

Ponderosa pine averaged 40.5 trees per hectare (16/acre) across the project area with a range of 21 to 67 trees/ha (9-27/acre). Over 95 percent of all trees had a DBH (Diameter at Breast Height-i.e. 1.6 m (4.5 ft) above ground) less than 33 cm (13 in). Trees with a DBH less than 12.7 cm (5 in) were not included in calculations. Over 80 percent had a DBH less than 20.3 cm (8 in). Pine stands were generally healthy and free of disease, except for an occasional tree infected by fungi or infested with pine bark beetles (Dendroctonus spp.). Timber stands in the area are used locally as a source of wood for firewood, fences, corrals, homesteads, barns, and small bridges.

No threatened or endangered plant species were found on or near the project areas.[5] Two plant species collected in Wyoming during summer 1976 were identified as being new state records. These two species, Dalea enneandra and Triodanis perfoliata, had not been previously collected in Wyoming. Neither species is considered threatened or endangered.

2.9.1.2 Impacts - Approximately 32 ha (80 acre) of shrub land, woodland, and grass land will be directly impacted by the proposed mining activities. Secondary activities such as house construction, road development and upgrading, and other off-site construction activities which will occur primarily in and near Edgemont will result in only minimum surface area disturbance. Table 2.9.1.2-1 lists disturbed areas by habitat type for each mine site.

Most of the 32 ha (80 acre) of vegetation will be displaced by construction of mine shafts, holding ponds, and other attendant facilities. Approximately 0.2 percent of the sagebrush, 0.01 percent of the pine and 0.03 percent of the grassland communities in the lease area will be disrupted by

Table 2.9.1.1-1

Areal Extent of Major Community Types

Community	Approximate Area Hectares (Acres)
Sagebrush	10,570 (26,100)
Ponderosa pine	7,290 (18,000)
Grassland	5,060 (12,500)
Prairie dog town	700 (1,740)
Rough breaks	3,640 (8,980)
Greasewood	490 (1,200)
Cottonwood bottoms	930 (2,300)

Table 2.9.1.1-2

Plant Communities of the Edgemont Project Area

Community	Total Perennial Cover (percent)	Representative Dominant Species
Abandoned-invaded	10.5	buffalo grass, blue grama, sand dropseed, needleandthread western wheatgrass
Silver sagebrush	26.0	silver sagebrush, buffalo grass, western wheatgrass, blue grama, sandberg bluegrass
Big sagebrush, medium stand	23.0	big sagebrush, buffalo grass, blue grama, western wheatgrass, sandberg bluegrass
Silver sagebrush-big sagebrush	30.0	big sagebrush, silver sagebrush, buffalo grass, blue grama, western wheatgrass
Big sagebrush, heavy stand	23.0	big sagebrush, blue grama, buffalo grass, sandberg bluegrass, western wheatgrass
Sand sagebrush	21.0	sand sagebrush, big bluestem, sandseed, plains prickly pear, threadleaf sedges, blue grama
Grassland	17.0	buffalo grass, blue grama, sandberg bluegrass, threadleaf sedge
Little bluestem	16.0	little bluestem, needle leaf sedge, wild buckwheat, prairie sandreed, Louisiana sagewort
Prairie dog town	17.0	buffalo grass, blue grama, plains prickly pear, scarlet globe mallow
Rough breaks	14.0	big sagebrush, wild buckwheat, blue grama, buffalo grass, side oats grama
Black greasewood-big sagebrush	19.0	black greasewood, big sagebrush, western wheatgrass, blue grama, alkali sacaton
Black greasewood	18.5	black greasewood, blue grama, sand dropseed, buffalo grass, western wheat grass
Cottonwood bottoms	16.5	plains poplar, western wheatgrass, buffalo grass, yellow sweet clover, common dandelion
Ponderosa pine	8.1	ponderosa pine, skunkbush sumac, blue grama, buffalo grass, western wheatgrass, big sagebrush, fringed and Louisiana sagewort

mining activities. These will be lost for the life of the mine or until reclamation practices are implemented. While these areas will be reclaimed, it is not likely that revegetated areas will closely resemble the existing plant species composition and diversity (i.e., it will be impossible to reintroduce all species lost). Disturbed areas that are not promptly revegetated will be susceptible to wind and water erosion (see Chapter 3).

Dust and gases resulting from construction and operation at mines may adversely affect some species of vegetation, especially near haul roads. Mine waste material generated as a result of underground and open pit mining may contain toxic materials. All toxic material will be handled in compliance with applicable regulations. If it is buried, it will be covered with material suitable for revegetation.

At the Burdock mine site, a layer of impermeable shale 87 m (285 ft) thick lies between the shallowest aquifer and the ground surface. For this reason, depressuring of the aquifers will result in no adverse impacts to vegetation.

The water from the underground Burdock mine will cause a temporary change in vegetation composition along the discharge waterway. After being treated (see Section 2.6.3), the water will be discharged in a natural drainage for approximately 2.4 km (1.5 mi) before entering Beaver Creek near the Cheyenne River. This relatively small flow of water will cause a slight shift along a narrow meandering course from arid to wetland vegetation for the life of the mine. After the mining activity ends and the water flow ceases, the vegetation in the drainage area will revert to a species composition similar to what is presently existing.

No threatened or endangered plant species or unique plant communities are known in the project area.

Due to the relatively small acreage of vegetation that will be impacted by the project and mitigation efforts employed, impacts to vegetation should not be of a significant adverse nature.

2.9.1.3 Mitigation - Vegetation impact mitigating measures will consist of the reclamation measures discussed in Chapter 3, the watering of roads to decrease dust problems, and the use of existing roads which will reduce the need for new road construction thereby reducing the amount of habitat disturbed.

2.9.2 Wildlife

2.9.2.1. Description - Wildlife investigations for this project were conducted during the period from fall 1975-fall 1977. The investigations were coordinated with personnel of the South Dakota Department of Game, Fish and Parks; Wyoming Game and Fish Department; U.S. Fish and Wildlife Service; and the U.S. Forest Service. The purpose of these investigations was to document important wildlife resources of the project area to allow assessment of future mining and reclamation activities.

Table 2.9.1.2-1

Area Disturbed Due to Mining

Mine Site	Plan Community Area Disturbed in Hectares (Acres)					
	H[1]	M	G	A	GB	P
Burdock No. 1	8 (20)	4 (10)	2 (5)	-	-	-
Burdock No. 2	-	13 (33)	-	-	1 (2)	-
Spencer Richardson	-	-	-	-	-	-
Runge East	-	1 (3)	-	2 (4)	-	1 (3)
Darrow	-	-	-	-	-	-
Subtotal	8 (20)	18 (46)	2 (5)	2 (4)	1 (2)	1 (3)
Total = 32 hectares (80 acres)						

H = Big sagebrush, heavy stand
M = Big sagebrush, medium stand
G = Grass land
A = Abandoned-invaded
GB = Black greasewood-big sagebrush
P = Ponderosa pine

The plant community complex described in Section 2.9.1 supports a diverse fauna. Numerous species of mammals, birds, reptiles, and amphibians are known to occur in the Black Hills and outlying areas. [6,7,8,9] A number of these species are important hunting resources while others have high esthetic and ecological value.

Wildlife field investigations for the most part were performed in conjunction with vegetation field studies during the period from fall 1975-fall 1976. These investigations were qualitative evaluations aimed at documenting the existance of critical wildlife habitats (e.g. threatened or endangered species, important big game wintering areas, sage grouse (Centrocercus urophasianus) strutting grounds, trout water, etc.).

After the Burdock underground mining site was located, it was discovered that the surface facilities will destroy a few acres of an existing prairie dog (Cynomys ludovicianus) town. For this reason, after consultation with the U.S. Fish and Wildlife Service and the South Dakota Department of Game, Fish, and Parks, TVA conducted an extensive black-footed ferret (Mustela nigripes) survey on the project area prairie dog town in September 1977 and found no evidence of ferrets.[14,15]

The Wyoming and South Dakota game and fish agencies consider the following habitat types to be of critical importance to wildlife in the project area: (1) aquatic habitat, (refer to Section 2.9.3.2) (2) riparian habitat, (3) shrublands, (4) rimrocks and canyons, and (5) ponderosa pine. [10,11,12]

Riparian habitat is found along permanent and emphemeral stream courses. Due to structure, composition and increased density of riparian vegetation, it serves as important nesting, spawning, resting, and escape cover area. Riparian habitat in the lease area is heavily used by turkey (Meleagris gallopavo) and mule deer (Odocoileus hemionus) and whitetailed deer (Odocoileus virginianus). White-tailed deer are primarily restricted to cottonwood bottoms along the Cheyenne River.[11,12]

Shrublands, particularly sagebrush, are extremely important to numerous species, especially antelope (Antilocarpa americana) and mule deer. Shrublands provide important winter feeding areas and in the case of sagebrush, strutting grounds for the sage grouse.

Ponderosa pine affords yet another habitat type and is utilized by a number of species for feeding, nesting, and escape cover. Wild turkey, raptors (hawks and owls) and mule deer utilize pine stands extensively.

A significant niche of rimrock and canyon habitat in the project area is that occupied by birds of prey which heavily use this habitat for feeding and nesting. Eleven species of hawks, owls, and vultures are considered common in the area and 22 species have been recorded.[9] Not all of these species intensively use rimrock and canyon areas but many nest and feed in these areas. This habitat also supports small birds, small mammals, deer, turkey, and reptiles and provides a rich food source for many predator species.

Due to moderate climate in the project area, big game species such as mule deer and antelope do not move to winter ranges but utilize the same habitat throughout the year. Off the project area to the north and east at higher elevations (Elk Mountain), big game species move to lower elevations during winter.

Hunting on and near the project area is primarily for antelope, deer, and turkey.[11,12] Since white-tailed deer are restricted to river bottom habitat along the Cheyenne River, hunting for mule deer is more common. Due to existing land use conditions, there is limited habitat for sharptail grouse (Pedioecetes phasianellus) and ring-necked pheasant (Phasianus colchicus). Sage grouse inhabit the South Dakota project area but there is no season for this species. In Wyoming, pheasant, chukar (Alectoris graeca), sage grouse, sharptail grouse and dove (Zenaidura macroura) are hunted. Waterfowl hunting on area streams and reservoirs is popular and significant numbers of migrating ducks and geese pass through the area. Cottontail rabbits (Sylvilagus spp.) also provide important small game hunting opportunities.

Predator red fox (Vulpes fulva), bobcat (Lynx rufus), coyote (Canis latrans)) and varmint (prairie dog) hunting is also popular in the area.[11,12] Mountain lion (Felis concolor) and bear (Ursus americanus) are not considered game species by South Dakota and therefore are not hunted. Bear are hunted in Wyoming but due to lack of suitable habitat, would not be expected on the Wyoming portion of the project area. The mountain lion is considered a trophy game animal in Wyoming and may be expected on the project area. Trapping for beaver (Castor canadensis), muskrat (Ondatra zibethica), and predators such as coyotes, red fox, and bobcat occurs in the area.[11,12]

The project area could provide potential habitat for the following threatened or endangered species:[13]

- Peregrine falcon (Falco peregrinus - endangered)
- Southern bald eagle (Haliaeetus leucocephalus endangered)
- Blackfooted ferret (Mustela nigripes - endangered)

None of these species were seen on or near the site during field investigation.

The peregrine is known to inhabit the Black Hills and conceivably could occur on or near the project area. The southern bald eagle could be found in the area during winter as a transient. The ferret is not known to be in the area but potential exists because of the presence of suitable habitat conditions (prairie dog towns). Black-tailed prairie dog towns provide habitat for the endangered ferret which preys on prairie dogs. After consultation with the U.S. Fish and Wildlife Service and the South Dakota Department of Game, Fish, and Parks, TVA conducted a ferret survey on the project area prairie dog towns in September 1977 and no found evidence of ferrets.[14,15]

2.9.2.2 Impacts - As shown in Section 2.9.1, 32 ha (80 acre) of habitat will be lost for the life of the mines. The bulk of the disturbance will occur at the Burdock shaft sites since these will cause new habitat disruption. The Spencer Richardson and Darrow mines are existing open pits for which the

surface disturbance should not be significantly increased; and no further habitat disturbance should occur. The Runge East mine is an existing underground mine that will be reopened, but little further surface disturbance will occur at this site.

Of a total of 32 ha (80 acre) of habitat lost, 26 ha (66 acre) will be sagebrush. This will result in the reduction of food and cover for a number of wildlife species. Antelope, in particular, are an important game species which heavily depend upon sagebrush habitat. Impacts to, less mobile species such as small mammals, reptiles and amphibians will be more severe due to their small home range and their inability to relocate. Due to the vast area of sagebrush, grassland, and pine found on or near the project area, loss of 32 ha (80 acre) of habitat should not cause significant adverse impacts to wildlife species (see discussion in Section 2.9.1.2).

Two or three holding ponds will be developed at the Burdock No. 1 shaft. Water will be released from the pond into an adjoining natural drainage (ephemeral stream) and will be suitable for livestock and wildlife use. Dewatering operations will not adversely affect streams or reservoirs.

The bald eagle and peregrine falcon should not be adversely affected by this project since habitat critical to their survival will not be impacted. They could be impacted by harrassment and illegal shooting. Efforts to control this potential impact are discussed in Section 2.9.2.3).

Construction at the Burdock shaft sites will destroy several acres of prairie dog towns but field investigations indicated ferrets were not present.

As discussed in Section 2.10, employment growth as a result of the project will amount to 160 people. Based upon this growth, it is estimated that the total population increase in the region attributable to this project will be about 565 persons (refer to Section 2.10). Increased road traffic of commuters and the influx of new people will cause additional stresses to the wildlife resource of the region. By using the percentage of the population in the State of South Dakota who hunt (23 percent), it is estimated that approximately 130 hunters will move into the area as a result of the project.[16] Illegal hunting and harrassment of wildlife constitute a potentially significant impact, particularly to big game species and the diverse raptor fauna of the region. It is difficult to quantify the magnitude of these potential impacts. Mitigation measures are discussed below.

2.9.2.3 Mitigation - Attempts to minimize impacts to wildlife will be made through reclamation and conducting a wildlife ecology information and education program for project employees. The reclamation program will ensure that all disturbed areas are revegetated (Chapter 3). Revegetated areas will not closely resemble existing plant communities in species composition and diversity, (e.g., shrublands will probably more closely resemble grasslands after reclamation). Even though vegetation composition on the reclaimed areas will be different from existing cover, the small amount of disturbance from mining (underground and extraction from existing pits) will cause only

very local changes that are insignificant to regional wildlife populations.

In an effort to help mitigate impacts to wildlife populations from the influx of additional people into the region, a condensed education program will be prepared by TVA in cooperation with Wyoming and South Dakota Fish and Game personnel. The objective of this program is to create in project employees an appreciation and awareness of regional fish and game values. The program will stress the need and importance of fish and game laws and notify employees that disregard of these laws may be cause for disciplinary action in addition to the penalty prescribed by law.

2.9.3 Aquatic Biota

2.9.3.1 Nonfish

2.9.3.1.1 Sampling: Sites and Frequency - Surface waters flowing through the Edgemont project area were sampled in September 1975 and in June 1976 to document the composition and diversity of indigenous aquatic communities during dry and wet seasons, respectively. Sampling sites were selected based on the following criteria: (1) the need to delineate preoperational conditions in the vicinity of potential mining activities*, and (2) the need to delineate the biota indigenous to each of the representative habitat types (riffles, pools, vegetative areas) and each of the major substrates (silt, clay, detritus, cobble, submerged and emergent aquatic plants). Two sites, Pass Creek and an unnamed pond near Burdock No. 1 shaft were sampled only in 1976 because they were not identified as being in the vicinity of mining activities until after the 1975 survey was completed. The upper two stations on Beaver Creek (Wyoming) were not sampled in 1976 because of flooding. Biological sampling stations and their proximity to the proposed mining sites are illustrated on Figure 2.9.3.1-1.

2.9.3.1.2 Description of Habitat and Stream Classification - Surface waters of the Edgemont project area provide habitats suitable for a variety of aquatic biota. Habitats range from dry stream courses which contain water only during or after heavy precipitation to streams which contain some flow throughout the year. The majority of the streams have intermittent and/or interrupted flows, being subject to alternate periods of drying and flooding. The effects of variable discharge upon habitat are significant as such discharges may deposit quantities of silt at one time and then scour the substrate at another.[17] Variable discharge also affects the habitat when periods of extremely low flow exist, since much of the benthic substrate can be exposed and subjected to rapid drying.

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*Based on information available at that time

There are five aquatic systems which occur near or on the Edgemont project area. These are: Beaver Creek and its major tributary, Stockade Beaver Creek (State of Wyoming Class I waters), Pass Creek (State of South Dakota--intermittent stream), Unnamed Pond (holding pond for mine dewatering), Cheyenne River (State of South Dakota--warm water semi-permanent fish life propagating waters, limited contact recreation, wildlife and stock watering, and irrigation), and Cottonwood Creek (perennial stream). Representative riffle pool habitats characterize the creeks and the Cheyenne River. The unnamed pond provides habitat for aquatic organisms for only a portion of the year.

2.9.3.1.3 - Description of Indigenous Fauna and Flora - The flora and fauna of the aquatic habitats in the site vicinity are representative of aquatic environments in semi-arid climates. Wide fluctuations in species diversity and numbers occurred and are expected due to frequent changes in habitat availability. No rare, threatened or unique species were identified from any of the site visits. Similarly, no unique habitats were identified. Detailed descriptions of the fauna and flora are available in a TVA report.[18]

2.9.3.1.4 Potential Impacts to Indigenous Faunal and Floral Communities Posed by Mining at this Site - Ecological populations of intermittant streams are transient and/or ephemeral. Recolonization of temporary dried areas is accomplished through surface water drift, survival of desicant resistant eggs, new egg deposition, and groundwater migration of larvae or adults. Water released from ponds will meet all NPDES requirements for the protection of aquatic life; thus, the primary impact of mining operations will be an increase in habitat, stream flow, and flow duration; and thus an increase in aquatic biological populations. The only undesirable aspect associated with such a population increase would be the corresponding increase in the population numbers, and perhaps the number of species of biting (pest) arthropods. These pests would most likely include mosquitos, black flies, horseflies, and deer flies. A secondary impact would involve compositional changes in the biota as a result of increased flow and/or physiochemical alterations. These compositional shifts would probably be insignificant with regard to most, if not all, of the biota because (1) they would be temporary (only during mining operations), and (2) the organisms would remain in surrounding areas and could recolonize affected areas as soon as mining ceased. Unusual or special precautions should not be necessary for protection of the area's nonfisheries biotic communities.

2.9.3.1.5 Mitigation - General mitigative measures which will be employed to the extent practical to prevent or reduce possible impacts include: (1) construction of dikes and ditches before other major surface construction and during the dry season to reduce suspended solids runoff during periods of heavy rainfall, (2) the initial release of pond effluents will be gradual so that any potential scouring of the streambeds will be minimized, (3) strict adherence to provisions stipulated within the NPDES permit.

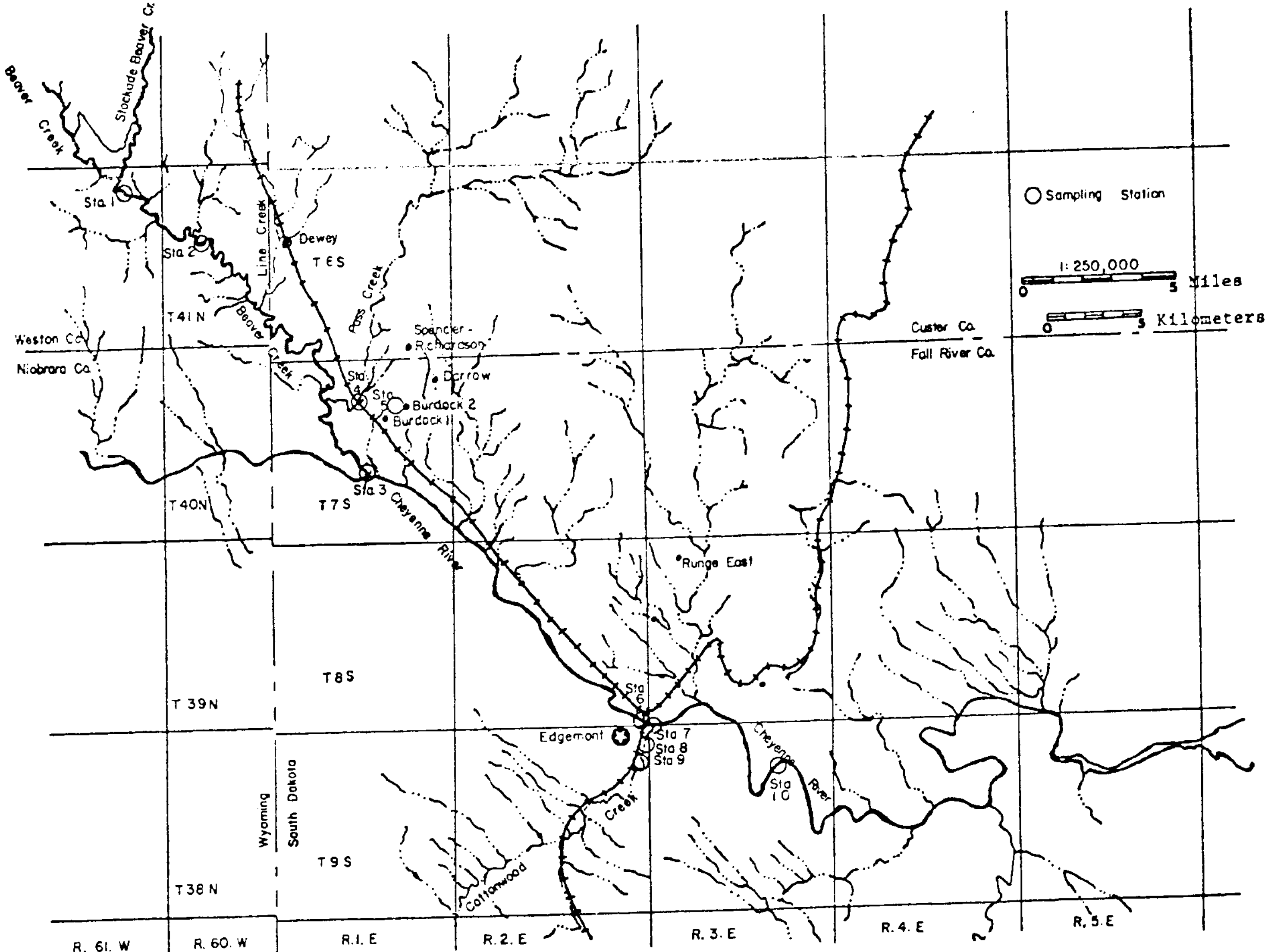

Figure 2.9.3.1-1 Biological Sampling Stations and Potential Mining Sites on the Edgemont Project Area

2.9.3.2 Fish

2.9.3.2.1 Description - As discussed in Section 2.9.2.1, the Wyoming and South Dakota game and fish agencies consider the aquatic habitat as one type of habitat to be of critical importance to wildlife in the project area.

Due to the arid regional climate, surface water (aquatic habitat) is extremely important. Table 2.9.3.2-1 lists fishery resources found on or adjacent to the project area.

Permanent streams and warm water reservoirs support such species as channel catfish (*Ictalurus punctatus*), bluegill (*Lepomis macrochiris*), carp (*Cyprinus carpio*), and numerous nongame species (plains top minnow (*Fundulus sciadicus*), plains minnow (*Stybognathus placitus*), black bullhead (*Ictalurus Melas*), and plains killifish (*Fundulus kansae*)). Cold water streams and reservoirs are stocked with trout. Aquatic habitat provides valuable watering areas for big game, turkey, and important nesting and feeding area for waterfowl and shorebirds.

2.9.3.2.2 Impacts - Two or three holding ponds will be developed at the Burdock No. 1 shaft. Water will be released from the pond into an adjoining natural drainage (ephemeral stream) and will be suitable for livestock and wildlife use. Dewatering operations will not adversely affect surface water streams or reservoirs.

As previously discussed in Section 2.9.2.2, employee growth as a result of the project will amount to 160 people with an estimated total population growth of 565. The influx of new people will cause additional stresses to the fish resource of the region. It is difficult to assess the magnitude of these potential impacts. Measures to be taken to ensure mitigation of these potentially severe impacts are discussed below. By using the percentage of the population in the State of South Dakota who fish (24 percent) it is estimated that approximately 135 fishermen will move into the area as a result of the project.[16] Careful planning and coordination between TVA, its operator, and the various state and federal agencies, will be necessary to reduce impacts.

2.9.3.2.3 Mitigation - The condensed education program discussed in Section 2.9.2.3 is applicable to help mitigate impacts to fish populations.

Table 2.9.3.2-1

Fishery Resources on and Adjacent to Edgemont Property

Water Body	Status[1]	Fishing
Streams		
Cheyenne River	P	Catfish
Beaver Creek	P	Catfish
Cascade Creek	P	Trout
Pass Creek	E	-
Plum Creek	E	-
Piney Creek	E	-
Red Canyon Creek	E	-
Cottonwood Creek	P	Catfish
Hat Creek	P	Catfish
Stockade Beaver Creek	P	Catfish
Reservoir		
Stock Ponds	P	Bass, bluegill
MW Reservoir	P	Trout
LAK Reservoir	P	Trout, bass, yellow perch
McMaster Reservoir	P	Trout

1. E=Ephemeral, P=Permanent

2.9 References

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2.10 Socioeconomic Considerations

2.10.1 Socioeconomic Environment - Projects creating increases in an area's basic employment (such as mining) have many positive effects but also have the potential for disrupting communities by overloading their public and private services and facilities. The net effect is contingent upon many factors including the existing capabilities of a community to absorb the projected additional growth. This section presents information regarding the capabilities of the governmental entities likely to absorb portions of the population increase.

2.10.1.1 Definition of the Impact Area - Examination of the regional map (see Figure 1.1.1-1) for the project area makes the definition of the impact area relatively straightforward. While uranium miners are willing to commute long distances 82 to 107 km (51-67 road mi)[1], they are unlikely to locate that far away if they are moving into an area with communities closer to the project. In this case, two communities--Edgemont and Hot Springs--are close enough to the project area to serve as potential locations for new residents. Also, they are both in Fall River County in which the project is located.

2.10.1.2 Impact Area Characteristics - Community profiles for Edgemont and Hot Springs are discussed in sections 2.10.1.2.1 and 2.10.1.2.2, respectively. These profiles contain a brief description of the status of community development, the facilities and services presently available, and the outlook for community growth and expansion. This information forms the basis for evaluating the potential for impacts created by the population influx presented in section 2.10.2.

2.10.1.2.1 Edgemont

Population and Employment - Since 1960, population and employment have undergone significant shifts in Edgemont. In 1960, the population was about 1,800 but by 1970, this had decreased to about 1,200 as a result of the closing of the Black Hills Army Depot in 1967. Although some small industries have located near Edgemont, the community reverted to essentially a small trade and service center for the surrounding agriculture-based population. However, the advent of major energy-related development in the west has begun to alter the situation. The biggest change has been the expansion of Burlington Northern Railroad's operation in Edgemont. As a result of coal activities in Wyoming, Burlington Northern's employees have increased from 20 in 1968 to about 200. This increase has included both construction employees for upgrading the tracks and train crews. As a result, Edgemont has reached an estimated population between 1,800 and 2,000.

The decrease in population because of the earlier loss of job opportunities resulted in another important characteristic of the county--a very low unemployment rate. From 1970 to 1974, it never exceeded 2.5 percent while the South Dakota rate stayed around 4 percent.

Education - Edgemont Independent School District No. 23-1 serves all but the eastern part of Fall River County.

Enrollment in the spring of 1977 totaled 432 students. Edgemont has consolidated all schools into one large structure, but has divided it up for administrative purposes. The enrollments and capacities are:

	Enrollment	Maximum Capacity
High School	109	159
Junior High	67	107
Elementary School	256	304

While physical capacity exists, part of the facility dates back to 1931. Also a large amount of the equipment was acquired from the schools in Igloo which were closed when the army depot closed.

Transportation - U.S. Highway 18 is the major highway through Edgemont. It runs through Hot Springs [43 km (27 mi)] to the east and into Wyoming to the west. This highway is presently being upgraded in the Edgemont Area. Already mentioned is the Burlington Northern Railroad which offers freight service. Bus service is provided by Continental Trailways with connections to Rapid City in the north and Denver, Colorado, to the south. The Edgemont area is also served by a sod runway which accommodates small private aircraft.

Utilities - Communications - Privately provided utilities include Black Hills Power and Light (electricity) and Peoples Telephone and Telegraph Company (telephone). The city provides water, sewer, and solid waste collection.

Water supply is obtained from wells with a flow estimated to be adequate for a population of 10,000. Present storage is 2.6 x 10^6 l (700,000 gal) which corresponds to the peak daily use. Although the quantity of the supply is adequate, the water is very hot (53° C, 128° F) and high in minerals which is damaging to water mains and valves. Recently a $150,000-Local Public Works grant was approved to finish a partially completed reservoir. The reservoir will have a capacity of about 23.8 x 10^6 l (5.3 x 10^6 gal) and will also serve as a cooling pond to lessen the adverse effects on the distribution system.

Wastewater treatment is provided by a single stabilization lagoon. Based on limited sampling, the facility does not meet the requirements of the National Pollutant Discharge Elimination System (NPDES) permit. Priority for funding the design of proposed improvements to the facility is 66 out of 117 towns in the state.

Solid waste disposal is contracted by the city with a private operator. The operator provides once-a-week pickup and also operates the city-owned and state approved landfill.

Housing - The recent surge in population growth has placed a great deal of pressure on the existing housing. From 1962 to 1976 only three houses were built, but the railroad expansion has resulted in 16 being built in the last year. Plans have also been made to build two 8-unit apartments, a 25-unit trailer park, and 10 to 12 modular units which are on order. In

addition, a senior citizens unit is expected to release about 18 older homes for purchase or rent. Expansion of the water and sewer distribution and collection systems is a constraint on any large-scale housing development.

One developer from Rapid City has plans for a 6.9 ha (17 acre) development containing a mixture of dwelling types and some commercial establishments. This scale of development is also contingent upon the emergence of a significantly expanded market.

Health, Police and Fire Protection - There are two dentists and one optometrist in Edgemont. One physician has established an outpatient clinc with services available on weekday afternoons. Most medical services must be obtained in Hot Springs, 43 km (27 mi) away. Ambulance service is provided by the volunteer fire department. About 10 members have completed an 81-hour emergency medical technician course.

Twenty-four-hour police protection is provided by four full-time and one part-time patrolmen. The department has two patrol cars and two persons serving as dispatchers. The local department is supported by a local deputy sheriff based in Edgemont.

Fire protection is provided by a 40-member volunteer fire department. Its equipment consists of two pumpers, one a 3,785 l (1,000 gal) pumper, two 4-wheel drive rural service trucks with 530 l (200 gal) capacity each, a salvage truck with smoke extractor, and a 16,000 l (6,000 gal) tanker used for water supply for rural fires. The insurance classification of Edgemont is eight [on a scale of 1 (best) to 10 (worst)].

Recreation - Volunteers presently operate the recreation program although local officials have indicated plans for hiring a recreation director to organize activities. There are two tennis-basketball courts, and the high school has a football-baseball complex. Activities in the summer include softball and hardball leagues for all ages and the city leases the motel swimming pool for public use during certain hours. In the winter, there are a few men's basketball teams.

2.10.1.2.2 Hot Springs

Population and Employment - Hot Springs underwent a small population decline from 1960 to 1970 dropping from 4,943 to 4,434. Since this period, the population has increased to approximately 4,800.

Employment in the government sector is one of the major reasons for the relative stability of the population. The Veterans Administration Center which employs about 500 people contains 232 general hospital beds and 511 domiciliary care beds. At the State Veterans Home, about 100 people are employed caring for about 69 patients. Since Hot Springs serves a very large trade area, trades and services employment constitutes the other major employment sector.

Education - Hot Springs Independent School District No. 23-2 covers the northeastern part of Fall River County. Enrollment in the spring of 1977 totaled 1,162 distributed among four elementary schools, one middle school and one senior high school. However, three of the elementary schools are rural schools and would not serve children of persons moving to Hot Springs. Thus, the relevant enrollments and capacities are:

	Enrollment	Maximum Capacity
High School	381	420
Middle School	312	270
Elementary School	427	500

Overcrowding exists in the middle school while excess capacity is available in both the high and elementary school.

Transportation - Bus service is provided by Continental Trailways and the Omaha-Rapid City bus line. Continental Trailways provides a direct connection with Rapid City to the north and Denver (through Edgemont) to the south. The Omaha-Rapid City bus line also connects with Rapid City but goes to Chadron, Nebraska, and other stops across Nebraska.

Rapid City offers the nearest commercial airline connection. However, there is a municipal airport in Hot Springs which serves light aircraft. This airport has a 1,372 m (4,500 ft) asphalt runway and 1,158 m (3,800 ft) sod runway and two hangars with fuel availability. Lights are operable by radio control.

Utilities - Communication - Private utilities include Black Hills Power and Light (electricity) and Peoples Telephone and Telegraph Company (telephones). The city provides water, sewer, and solid waste disposal service.

Water supply is from groundwater sources which are adequate for the existing population. Additional sources exist which can be tapped to serve population growth. Improvements are planned which include expanding storage capacity by 9.5 x 10⁶ l (2.5 x 10⁶ gal) and building a new water collection gallery from which water is pumped to the central storage reservoir.

Wastewater treatment facilities are old and provide inadequate treatment. Improvements have been designed which would provide treatment capacity for 6,500 people. Priority for funding these improvements is 16 in the state which is expected to result in construction beginning in 1978.

Housing - Conventional housing is in short supply, but market response to increased demand should be assisted by the large availability of building lots in the city. Construction on these lots could make use of existing utility lines thus eliminating both the time and expense associated with developing, new unserved areas. Mobile homes supplement conventional housing with about 15 mobile home parks containing about 300 spaces. The individual vacant building lots are not available for placement

of mobile homes because community regulations restrict mobile homes to approved mobile home parks.

Health, Police and Fire Protection - The Southern Hills General Hospital is the only civilian hospital in the area. It contains 50 beds and is operating at about 30 percent occupancy. Further, the auxiliary facilities already in the hospital are sized to serve 150 beds. Thus, it has a great deal of capacity to serve additional needs. Four doctors, one surgeon, and three general practitioners are in the community and utilize the hospital. There are also two dentists and two optometrists in Hot Springs. In addition to the general hospital, there is a 50-bed nursing home which is operating at capacity.

The police department which provides 24-hour protection has six patrolmen, three desk sergeants, and a dispatcher shared with the county. There is a new city-county jail and the department has two patrol cars.

Fire protection is provided by a volunteer department consisting of 57 men. Facilities include two 1,892 l (500 gal) pumpers, a ladder truck, smoke extractor, two rural service pumper trucks and an emergency ambulance.

Recreation - A full range of community recreation facilities is available. Swimming is available at the Evans Plunge and Larive Lake. Tennis courts are located at the high school and at Butler Park. The high school also has a football field and baseball facilities are available at the VA center. There is a nine-hole golf course at the country club and another under construction at Butler Park. Recreation activities are sponsored by various civic organizations such as the American Legion, Jaycees, VFW and Elks.

2.10.2 Socioeconomic Impacts

2.10.2.1 Introduction - This section discusses potential socioeconomic impacts of this project in the context of all known energy-related development in the area. This analysis is based on a set of assumptions which TVA considers reasonable in light of present information. However, methodology and results are presented in some detail to enable the effects of variations to be easily assessed.

2.10.2.2 Magnitude and Distribution of Impacts - A number of energy-related developments are occurring or expected in the Edgemont area. These include expansion of railroad and related activity, the proposed project, and another small uranium mining operation. Based on present plans, the total energy-related employment is expected to increase from about 200 in 1975 to 1,155 in 1981. TVA's operator employed about 40 people in the Edgemont area in 1975. Employment for the Edgemont mining project and associated exploration and milling will level off at 200 in 1981. Thus, employment growth from 1975 to 1981 totals 955 with the project accounting for 160.

Increases in basic employment such as mining and transportation will eventually result in increases in secondary employment such as clerks, barbers, etc. In 1973, the ratio of

secondary to basic employment in Fall River County was about one. Assuming this ratio to hold through 1981, 955 secondary employment opportunities will be created with 160 due to this project.

Estimating the employee influx associated with the employment increase took into account the size of the present population within commuting distance, the unemployment rate, the types of skills required, etc. The new employees for the Edgemont project will consist primarily of underground miners and supervisory personnel which are skills generally in short supply. The other mining activity will face a similar situation. The railroad-related activities will use skills more generally available or more easily developed than underground mining. However, Fall River County had an unemployment rate of about 2 percent from 1970 through 1974 which indicates a lack of available individuals in the area. Considering these factors, an employee influx rate of 90 percent was used for energy-related development.

Secondary employment is made up largely of positions filled by women or young people. Thus, as new mining employees move in with their families, they will create a pool of potential secondary employees. Based on these considerations, a secondary employee influx rate of 50 percent was used.

Converting the employee influx into a population estimate was based on 75 percent of the employees having families and 25 percent being single. Family size was based on national trends and averages because these employees would be drawn from a multi-state area. The family size used was three. Applying the various rates and factors to a basic employment increase of 955 results in a population increase of about 3,350. For the project, the 160 new jobs result in a population increase of 565. Of the total population influx, 755 were school age (0.75 school-age child per family) with 125 due to the project.

To evaluate the potential impacts on community facilities, the total population increase was distributed between the towns of Edgemont, Hot Springs, and Igloo-Provo (see Table 2.10.2.2-1). Igloo-Provo is not considered as part of the project impact area because no significant portion of the project employees are expected to locate there. However, Igloo is the location of one of the railroad-related projects and could be expected to absorb a portion of the associated population increase. Some employees may scatter among the small settlements in the area or in isolated individual dwellings. However, this is expected to be only a small fraction (less than 5 percent) and is not subtracted from the total allocated to the impact communities. Based on factors such as community size, distance from the work location, employee characteristics, and other judgments, Edgemont was projected to receive 600 of the basic employee influx and Hot Springs, 240.

Secondary employee distribution is expected to follow a different pattern because of the predominant role played by Hot Springs in this sector. A total of 480 secondary employees were distributed with 360 to Hot Springs and 120 to Edgemont. The total employee influx to each community was 720 to Edgemont and 600 to Hot Springs. This produces an estimated population influx

of 1,800 to Edgemont and 1,500 to Hot Springs. Of the total population influx, the project accounts for 340 (19 percent) in Edgemont and 225 (15 percent) in Hot Springs.

Table 2.10.2.2-1 summarizes the employment and population influx discussed above and presents projections of the school-age influx and projected housing demand.

One general and fundamental conclusion can be drawn from just the total population influx projections. Edgemont is faced with the prospect of very rapid growth while Hot Springs should be able to accommodate the growth with no significant problems. Generally, communities can absorb indefinitely annual population growth rates of 5 percent or less without special fiscal or administrative actions. Growth rates between 5 and 10 percent require special efforts to maintain adequate service levels and facilities over an extended period, but it is generally possible and feasible. At growth rates greater than 10 percent, for periods exceeding 5 years, the demand for services and facilities calls for additional expenditures at a much faster rate than additional revenues are generated so that facilities and service levels often deteriorate[2]. Edgemont is projected to grow at an average annual rate of about 17 percent and Hot Springs at about 5 percent. Even without the proposed project, Edgemont's growth rate would still be about 14 percent which could still create a very stressful situation.

These projections are subject to an important qualification. Rapid growth in Edgemont could create conditions which would cause some of the influx projected for Edgemont to locate in Hot Springs. However, there is no information upon which to quantify this possibility. Also, it would not occur until the situation in Edgemont had deteriorated to unacceptable levels. Thus, projections of impacts for specific community facilities and services will be based on the projections as presented.

<u>2.10.2.3 Impacts on Schools</u> - Edgemont school system is projected to receive 415 additional students and Hot Springs, 340. By continuing to use present facilities up to their rated capacity, Edgemont would have to provide additional space for 277 students or about 10 classrooms. Hot Springs would require space for an additional 230 students (about 8 classrooms) if the present level of overcrowding were to continue. If the overcrowding was to be relieved, space would be required for 272 students (about 10 classrooms).

There are no plans in either school system to expand facilities. In the immediate future, the excess capacity can be used to accommodate the students. If permanent facilities are expected to meet future needs, the lead time required to plan, locate, design, and construct a school means that efforts should be undertaken very soon. If present school sites are adequate, portable classrooms can be purchased and placed in use in a much shorter time. However, if the latter alternative is to be a conscious decision rather than one forced by future enrollments, planning should begin very soon.

<u>2.10.2.4 Impacts on Housing</u> - On the average, 105 new dwelling units per year will be required in Edgemont and 90 in

Table 2.10.2.2-1

Edgemont Uranium Mining Project
Selected Socioeconomic Impact Indicators
Comparison of Project to Total in the Area

	Edgemont		Hot Springs		Igloo-Provo	
	Total[1]	Project[2]	Total[1]	Project[2]	Total[1]	Project[2]
Employee Influx						
Basic	600	115	240	30	20	0
Secondary	120	20	360	60	0	0
Total	720	135	600	90	20	0
Population Influx	1,800	340	1,500	225	50	0
School-Age	405	75	340	50	10[3]	0
Housing Demand	630	120	525	80	20	0

1. Total due to all energy-related development including the TVA project.
2. Amount due to TVA project alone.
3. Included in the Edgemont school district.

Hot Springs. In Edgemont, there may be approximately 70 additional dwellings by mid-1978 plus the potential of one small 6.9 ha (17 acre) development. In Hot Springs, there are no announced plans for new housing developments. Thus, it will be very difficult for new residents to find a place to live, let alone find the type of dwelling they prefer. Given the high level of demand, the cost and length of time to construct conventional homes, most of the new dwellings will likely be mobile homes plus some modular dwellings. Planning for this growth is important so that the needed development in the near future provides a sound basis for longer-term development.

2.10.2.5 Impact on Water and Sewer Systems - Water supply capacity does not create a constraint to achieving the projected population growth in either Edgemont or Hot Springs. Hot Springs' distribution system is extensive and undergoing improvement which should enable the water to be provided where needed without major additional extensions. In Edgemont, water line extensions required by new development could become a constraint. Financing could be one significant problem but use of a mix of available mechanisms--bonds, grants, loans, rate structure, agreements with developers, etc.--could provide the necessary funds. Just as important are the extension plans so that lines are located and sized to meet long-term development without duplication or undersized lines. This planning should begin soon in order to provide the basis for proposing financing.

In Edgemont, the population growth could further overload the present sewage treatment system until the planned improvements are made. However, the improvements are based on a future population of 2,000. Thus, it appears that the design should be adjusted to take into account the new growth. An alternative to tying into the sewer system is to use septic tanks, because soils in the vicinity of Edgemont are generally suitable.

Hot Springs is faced with a situation similar to Edgemont in that, until planned improvements are made, more population growth could further overload the existing sewage treatment system. In addition, the improvements are planned to serve a population of 6,500. Based on the projections in this analysis, the population of Hot Springs will be approximately 6,300 in 1981 so some thought should be given to revising the design in order to extend the time until expansion is required. Septic tanks may offer an alternative to tying onto the sewer system in the Edgemont area but soil characteristics in the Hot Springs area essentially prohibit this alternative.

2.10.2.6 Impact on Medical Services - Most of the demand for medical services in Edgemont will probably transfer to Hot Springs. If this occurs, the demand for emergency medical services could essentially double. The increased population could also make feasible the establishment of a satellite clinic from the hospital in Hot Springs.

In Hot Springs, the Southern Hills General Hospital is fully adequate to meet the needs of the total population influx. Based on Department of Health, Education, and Welfare criteria for a physician shortage (one physician to 1,500 people), the eight doctors already in Hot Springs would also be adequate to

serve the total influx. However, that would likely result in a lessened level of service based on the present physician to population ratio of 1 to 1,050. Using the existing ratio, three more physicians would be required.

2.10.2.7 Other Impacts - Population increases on the order of those projected for Edgemont and Hot Springs will create a need to expand most other public services and facilities such as police protection, solid waste disposal, fire protection, and recreation. In Edgemont, the doubling of population indicates a probable doubling of all of these aspects of government. In Hot Springs, the increase is about 30 percent which indicates that certain elements might be capable of accommodating without a proportional expansion. Depending on the pattern of new development, it might be possible that existing fire protection equipment and personnel would be completely adequate. It is also possible that recreation and police protection will have some ability to absorb additional demand without either expansion or significant reduction in the level of service. On the other hand, solid waste pickup and disposal would be more directly proportional to increases in population.

2.10.3 Socioeconomic Mitigation - Mitigation of the potentially adverse impacts described in section 2.10.2 will take place through a combination of three types of actions. The first which could possibly take place is direct action by the project; for example, providing funds for a planning program. The second is indirect action by the project such as payment of taxes by the project and its employees. The third is external action by others such as Federal loans or grants. All three types of actions function within a legislative framework set forth by the state and Federal government. The degree to which mitigation occurs depends upon how well existing legislation works and the extent to which new state and Federal legislation is enacted which would supplement the existing revenue flow.

Direct actions by the companies impacting the area could take many forms, but the most likely is in the area of housing in order to attract and keep employees. However, there are no announced plans at this time. TVA is prepared to cooperate with other companies in the area to work with the communities to provide direct assistance for other purposes. One purpose for which assistance already has been requested is a planning program for Edgemont. This planning program would work toward the timely provision of the additional services and facilities required by the rapid population growth. TVA is presently evaluating funding this program in cooperation with other impacting industries and the city of Edgemont.

For operating expenses local governmental entities rely heavily on gross receipts tax, gasoline tax, property tax, state redistributions and revenue sharing. Gross receipts tax, gasoline tax and most redistribution follow very closely changes in population and income and do not lag very far behind. To specifically aid energy-impacted areas, South Dakota amended its severance tax act to increase the rate and provide partial redistribution to the counties in which the minerals are produced. The new rate is 4.5 percent and until the end of 1979, two-thirds of the collected tax will go to the producing county and one-third to the State. From 1980 on, the split will be 50

percent for the county and 50 percent for the State until the county receives $300,000 over which amount the State retains everything. At the county level, the board of county commissioners is responsible for allocating the funds "for school, roads, law enforcement and municipal purposes to offset social, economic or physical impacts, either direct or indirect, resulting from the extraction of severed energy minerals in the county." Property tax revenue and revenue sharing can lag up to two years behind increases in population.

School districts with children whose parents are working at TVA's mill may qualify for operating funds from the Federal government under P.L. 81-874. The funding varies directly with changes in membership, but some lag could occur if the membership is growing rapidly. State support for school operating funds functions in a similar manner.

Local funding of major capital expenditures is generally through bonds. The level and life of the projects affecting the impact area should provide a strong basis for revenue bonds. Bonds subject to tax rate and assessment limits may be more difficult to float on a timely basis due to the lag in new development being listed on the tax rolls.

Other support for capital expenditures comes from Federal grants and loans. Extensive use of this mechanism is already in evidence in the area for such things as water and sewer system improvements. In the future, areas with high rates of growth due to energy development may qualify for higher priorities, larger projects, smaller local shares, etc.

Housing is generally expected to be developed and financed by conventional means. The source of funds for large-scale development is nationwide and the number and duration of employment opportunities should indicate a sound investment opportunity. However, some initial reluctance may be encountered which could result in the direct project participation described above.

Interest in mitigating energy-related socioeconomic impacts is quite high at the Federal level. The U.S. Senate is considering a bill (S. 1493) to assist energy-impacted states, local governments, and Indian tribes. The bill proposes a program of grants and loans for planning and implementation of actions to mitigate impacts arising from energy-related development.

2.10 References

1. Kiner, Phil and Dobbs, Thomas. "Location Aspects of a Rural Work Force: The Wyoming Uranium Industry," contributed paper for the AAEA/CAES/WAEA Joint Annual Meetings, Edmonton, Canada, August 8-11, 1973.

2. Gilmore, John S. Presentation to the First Annual Economics of Energy Workshop sponsored by the Association for University Business and Economic Research, Snowbird, Utah, August 23, 1977.

2.11 Natural, Scenic, and Cultural Resources

2.11.1 Scenic and Natural Features

Description - The topographic variety of the Edgemont project area provides a number of features of scenic and natural interest, principally canyon formations and Ponderosa pine-covered hills interspersed with the grass and sagebrush-covered plains which comprise the majority of the project area. Distinctive natural and scenic features on or in the vicinity of the project site are identified in Figure 2.11.1-1. Although the characteristics and variety of these features provide aesthetic appeal, none are unique to the area.[1]

The only feature in the project vicinity proposed for special scenic designation is Red Canyon-Fourmile Creek Drive extending from U.S. Highway 18 east of Edgemont to U.S. Highway 16 west of Custer. This area is proposed by the South Dakota Department of Transportation for inclusion in the Federal scenic roads and parkways plan.[2] The Red Canyon segment of the route passes in a north-south direction between the central and southern blocks of the project area and intersects one disjuncted 6 ha (15 acre) parcel under lease. The proposed Runge East mine site is located approximately 1.9 km (1.2 mi) west of the route at the nearest point.

Major regional scenic resources and tourism associated with these attractions are discussed in Section 2.11.4.

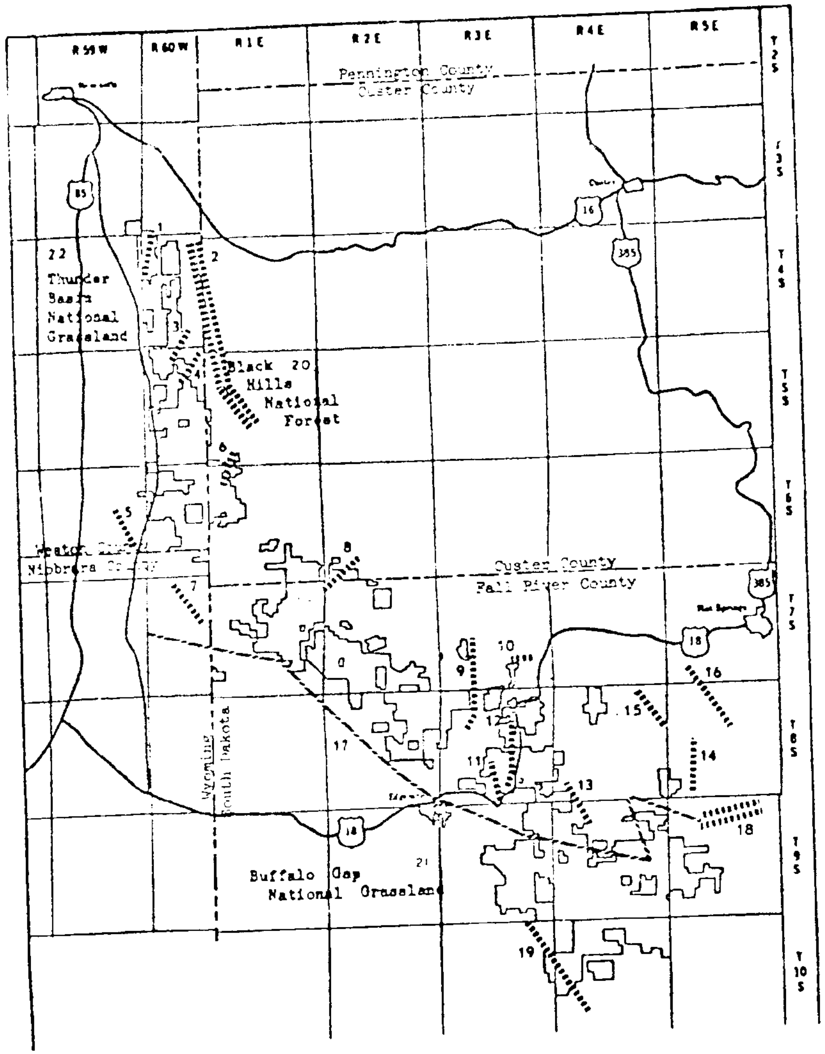
Impacts - Surface disturbance from mining operations will be very limited. The reclamation program will ensure that such alterations eventually blend with the existing landscape.

Intervening topography between the Runge East mine site and the proposed scenic road through Red Canyon precludes viewing of the site from the route. Primary access to the Runge East mine is from existing roads to the west, and these routes will be used as haul roads. Thus, the project will not adversely affect the proposed scenic road, or other scenic and natural features.

2.11.2 Historical Resources

Description - A historical and cultural site survey of the Edgemont Project area was conducted.[1] An archaeological survey of portions of Fall River and Custer Counties, South Dakota, done for TVA by the South Dakota Archaeological Research Center also addressed historic sites. The Historic Sites Survey included the documentation of essentially all habitable structures, structure remains, and manmade improvements existing within or on the immediate fringe of the Edgemont project area. These were plotted on maps and accompanied by both written and pictorial descriptions of features. Copies of these materials have been furnished to the State Historic Preservation offices of Wyoming and South Dakota.

Using these inventory records as a guide, a field review was conducted to evaluate significance of sites and assess potential impacts. Since the majority of the project area and sites in question were located in Fall River and Custer Counties, South Dakota, representatives of the South Dakota Historic Preservation



LEGEND

Distinctive natural features on or adjacent to the project area:

1. Whoopup Canyon
2. Elk Mountains
3. Clifton Canyon
4. Carr Canyon
5. Rattlesnake Ridge
6. Plum Canyon
7. Twentyone Divide
8. Bennett Canyon
9. Red Canyon
10. Matias Peak
11. Sheep Canyon
12. Dead Horse Canyon
13. Chilson Canyon
14. Cascade Spring and Falls
15. Lindsey Canyon
16. Arabaugh Canyon
17. Cheyenne River
18. Angostura Reservoir
19. Unnamed Ridge
20. Black Hills National Forest
21. Buffalo Gap National Grassland
22. Thunder Basin National Grassland

Figure 2.11.1-1 Natural Features on or in the Vicinity of the Edgemont Uranium Mining Project

Office participated in the field review, which also included the project area in Weston County, Wyoming. In a subsequent meeting, these representatives reviewed the results of the field analysis.

No sites currently listed in the National Register of Historic Places are located within the project area. Other than the route of the Cheyenne and Deadwood Stage which passes through the town of Edgemont, no Register sites are located within 8 km (5 mi) of the project area boundaries. One potential Register site, the Whoop-up Canyon Petroglyph, is located at the northern extremity of the project area in Weston County, Wyoming. This site appears in the State Register of Historic Places and is proposed for nomination to the National Register. The petroglyphs, appearing on both sides of the narrow canyon, are contained in a section extending over perhaps 27-37 m (30-40 yd).

Six of the approximately 600 "ghost towns" recorded[1] in the Black Hills region are within the vicinity of the project area, along with three sidings of the Chicago, Burlington, and Quincy Railroad. Two of these "towns" containing the remains of a few buildings are on the fringe of the project area itself and the rail sidings (little remains except ruins) are within the area. These sites were generally poor and were judged to have no historical or architectural significance.

The S&G (Sturgis and Goddell) Ranch Site (extant 1870's) may represent one of the first permanent pioneer settlements in the region. It is located at the edge of the project area near the site of the former town of Dewey (new buildings now exist on the rail siding at this postal station). Little remains of the ranch site except foundation stones, a few logs, and a cellar. Scattered domestic debris was noted. Further photographic documentation of this site and the site of two abandoned ranch buildings at other locations is being done for the South Dakota Historic Preservation Office by TVA for purposes of completing their research. These sites are privately owned.

No other features of interest were noted in the evaluation and field review. Other than the site of the S&G Ranch, no additional sites or structure eligible or potentially eligible were judged to exist within or immediately adjacent to the project area.

<u>Impacts</u> - The proposed mining activity will not directly or indirectly impact any sites or structures with architectural or historical significance. No such sites or structures are on lands proposed to be mined nor are any found within the fenced compounds associated with mining activity. Sites with any identified potential are located at considerable distances from the proposed mining so that indirect impact is of no consequence. Knowledge gained from the inventory and the evaluation process associated with this proposal should measurably add to the states' information about cultural resources in the counties involved.

The State Historic Preservation officers of South Dakota and Wyoming are in general agreement with the impact analysis contained herein.

Because of this, TVA believes that no adverse effect from the proposed project will occur to any historic site or structure now in or potentially eligible for inclusion in the National Register of Historic Places.

2.11.3 Archaeology - Archaeological reconnaissances and surveys were performed intermittently in the project area from March 1975 until August 1977 by the State of South Dakota's Archaeological Research Center. One hundred twenty-six (126) archaeological sites and seventy-five (75) archaeological loci were encountered. The sites range in time from Paleo to Plains Villages and consist of pictograph and petroglyph sites to small resource exploitation sites to large habitation sites occupied for extended periods of time. Although no sites listed in the National Register will be affected by the project, National Register eligibility status for the surveyed sites is currently being evaluated by the State of South Dakota.

No archaeological sites are located in the 1/4 section with either the Burdock shafts or the Darrow Extensions. One site is located in the 1/4 section with the Spencer-Richardson mine, and two sites are located in the 1/4 section with the Runge East mine.

Archaeological site avoidance was maintained during the exploration phase of the project, and site avoidance is the continued goal during development and mining. Where required, sites in the area of mining activity will be fenced. If during the course of mining it becomes necessary to adversely impact a site that has been determined eligible for the National Register appropriate mitigation of the impact will be implemented through consultation with the Advisory Council on Historic Preservation and the State Historic Preservation Office.

Mining personnel will be made aware that archaeological resources exist in the project area. Known archaeological sites will be delimited, and if a new site is discovered, the state archaeologist will be notified and the site protected, pending investigation.

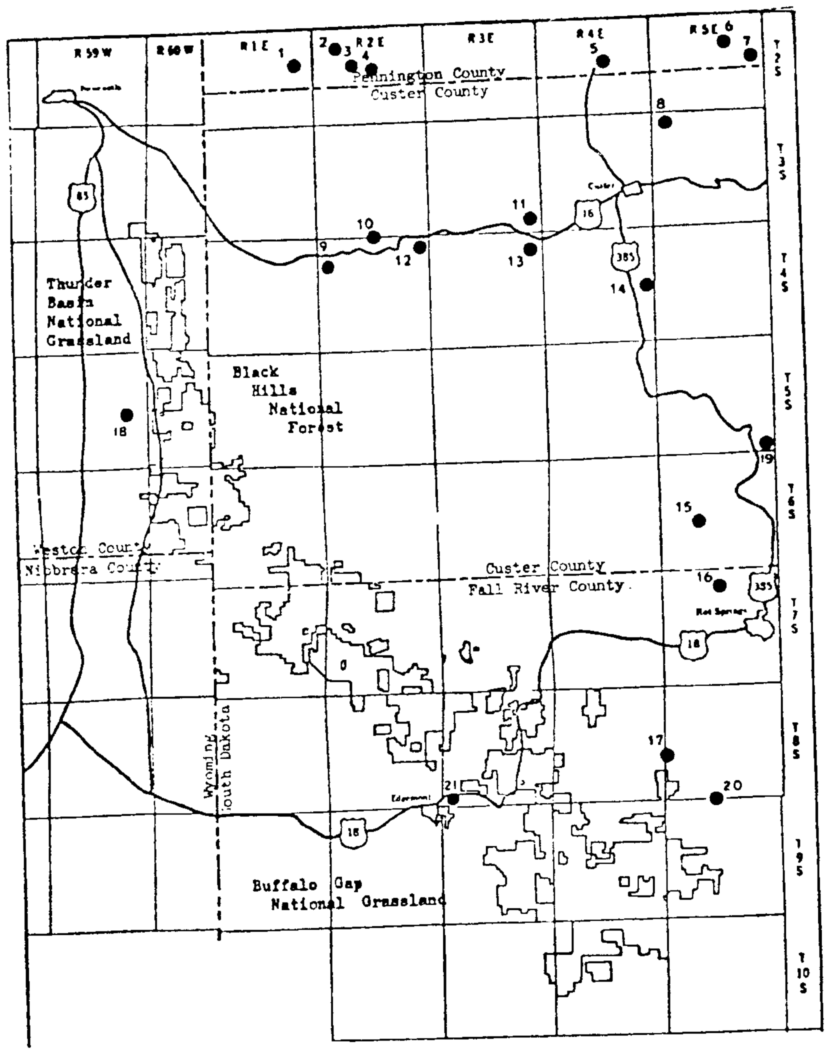
2.11.4 Recreation

Description - No existing recreation facilities are located on the Edgemont project area. As discussed in Section 2.11.1, the project area and vicinity possess a number of scenic features which have some potential recreation value, including a proposed scenic road through Red Canyon. Fringe areas of the Black Hills National Forest are located within the project area, but these areas have no developed facilities and potential use is limited further by poor accessibility.

Recreational activity in the project vicinity is associated chiefly with tourism and hunting. Because of the proximity of the project area to the Black Hills and other western South Dakota-eastern Wyoming attractions, the project vicinity is exposed to more tourist activity than other regions of these states. Hunting activity is discussed in Section 2.9.2. Due to low flows and turbid water conditions, fishing and other water-based recreation activity on project vicinity streams is very limited.

Major regional recreation areas and attractions include Buffalo Gap and Thunder Basin National Grasslands, Wind Cave National Park, Jewel Cave National Monument, Mt. Rushmore National Memorial, Custer State Park, and Angostura State Recreation Area as well as the Black Hills National Forest. These and other regional facilities are identified in Figure 2.11.4-1. A wide variety of public and commercial recreation facilities and services are associated with these areas.[2,3]

Impacts - The Edgemont project will not result in significant impacts to recreational activity in the project area. Project-related impacts will be negligible. No mining is currently planned on National Forest lands, and any future proposals for mining on these lands would be subject to the continuing review and approval of the U.S. Forest Service. Portions of the project area are visible from scenic overlooks located south and southeast of the properties on U.S. Highway 18 and South Dakota Highway 89, respectively; but the proposed mining activities are removed from highways. As noted in Section 2.11.1, the proposed scenic road through Red Canyon would not be affected visually or by traffic associated with mine operations at the nearby Runge East mine. Thus, impacts will be confined essentially to increased use of regional recreation facilities and pressure on wildlife resources from in-moving project employees. Within the context of overall regional development, cumulative recreation impacts from in-movers associated with this and other mining projects become more important because of limited state, county, and municipal recreation lands and facilities in this area.[3] However, project-related effects on regional recreation opportunities are expected to be minor. (See Section 2.10 for information related to community recreation and the project's relationship to regional development patterns and cumulative socioeconomic impacts).



LEGEND

Recreation areas in the vicinity of the project area:

1. Rogers Lake
2. Ice Cave
3. Bear Trap Cave
4. Igloc Cave
5. Oreville Campground
6. Pine Creek Natural Area
7. Mt. Rushmore National Memorial
8. Sylvan Lake - Custer State Park - The Needles
9. Teepee WC
10. Jasper Cave
11. Harry Mills Campground
12. Jewel Cave National Monument
13. Comanche Park Campground
14. Beecher Rock
15. Onyx Cave
16. Cold Brock Reservoir
17. Cascade Springs
18. MW Lake
19. Wind Cave National Park
20. Angostura Reservoir and State Recreation Area
21. Cheyenne River Campground

Figure 2.11.4-1 Location of Recreation Areas in the Vicinity of the Edgemont Uranium Mining Project

2.11 References

1. Mine Reclaimation Consultants, Historical Resources in the Edgemont Lease Area. Unpublished Manuscript. TVA. Norris, Tennessee.

2. South Dakota Division of Parks and Recreation. South Dakota Comprehensive Outdoor Recreation Plan. 1975.

3. University of Wyoming, Division of Business and Economic Research. Outdoor Recreation in Wyoming. Vol 1-3, 6-7. 1969-72.

2.12 Other Considerations

2.12.1 Liquid Wastes

2.12.1.1 Underground Mine Water - Of the three underground mine areas identified, only the Burdock area is expected to require significant depressuring. Depressuring will be accomplished by pumping two or three wells located around the periphery of each mine shaft and by the mine's subsurface drainage system. Each of the peripheral dewatering wells at Burdock No. 1 shaft will be pumped at an average rate of 14.2 l/s (225 gal/min), beginning prior to shaft construction and lasting for as long as needed during the mining. The subsurface drainage system routes infiltrated water to each shaft's mine sump for pumping to the surface. This flow for the Burdock No. 1 shaft is estimated to be 42.6 l/s (675 gal/min).

This mine water, if contaminated, will be temporarily retained in impervious holding ponds before release into the local drainages. The pond effluents must comply with the applicable limitations which will be established in the NPDES permit for the mining operations. Other than suspended solids, it is anticipated that radium-226 and possibly uranium will be the only constituents that may occur in sufficiently high concentrations to require treatment before discharge. If radium removal is necessary, a barium chloride coprecipitation process will probably be used in conjunction with the impervious, settling pond system. Any uranium removal necessary will be by ion exchange. No significant adverse water quality impacts are anticipated from the discharge of the mine waters into the local drainage.

The rate of water discharge associated with depressuring at Burdock No. 2 shaft is not known at this time but will be less than that identified for shaft No. 1. Little or no water is expected from the Darrow and Runge East mines. The water from each of these mines will be managed in a similar manner as described for Burdock No. 1 shaft, if necessary.

2.12.1.2 Surface Mine Water - Ground water is not expected to be encountered at the Spencer Richardson surface mines. Any water accumulated in the open pit will be managed in a manner similar to the underground mines, if necessary (see Section 2.12.1.1).

2.12.1.3 Runoff - Area runoff outside the boundary of the mining operations will be diverted around the areas disturbed by mining. Runoff from overburden storage, topsoil storage, revegetated areas, and other disturbed areas will be controlled as necessary by a system of dikes, trenches, ponds or other appropriate measures. Except for ore-storage runoff, which may be controlled separately, any runoff at the mine sites contaminated by radioactive constituents will be routed to the mine water treatment facilities described in section 2.12.1.1.

2.12.1.4 Sanitary Wastes - The sanitary wastes at the Burdock mine will be treated by conventional, state-approved systems, consisting probably of a combination of septic tanks, and/or sewage lagoons. At the other proposed mines, portable

toilet facilities will be provided. All systems will be operated in accordance with state and Federal requirements.

2.12.2 Solid Waste - All solid waste, by defined as Public Law 94-580, generated by the mining and associated activities will be stored, collected, and disposed of in accordance with applicable solid waste management regulations (local, state, or federal). Municipal-type solid waste will be generated at a rate of approximately 1.8 kg (4 lb) per worker per day. This solid waste will consist primarily of paper, cans, bottles, rags, wrappers, containers, packing materials, oil filters, and garbage. At the peak employment of 140 people, about 252 kg (560 lb) of solid waste will be generated per day. Since this is a relatively small quantity of waste, the most economical method of disposal will be to use a local, approved sanitary landfill.

Scrap wood will be offered to the general public for salvage (firewood or other use). Residue from public salvage will be burned and/or buried on-site, or disposed of off-site with the "domestic-type" solid waste. The recoverable resource portion of domestic-type solid waste (metals, rubber, etc.) will be recovered for sale if feasible.

All potentially hazardous wastes (as defined by P.L. 94-580) will be stored in suitable labeled containers on-site until they can be transported to an approved hazardous or chemical waste disposal facility.

2.12.3 Noise - A survey of onsite baseline noise was conducted May 2, 1978, at the proposed mining sites on the Edgemont properties. Weather conditions during daytime measurements consisted of partly cloudy skies and wind speeds relatively constant in a range between 22 to 33m/s (10-15 mi/h) with gusts up to 67 m/s (30 mi/h). Wind screens were used to minimize the wind effects. Nighttime values were taken under clear skies and low wind speeds of 0 to 11 m/s (0-5 mi/h). Baseline noise levels were recorded for approximately 15 min at each of the locations during both day and night. These measurements were used to calculate the L_{eq}, L_d, L_n, and L_{dn}. The L_{eq} is an equivalent steady state noise level which in the stated period of time would contain the same noise energy as the time varying noise measured during the same time period. The day/night equivalent sound level (L_{dn}) is a L_{eq} for a 24-hour period with a 10 dB weighting applied to nighttime values. A daytime equivalent (L_d) is a L_{eq} for the daytime period (0700-2200 hours) and nighttime equivalent (L_n) is a L_{eq} for the nighttime period (2200-0700 hours).

At the proposed mining sites, baseline noise levels are low compared to EPA guidelines.[1] The major sources of noise at these locations are the proximity of railroad tracks and wind noise through nearby vegetation (pines). Other noise sources are birds and other animals, both domestic and wild, and some vehicle traffic on nearby roads. There are 35-40 coal-hauling trains per day, each consisting of 100-110 cars. It is estimated that as many as 80 such trains per day will pass along this route by 1980.

Construction Noise - Noise radiated from the mining areas during construction will have minimum impact on residents of the

area. The area is scarcely populated with only 25 people living in nine residences within the vicinity 3.2 km (approximately 2 mi) of the mines. Noise radiated during construction will originate from the use of heavy construction equipment located above ground. Federal noise regulations covering noise emissions from construction equipment, such as crawler tractors, portable compressors, and medium and heavy duty trucks, will be met.

Operational Noise - Operational noise from the mining operations will originate from ore hauling equipment and pumps; surface-mounted equipment such as ventilation fans and compressors; and other heavy equipment as listed in Tables 1.1.2.1-1 and 1.1.2.2-1. Mine ventilation equipment and compressors are expected to operate 24 hours per day while other equipment will operate only 8 hours per day with the possible exception of truck operations for 16 hours per day. Noise levels at the site boundaries are not expected to exceed 60 dB(A) during daytime hours and 55 dB(A) during nighttime hours. The nearest residence is approximately 1.8 km (1.1 mi) from a proposed underground mining site. The average baseline-noise level for the area is approximately 66dB (L_{dn}). With a property line sound level of 60 dB(A), impact from mining operations at that residence will be insignificant. This sound level should be well within the EPA guideline values. There are no known noise ordinances near the mine sites.

When mining operations begin a survey will be made to determine site boundary noise levels. Operation of these mines shall conform with all applicable noise regulations.

2.12 References

1. U.S. Environmental Protection Agency Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety, Report No. 550/9-74-004. March 1974.

3. Reclamation

Purpose: The objective of this reclamation plan is to outline the procedures which will be used to return lands disturbed during mining and associated operations to a self-sustaining and productive vegetation. This reclamation plan is flexible and designed to take advantage of the most appropriate procedures for each site to be reclaimed. Inasmuch as the proposed plan of reclamation is written to comply with state and federal regulations, it is standard procedure for the area. As individual sites are identified, this reclamation plan will be supplemented with a detailed plan covering only the immediate area of disturbance. In South Dakota, specific reclamation objectives and procedures will be established after consultation between TVA and the surface landowners. Since the land is primarily used for livestock grazing, reclamation for livestock grazing will be the primary objective. The South Dakota Department of Wildlife, Fish, and Parks; the South Dakota Conservation Commission; and other appropriate Federal and state agencies will be consulted when the surface owner has other land-use objectives. There is no mining planned on the Wyoming property. If mining is extended into Wyoming, however, affected land will be reclaimed to a use equal to or greater than its highest previous use. Standards adopted by the Wyoming Department of Environmental Quality, Land Quality Division, will be followed and the reclamation goal will be to establish the vegetative cover on the affected land such that it will be capable of renewing itself under natural conditions.

Successful reclamation requires the use of (1) proven water conservation and wind and water erosion prevention practices; (2) soil and plant species compatibility; (3) proper time, depth, rate of seeding and transplanting techniques; (4) topsoil or other material identified as suitable for a plant growth medium; and (5) experienced personnel who can make on-the-spot judgments on the adequacy of the seedbed, moisture, and other physical conditions of the soil on the area to be revegetated.

3.1 Topsoil and Overburden Stockpiling

Since most of the planned mining will be underground, surface disturbance will be limited. Topsoil will be removed from all areas affected by mining activities (see Section 1.1), segregated from other overburden materials, and marked in accordance with the applicable regulations. Where feasible, stockpiles will be located on leeward slopes of existing hills and away from existing drainages to protect them from prevailing winds and from water erosion. If the stockpiled topsoil is not to be used for as long as six months, it will be seeded to provide temporary cover.

3.2 Surface Preparation

If new open pits are developed, they will be backfilled with overburden. Extended surface mining from old pits and other surfaces disturbed by mining activities will be graded and contoured to blend in with the surrounding undisturbed topography and covered with topsoil or suitable subsoil (see Section 3.4). If final placement and shaping of overburden material results in excessive compaction, the top 46 to 61 cm (18-24 in) will be ripped while the material is relatively dry so that better shattering will be obtained.

Haul roads that are abandoned will be ripped and covered with topsoil. Shafts in the underground mine areas will be sealed in accordance with applicable Federal and state regulations. Procedures described in Section 3.4 through 3.7 will be implemented.

3.3 Placement of Overburden Containing Undesirable Materials

Underground mine waste will be tested for toxic materials. If toxic concentrations are encountered, the stockpiled material will be covered with an impermeable layer of nontoxic overburden (according to the appropriate state requirements) and compacted to minimize release into surface and subsurface water or, some other approved method of handling will be used. Upon permanent disposal, no toxic material will be placed into the subsurface hydrologic system nor within 2.4 m (8 ft) of the surface. Results of the overburden analysis[2] from the Spencer Richardson mine show that overburden materials should not pose a revegetation problem. Both the topsoil and subsoil at the Spencer Richardson mine have chemical and physical properties which make them suitable for use as a surface covering. Other overburden ranges from moderately to highly saline, but will be covered with at least .3 m (1 ft) of subsoil and topsoil prior to revegetating.

3.4 Topsoil Preparation

Fifteen to 22 cm (6-9 in) of topsoil will be spread over the shaped and prepared surfaces. Care will be exercised to avoid movement of topsoil when it is wet, particularly heavy, fine-textured material. If periods occur when permanent cover cannot be established, topsoil will be graded to provide a rough surface to minimize wind and water erosion. Before seeding, the need for surface modification (such as scarification) for water conservation will be determined and implemented.

3.5 Species, Seeding Rates, and Methods of Application

Table 3.5-1 lists the species and rates suggested for the various soil conditions. The species listed are adapted to the climatic and soil conditions existing in the area and are highly palatable to livestock, tolerant to grazing, and available for year-round use by livestock. The seed mixtures are designed to yield the maximum number of seedlings that the area can support. If other land use objectives are sought by the surface land owners, appropriate governmental agencies will be consulted for advice on seeding mixtures. Modification of the seeding mixtures will be considered throughout the period of reclamation if onsite performance of the species indicates that changes are needed.

Drill seeding will be used where practical. Seeding will be on the approximate contour so drill furrows will trap moisture and prevent excessive erosion of the newly seeded areas. If slopes are too steep for drill equipment, the seed mixture will be broadcast at approximately twice the rate given in Table 3.5-1 and followed by brush drag or similar treatment to ensure seed coverage, or seed may be applied by other acceptable methods such as hydroseeding.

TABLE 3.5-1

Recommended Seeding Rates
of Pure Live Seed kg/ha (lb/acre)*

Species	Ordinary Uplands	Heavy Soils Depressions	Sandy Soils	Wet or Subirrigated Areas
Agropyron smithii Rosana	4(4.5)	6(6.7)		4(4.5)
Agropyron dasystachyum Critana	3(3.4)	3(3.4)		
Agropyron riparium Sodar		2(2.2)	3(3.4)	3(3.4)
Bouteloua curtipendula Pierre or Butte	2(2.2)			
Calamovilfa longifolia			1(1.1)	
Schizachyrium scoparium Blaze	2(2.2)	2(2.2)	2(2.2)	
Oryzopsis hymenoides			3(3.4)	
Stipa viridula Lodorm			2(2.2)	
Agropyron elongatum Alkar or Orbit				4(4.5)
Astragalus cicer				3(3.4)
*Atriplex canescens***			2(2.2)	

*Rates indicated are for drilled stands.
**Add to mixture if a palatable shrub is desired by landowner.

3.6 Time of Seeding and Protection of Seeded Areas

Due to the low annual precipitation (see Section 2.7), seeds must be sown when maximum moisture is present for germination and seedling establishment. Fall seeding will be done from October 1 until the ground freezes, about December 1. Spring seeding will be done between March 15 and May 1.

To ensure optimum plant establishment, seeded areas will be protected by fencing, herding, or similar approved animal control techniques, for two growing seasons or until the vegetation cover becomes self-sustaining. TVA will seek the cooperation of the surface owners to achieve successful reclamation. Weed control should not be needed once the desired plant species become established.

3.7 Planting of Trees and/or Shrubs

Areas which are to be reclaimed for tree and shrub production will receive the same preparation as those for grazing. A good stand of desirable grasses will provide understory cover and prevent invasion by weeds as well as help control erosion.

The trees to be transplanted will be placed in depressions approximately 18.6 dm^2 ($decimeter^2$), (2.0 ft^2) to trap additional moisture and aid in establishment. The depressions will be made after the grass seeding to minimize competition between the new transplants and grasses. Ponderosa pine or a mixture of ponderosa pine and Rockymountain juniper will be planted on the dry upland sites.

3.8. Previously Mined Pits

On the project area there are several unreclaimed pits and adits left by previous owners of the mineral rights. These mines date back as far as 1951 and were developed prior to effective regulations on reclamation. Where TVA will extend existing mines, new surface disturbed areas will be reclaimed in accordance with the procedures described in the preceding sections. As a minimum, this will consist of reclamation to a condition equivalent to that existing before mining by TVA.

3.9 Reclamation Schedule

As mining and associated activities are completed on any area, reclamation as described in Sections 3.2 thru 3.7 will be implemented. If the former activities cease during a seeding and planting season, reclamation procedures will be implemented immediately. If not, the procedures will be implemented the following season.

3.10 Alternative to the Proposed Reclamation

Reclamation alternatives will be governed by mining; i.e., in the event of mining and/or associated activities, the most site specific reclamation information available will be followed. However, roads and buildings or other structures may be retained by the surface owners for uses after mining activities have ceased. This would be reported to the South Dakota State Conservation Commission (or the Wyoming Land Quality Division in the case of Wyoming property), and these facilities would then become the responsibility of the surface owner.

3.11 Reclamation Monitoring

An onsite revegetation monitoring program will be conducted. TVA will work with the South Dakota Conservation Commission and/or the Wyoming Land Quality Division and other agencies suggested by them to develop a program with acceptable monitoring techniques.

3. References

1. TVA, Division of Forestry, Fisheries, and Wildlife Development. Reclamation plan, Edgemont lease. January 1977. In TVA Files.

2. Colorado School of Mine Research Institute. Chemical and Physical properties of Edgemont topsoil. May 1977. In TVA Files.

4. Alternatives to the Proposed Actions

In developing this proposal, TVA considered the following alternatives:

1. No Action - TVA has a statutory obligation to supply an ample amount of electricity at the lowest feasible cost to the area TVA serves. Since by 1986 nearly half of TVA's installed capacity of 48 x 10^6 kw will be nuclear fueled, an adequate supply of uranium must be made available on a timely basis. Not participating in the proposed action would require TVA to obtain an equal amount of uranium from other sources. TVA has identified no advantages, environmental or other, which would accrue from adoption of this alternative. Pursuing this course would impair TVA's ability to provide the required power without incurring substantially higher costs. Therefore, no action is considered to be an unacceptable alternative.

2. Purchase of Uranium - TVA has the largest commitment to power production from nuclear sources of any electric generating system in the United States. This large commitment requires a stable, long-term, ensured supply of uranium fuel. This objective is best met through a diversity of sources; therefore, it is unwise to depend entirely on purchases of uranium for the only source of supply. In addition, the present market conditions for the purchase of uranium are not favorable. The supply-demand imbalance has created a situation in which many uranium producers are able to sell their product at a premium without regard to cost of production. It is, therefore, to TVA's benefit and that of the utility industry as a whole, to take steps to increase uranium production. To this end, TVA has begun mineral rights acquisition activities to provide a stable long-term supply and to allow the acquisition of uranium at a lower cost than that which would be possible through purchases on the open market.

3. Mining Other Properties - TVA is also considering participating in mining ventures at other locations. However, substantial lead times are required in order to properly plan, develop, and achieve production from an uranium mine. Although exploration and planning for other mining ventures are continuing, this does not preclude the necessity for the proposed project. Moreover, a decision by TVA to abandon this proposal in favor of mining at other locations would not preclude the development of these properties by someone else. Furthermore, mining at other locations would likely result in similar types of impacts of equivalent magnitude.

4. Alternative Mining Techniques - Alternative mining techniques were considered before choosing the methods outlined herein. In TVA's opinion, the planned mining techniques represent the best balance among environmental, economic, technical, and other factors. Mining techniques will be continually reevaluated with the above factors in mind and as additional minable reserves are discovered.

5. Delay in Mining Schedule - Although delay in the proposed mining for several years might allow the incorporation of future technological advances in mining techniques which would result in reduced environmental impacts, we have identified none which are expected to be available during the life of the project. The timing of uranium production from the Edgemont project is critical because this production is needed to fuel TVA's reactors during the early 1980's. In the event production is delayed, it would be necessary to obtain substitute fuel from other sources which would be mined by present technology and probably at greater cost to TVA. Since TVA has identified no significant environmental or other benefits from a delayed mining schedule, the cost of delayed production dictates the rejection of this alternative.

6. Conclusions - The alternatives of no action, of purchasing uranium or of mining at other locations do not avoid the types of environmental impacts which will result from the proposed Edgemont mining project, nor would these alternatives prevent development in the proposed project area because the identified ore deposits would most probably be mined by other producers. Moreover, each of the alternatives considered would result in higher economic cost to TVA than the proposed action.

5. Adverse Environmental Effects Which Cannot Be Avoided

Mine-water discharge will cause a temporary depression of ground water levels in the Lakota Formation and to a lesser extent, in the Fall River Formation in the vicinity of the mines, and water levels in wells in the area will decline. Many artesian wells that now flow within the affected area will cease to do so after mining operations begin; however, the aquifers will remain saturated and water will still be available by pumping except possibly in the immediate vicinity of the mine.

The increase in population due to the project will place additional pressure on the surrounding communities and counties to provide needed community services.

There will be a minor alteration of specific topographic features near the shaft sites due to the mine waste piles. However, the land surface will be reclaimed to blend with the natural topography.

There will be a temporary minor degradation of air quality in the immediate vicinity of the mining operations due to fugitive dust and exhaust emissions from combustion-driven mining and support vehicles and equipment and releases of radon and short-lived radon progeny from the shafts and ore piles. This degradation is not expected to exceed air quality standards and will cease after the project is completed.

There will be a loss of plant and animal species from mined areas. Reclamation will mitigate impacts to flora and fauna, but it is unlikely that reclaimed communities will closely resemble existing species composition and diversity.

There will be a temporary change in land use from rangeland and forest to mineral extraction during the life of the project. However, since the operation is primarily underground mining, surface disturbance will be minimal. No surface subsidence is anticipated.

Depending on the mill location chosen, there will be an increase in vehicular emissions resulting from the transport of the uranium ore to the mill, an increase in vehicular traffic, and associated increased wear and tear on public roads.

6. Irreversible and Irretrievable Commitments of Resources

The principal irreversible and irretrievable commitment of resources will, of course, be the use of the mined uranium for energy production. It is estimated that a minimum of 1.9 x 10^6 kg (4.3 x 10^6 lb) of U_3O_8 will be extracted. As much as 10 percent of the underground minable ore will be left in the ground. About 8.5 x 10^6 l (2.2 x 10^6 gal) of petroleum fuels will also be expended plus a yet to be determined amount of electricity. Some of the materials used in the mine and support buildings and equipment will also be unrecoverable.

7. Relationship Between Local Short-Term Uses Of The Environment Versus Long-Term Productivity

There will be no significant long-term effects on the environment due to the proposal. During the proposed mining, approximately 32 ha (80 acre) would become unavailable for other uses. Virtually all of this new disturbance would be reclaimed after mining (see Chapter 3) and would then be available for essentially the same purposes as before mining. Differences in aquifer water levels attributable to aquifer depressuring for mining should be insignificant relative to premining levels about 10 years after completion of the project.

8. Milling

Plans for milling of the Edgemont ores are in the early stages of development. Alternative locations, processes, and capacities are being evaluated. A maximum capacity is expected to be 680 t/d (750 ton/d), and the following analysis is based upon this capacity. Process parameters used in this analysis are from one process under study, but should not differ significantly if an alternative process is selected.

A design feed of 0.12 percent U_3O_8 and 0.18 percent V_2O_5 ore will provide a daily mill input of 817 kg (1,800 lb) U_3O_8 and 1,226 kg (2,700 lb) V_2O_5. Probable extraction efficiencies will be 98 percent for uranium and 80 percent for vanadium.

The mill site fenced area should be about 80 ha (200 acre). Additional land may be purchased around the fenced site as a buffer zone and to allow for future expansion should ore reserves be expanded greatly.

Tailings disposal facilities will be of two types. A pond of about 16 ha (40 acre) will be required for disposal of solid tailings for ten years of mill operation, assuming that the thickness of tailings does not exceed 12 m (40 ft). A lined evaporation pond will also be required for waste effluent. This pond should not exceed 8 ha (20 acre) in size.

All of the non-recoverable U_3O_8 is expected to be released to the solid tailings disposal pond. Approximately 20 percent of this U_3O_8 is expected to be dissolved in the residual liquid in the solid tailings. Practically all of the non-recoverable V_2O_5 will also be released to the solid tailings. Only about 3 percent of this should be dissolved in the interstitial liquid. Less than 1 percent of the lost V_2O_5 is expected to be released to the evaporation pond.

Water consumption for the entire process should be about 246,000 l/d (65,000 gal/d). Annual fuel consumption is expected to be 159,000 l (42,000 gal) propane, 5,110,000 l (1,350,000 gal) No. 6 fuel oil, and 350,000 l (92,400 gal) No. 2 fuel oil. In addition, approximately 933 kW of electrical power will be required to operate the mill.

It is believed the following sections provide a reasonable discussion on a generic basis of the potential environmental impacts of a uranium milling facility of the type and capacity anticipated to be required. However, the impacts could be somewhat different depending on advances in the state-of-the-art in uranium milling techniques and the details of the final mill design. When milling arrangements have been agreed upon, a more detailed environmental assessment of the proposed mill and mill site will be developed in the context of the application for the mill license.

In summary, no unacceptable environmental impacts associated with building and operating a mill were identified in this generic assessment.

8.1 Air

Operation of the Edgemont mill facility will result in increased ambient concentrations of gaseous pollutants (sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide) and suspended particulate matter. Fugitive dust and fossil fuel combustion emissions will both contribute to the increase in ambient concentrations.

Fugitive dust releases will result from construction and hauling activities; tailings piles, ore piles, and stockpiles; and other disturbed land surfaces associated with the milling operation. However, mitigative procedures are expected to reduce the potential for significant nonradiological air quality impacts due to fugitive dust releases. Estimates of the emission rates of dust discharged to the atmosphere from the dust control equipment are presented in section 8.2 of this chapter.

The combustion of fossil fuels will release pollutants to the atmosphere. It is estimated (based on the annual fuel consumption rates presented in preceding section) that approximately 42 l/h (11 gal/h) of No. 2 fuel oil, 19 l/h (5 gal/h) of propane and 855 l/h (226 gal/h) of No. 6 fuel oil will be consumed, producing approximately 18.3 g/s (145 lb/h) of sulfur oxides, 1.25 g/s (10 lb/h) of particulates, 0.15 g/s (1.2 lb/h) of carbon monoxide, 0.03 g/s (0.2 lb/h) hydrocarbons, and 1.8 g/s (14 lb/h) of nitrogen oxides. The use of gasoline-powered vehicles will generate additional combustion emissions.

These combustion products will be emitted from multipoint sources at varying locations and with different release characteristics. Therefore, detailed assessment of the air quality impacts which can be expected to result from these emissions is not possible until more specific design information becomes available. However, the Edgemont mill facility will meet all applicable ambient air quality standards and air pollution control regulations.

8.2 Radiological

During operation of a uranium mill, small amounts of radioactive materials are released to the atmosphere and ground and surface waters. These releases may result in exposure of area residents to above-background concentrations of radioactive materials, primarily through inhalation of air and ingestion of food or water. Of importance in some cases, may be direct irradiation by materials confined on the mill site.

For conventional drying and packaging, discharges to the atmosphere from dust control equipment will consist of the off-gas from the ore dryer, the effluent from two baghouses on the crushing circuit, and the effluent from the scrubber serving the yellowcake finishing circuit. The ore dryer will operate at about 6,800 l/s (14,400 ft³/min) with the off-gas at a temperature of 70° C (160° F). With two cyclones in series in the offgas stream, ore dust will be emitted at a rate of about 20 kg/h (45 lb/h). The baghouses will include a large baghouse operating at about 7,900 l/s (16,800 ft³/min) and emitting less than 2.3 kg/h (5 lb/h) ore dust and a small baghouse operating at 520 l/s (1,100 ft³/min) and emitting less than 0.5 kg/h (1 lb/h) ore dust. The yellowcake finishing circuit scrubber will be essentially 100 percent efficient with no detectable quantities of yellowcake dust expected in the effluent stream.

Radioactive particles may also be suspended into the atmosphere as a result of wind action on exposed ore stock piles and mill tailings. Radon-222 and its short-lived decay products also will be released to the atmosphere from the mill building, the tailings retention system, and ore stock piles. Releases to area waters will result from leakage, if any, from the tailings ponds. With proper design, construction, and operation of the mill, concentrations of radioactive materials released to the environment will be below applicable regulatory limits. The health and safety of the public should not be impaired either by the planned releases or by accidental or short-term releases. Further, direct radiation is not expected to be an important exposure pathway for a mill. The releases would be significantly reduced if the yellowcake is shipped as a slurry rather than undergoing conventional drying and packaging processes.

8.3 Water

Impacts on water quality resulting from the proposed uranium mill should be minimized by utilizing proper design, construction, and operation procedures. However, impacts could result from nonradiological liquid effluents produced in the milling process.

The uranium mill will be designed to prevent the release of radioactive liquid effluent directly to the surface water as required by Federal Regulations.* Liquid discharge from the mill is to tailings ponds. The liquid waste streams contain natural uranium, thorium-230, and radium-226, as well as nonradiological waste products (kerosene, amine, alcohol, and waste resins) of the leaching and precipitation process.

The liquid phase of the tailings contains a portion of the organic phase from the solvent-extraction step. Chemical laboratory waste and runoff from the ore storage areas during heavy precipitation will also be routed to the tailings pond. Contamination of the ground water might occur due to seepage both vertically and horizontally from the tailings pond; however, the tailings ponds will be designed to minimize this seepage.

Hazardous or toxic materials will be handled and stored to prevent accidental releases to the environment.

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*40 CFR Part 436 (1976)

8.4 Land

Impacts of the uranium mill to land use will probably include removal of range land from grazing and wildlife usage for the mill facilities and tailings ponds estimated at 80 ha (200 acre). The locating of the mill and facilities will be done with a knowledge of any historical or archaeological sites in the area so impacts to these sites can be minimized. Land disturbance in relation to transportation could include the construction of new roads and upgrading of existing roads, the extent of which depends on the specific location of the mill.

Impacts to the soil will be localized within the mill site area. General impacts will include disruption of the soil forming processes, mixing of existing soils, and destruction of the soil which will have an effect on vegetation and subsequently wildlife. Because of the limited amount of area to be disturbed by a mill operation, these impacts will not be significant in terms of regional land use.

Effects to vegetation and wildlife include the disturbance to the land and vegetation in the area of the mill. Destruction of some animals may occur due to increased traffic on local roads. Hunting pressure on local populations of game species would probably increase.

8.5 Socioeconomic

Construction of a new uranium mill can impact communities in several ways. An increased number of employees associated with the mill has the potential for impacting a community's public and private facilities and services. The trend in mill design is toward increased automation. In the future, a mill of this capacity could probably be operated with about 60 employees. Increased traffic will result from commuters and operation of construction vehicles. Resulting impacts would be an increased accident frequency, possible inconvenience to local residents due to increased traffic, and increased wear and tear on the roadways. Because of the small amount of current traffic and relatively small amount of traffic generated by the mill, the impacts due to increased traffic should not cause unacceptable conditions.

Section 2.10 discusses other socioeconomic impacts arising from population influx due to the mill.

8.6 Safety

The environment may be affected by accidents associated with the milling of uranium. The occurrence of accidents related to the mill operation will be minimized through proper design, manufacture, and operation, as well as through a quality assurance program designed to establish and maintain safe operations. A detailed analysis of potential accidents will be addressed in the required environmental assessment when mill location, design and operating procedures are known.

8.7 Transportation

The mode of transport of ore to the mill has not been determined but in all probability will be by heavy-duty diesel-powered trucks. The impact associated with the transport of this ore will relate primarily to the generation of increased air pollutants and an increase in vehicular congestion. There is the possibility of other similar operations in the area contributing to the generation of increased air pollution and traffic. The actual transportation impacts of this mill and others cannot be accurately determined at this time.

Accidents during transportation of yellowcake to a UF_6 conversion facility could result in releases of this material to the environment. Yellowcake is conventionally packaged at the mill in 208 l (55 gal), sealed steel drums containing about 360 kg (800 lb.). According to published statistics,[1,2] the probability of truck accidents involving shipment of the yellowcake occuring is in the range of 2.6 to 4.2 x 10^{-6}/km (1.6 to 2.6 x 10^{-6}/mi). Only a small fraction of the accidents would result in the release of the contents of the shipping container. A recent accident (September 1977) involving a shipment of yellowcake resulted in a spill of 6,800 kg (15,000 lb) on the ground and truck trailer. It was estimated[4] that approximately 56 kg (123 lb) of U_3O_8 would be released to the atmosphere. The consequence for the accident area with a population density of 5.52 people/km^2 (2.13 people/mi^2) would be a 50 year dose commitment of 0.146 man-rem. Natural backround results in a 50 year integrated lung dose of 19 man-rem. Even for a large spill, cleanup of the released material and contaminated soils would be readily accomplished, thus further reducing the risk of significant radiation exposures. Another method which could be used is shipping yellowcake slurry in a tanker truck. In the event of an accident, the release of radionuclides would be reduced, and cleanup of the released material and contaminated soil could be more readily accomplished than cleanup of a dry spill.

8. References

1. Environmental Survey of Transportation of Radioactivity Materials to and from Nuclear Plants; U.S. Atomic Energy Commission. Directorate of Regulatory Standards. WASH-1238. December 1972.

2. An Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck. Battelle Northwest Laboratories Report BNWL-1046. August 1975.

3. Clarke, R. K. et al. "Severity of Transportation Accidents". Sandia Laboratory Report SLA-74-0001, Vol. I-IV. Unpublished.

4. U.S. Nuclear Regulatory Commission. Draft Environmental Statement Related to the Operation of Moab Uranium Mill, Atlas Mineral Division Atlas Corporation. Office of Nuclear Materials Safety and Safeguards. Docket No. 3453. November 1977.

Appendix A

The Associated Soil Series Interpretations and Estimated Engineering Properties of the Edgemont Project Area Soils

APPENDIX A

TABLE A-1 SOIL INTERPRETATIONS FOR USE AS TOPSOIL AND SUITABILITY OF SOIL MATERIAL FOR PLANT GROWTH

MAP SYMBOL	SOIL SERIES	SLOPE (PERCENT)	COMPOSITION (PERCENT)	THICKNESS OF "A" HORIZON IN INCHES	SUITABILITY AS TOPSOIL[1]	REMARKS	DEPTH TO BEDROCK IN INCHES	SUITABILITY OF SOIL MATERIAL FOR PLANT GROWTH[2]	REMARKS
10	PITS, MINE	---	95	---	---	---	---	POOR	TOO ROCKY
16	HISLE-SLICKSPOTS COMPLEX	0-6							
	HISLE PART		65	2	POOR	THIN LAYER, EXCESS SODIUM, DENSE COMPACT SUBSOIL	20-40	POOR	EXCESS SODIUM
	SLICKSPOTS PART		25	---	---	---	---	---	---
19B	SATANTA LOAM	2-6	85	9	GOOD	---	>60	GOOD	---
19C	SATANTA LOAM	6-9	85	9	GOOD	---	>60	GOOD	---
40B	NORKA SILT LOAM, SANDSTONE SUBSTRATUM	2-6	85	7	FAIR	BEDROCK BELOW 30 INCHES	>30	FAIR	THIN LAYER
42D	BUTCHE-BONEEK LOAMS	3-15							
	BUTCHE PART		60	4	POOR	THIN LAYER	<20	POOR	THIN LAYER
	BONEEK PART		25	6	FAIR	THIN LAYER, SLOPE, TOO CLAYEY	>40	FAIR	TOO CLAYEY, SLOPE
42E	BUTCHE-ROCK OUTCROP COMPLEX	15-30							
	BUTCHE PART		60	4	POOR	THIN LAYER, SLOPE	<20	POOR	SLOPE, THIN LAYER, ROCKS
	ROCK OUTCROP PART		25	---	---	---	---	---	---
49B	TUTHILL FINE SANDY LOAM	0-6	85	15	GOOD	---	>60	GOOD	---
69B	**NORKA SILT LOAM**	2-6	90	6	GOOD	---	>60	GOOD	---

TABLE A-1 (Continued)

76D	MINNEQUA-MIDWAY SILTY CLAY LOAMS	6-25							
	MINNEQUA PART		50	13	POOR	SLOPE	20-40	POOR	SLOPE
	MIDWAY PART		40	8	POOR	SLOPE, THIN LAYER	< 20	POOR	SLOPE, THIN LAYER
79F	SHINGLE-PENROSE-ROCK OUTCROP COMPLEX	15-40							
	SHINGLE PART		55	9	POOR	THIN LAYER, SLOPE	< 20	POOR	THIN LAYER, SLOPE
	PENROSE PART		20	6	POOR	THIN LAYER	< 20	POOR	THIN LAYER
	ROCK OUTCROP PART		15	---	---	---	---	---	---
86	DEMAR SILTY CLAY LOAM	0-2	90	3	POOR	THIN LAYER, TOO CLAYEY	>40	POOR	TOO CLAYEY
90	GRUMMIT-SNOMO CLAYS	3-15							
	GRUMMIT PART		55	6	POOR	TOO CLAYEY	<20	POOR	TOO CLAYEY, THIN LAYER
	SNOMO PART		30	7	POOR	TOO CLAYEY	>40	POOR	TOO CLAYEY
91	GRUMMIT-ROCK OUTCROP COMPLEX	3-40							
	GRUMMIT PART		60	6	POOR	TOO CLAYEY, TREES	<20	POOR	TOO CLAYEY, THIN LAYER
	ROCK OUTCROP PART		30	---	---	---	---	---	---
95A	KYLE CLAY	0-2	90	4	POOR	TOO CLAYEY	> 60	POOR	TOO CLAYEY
95B	KYLE CLAY	2-6	85	4	POOR	TOO CLAYEY	> 60	POOR	TOO CLAYEY
96B	PIERRE CLAY	2-6	85	4	POOR	TOO CLAYEY	20-40	POOR	TOO CLAYEY
97D	PIERRE-SAMSIL CLAYS	6-25							
	PIERRE PART		60	4	POOR	TOO CLAYEY, SLOPE	20-40	POOR	TOO CLAYEY, SLOPE
	SAMSIL PART		25	3	POOR	TOO CLAYEY, SLOPE	< 20	POOR	TOO CLAYEY, THIN LAYER, SLOPE
197D	PIERRE-GRUMMIT CLAYS	6-25							
	PIERRE PART		55	4	POOR	TOO CLAYEY, SLOPE	20-40	POOR	TOO CLAYEY, SLOPE
	GRUMMIT PART		30	6	POOR	TOO CLAYEY	< 20	POOR	TOO CLAYEY, THIN LAYER

1. Suitability for use as topsoils refers generally to the A horizon.

2. The column "Suitability of Soil Material (Mixed) for Plant Growth" refers to suitability of materials to 60 inches or to bedrock that will support vegetation or is a medium of plant growth, based upon general texture, structure, erodibility, available water capacity, soluble salt content, depth, and accessibility or availability.

A-3

TABLE A-2 ESTIMATED ENGINEERING PROPERTIES OF SOILS

		DEPTH TO			CLASSIFICATION									CORROSIVITY	
MAP SYMBOL (1)	SOIL SERIES (2)	BED-ROCK (3)	SEAS-ONAL WATER TABLE (4)	DEPTH FROM SURFACE (5)	DOMINANT USDA TEXTURE (6)	AASHO (7)	LIQUID LIMIT (8)	PLASTIC-ITY INDEX (9)	PERMEA-BILITY (10)	AVAILABLE WATER CAPACITY (11)	REAC-TION (12)	SALINITY (13)	SHRINK-SWELL POTENTIAL (14)	UNCOATED STEEL (15)	CONCRETE (16)
---	---	IN.	FT.	IN.	---	---	---	---	IN/HR	IN/IN OF SOIL	pH	MMOHS/CM	---	---	---
42E	BONEEK, BEDROCK SUBSTRATUM	40-60	>6.0	0-6	SILT LOAM	A-4, A-6	25-40	5-15	0.6-2.0	0.19-0.22	6.1-7.3	---	LOW	MODERATE	LOW
				6-17	SILTY CLAY LOAM, SILTY CLAY	A-6, A-7	35-50	11-25	0.2-0.6	0.11-0.17	6.1-7.8	---	MODERATE	MODERATE	LOW
				17-50	SILTY CLAY LOAM, LOAM	A-4, A-6, A-7	30-45	5-20	0.6-2.0	0.17-0.20	7.4-9.0	---	MODERATE	HIGH	LOW
				50-60	BEDROCK										
42D	BUTCHE	<20	---	0-4	FINE SANDY LOAM	A-4	20-30	NP-7	0.6-6.0	0.12-0.15	6.1-7.8	---	LOW	MODERATE	MODERATE
				4-9	STONY FINE SANDY LOAM	A-4	20-30	NP-7	0.6-6.0	0.12-0.15	6.1-7.8	---	LOW	MODERATE	MODERATE
				9-12	BEDROCK										
86	DEMAR	40-50	>6.0	0-3	SILTY CLAY LOAM	A-6 A-7	30-45	8-20	0.6-2.0	0.16-0.20	6.1-7.3	<2	MODERATE	HIGH	MODERATE
				3-13	CLAY	A-7	40-60	20-35	<0.06	0.08-0.12	5.1-7.3	<2	HIGH	HIGH	MODERATE
				13-45	CLAY	A-7	40-60	20-35	<0.06	0.08-0.12	<5.0	8-16	HIGH	HIGH	HIGH
				45-60	BEDDED SHALE										
90 91 197D	GRUMMIT	5-20	---	0-9	CLAY	A-7	50-65	20-35	0.6-2.0	0.08-0.12	3.6-5.5	---	HIGH	HIGH	HIGH
				9-60	SHALE										
16	HISLE	20-40		0-29	CLAY	A-7	45-85	20-55	<0.06	0.05-0.12	6.1-8.4	---	HIGH	HIGH	MODERATE
				29-60	SHALE										

TABLE A-2 (Continued)

95A 95B	KYLE	>60	>6.0	0-4	CLAY	A-7	50-75	20-45	<0.06	0.08-0.12	6.6-7.8	---	HIGH	HIGH	LOW
				4-60	CLAY	A-7	50-75	20-45	<0.06	0.08-0.12	7.9-8.4	<4	HIGH	HIGH	LOW
76D	MIDWAY	6-20	---	0-17	SILTY CLAY LOAM	A-6, A-7	45-60	20-35	0.06-0.2	0.17-0.20	7.4-8.4	2-8	HIGH	HIGH	MODERATE
				17-60	SHALE										
76D	MINNEQUA	20-40	---	0-5	SILTY CLAY LOAM	A-4, A-6	30-40	8-15	0.6-2.0	0.19-0.22	7.4-8.4	---	MODERATE	HIGH	LOW
				5-24	SILTY CLAY LOAM, SILT LOAM	A-4, A-6	30-40	5-15	0.6-2.0	0.17-0.20	7.4-8.4	---	MODERATE	HIGH	LOW
				24-60	CHALK AND LIMESTONE										
69B	NORKA	>60	>6.0	0-6	SILT LOAM	A-4	20-30	2-7	0.6-2.0	0.19-0.22	6.6-8.4	---	LOW	LOW	LOW
				6-11	SILTY CLAY LOAM, CLAY LOAM	A-4, A-6	30-40	5-15	0.2-0.6	0.17-0.20	6.6-8.4	---	MODERATE	MODERATE	LOW
				11-60	SILT LOAM, LOAM	A-4	15-25	NP-7	0.6-2.0	0.16-0.20	7.4-8.4	---	LOW	MODERATE	LOW
40B	NORKA, BEDROCK SUBSTRATUM	30-60	---	0-7	SILT LOAM	A-4	20-30	2-7	0.6-2.0	0.19-0.22	6.6-8.4	---	LOW	LOW	LOW
				7-15	CLAY LOAM, SILTY CLAY LOAM	A-4, A-6	30-40	5-15	0.2-0.6	0.17-0.20	7.4-8.4	---	MODERATE	MODERATE	LOW
				15-30	CLAY LOAM, SILTY CLAY LOAM, SILT LOAM	A-4, A-6	30-40	5-15	0.6-2.0	0.17-0.20	7.4-8.4	---	LOW	MODERATE	LOW
79F	PENROSE	10-20	---	0-6	LOAM, CLAY LOAM	A-4	15-30	NP-10	0.6-2.0	0.16-0.18	7.9-8.4	---	LOW	HIGH	LOW
				6-14	SHALY CLAY LOAM	A-4	15-25	NP-10	0.6-2.0	0.14-0.17	7.9-8.4	---	LOW	HIGH	LOW
				14-16	LIMESTONE										

TABLE A-2 (Continued)

963 197D	PIERRE	20- 40	---	0-29	CLAY, SILTY CLAY	A-7	50-75	22-45	<0.06	0.08-0.12	6.6- 8.4	---	HIGH	HIGH	MODERATE
				29-34	SHALY CLAY	A-7	50-85	25-60	<0.06	0.08-0.12	6.6- 8.4	---	HIGH	HIGH	MODERATE
				34-60	SHALE										
97D	SAMSIL	4-20	---	0-18	CLAY, SHALY CLAY	A-7	50-85	25-60	0.06- 0.2	0.08-0.12	7.4- 8.4	---	HIGH	HIGH	MODERATE
				18-60	SHALE										
19B 19C	SATANTA	>60	>6.0	0-9	LOAM	A-4, A-6	25-35	2-15	0.6- 2.0	0.18-0.20	6.1- 7.3	---	LOW	HIGH	LOW
				9-20	LOAM, SANDY CLAY LOAM	A-6, A-7	30-45	11-25	0.6- 2.0	0.16-0.18	6.6- 8.4	---	MODERATE	HIGH	LOW
				20-60	LOAM	A-4, A-6	20-35	2-15	0.6- 2.0	0.16-0.18	7.4- 8.4	---	LOW	HIGH	LOW
79F	SHINGLE	10- 20	---	0-13	LOAM, SHALY LOAM	A-6	30-40	5-15	0.6- 2.0	0.16-0.17	7.9- 9.0	---	MODERATE	HIGH	LOW
				13-60	SHALE										
90	SNOMO	40- 60	---	0-45	CLAY, SILTY CLAY	A-7	50-70	20-38	0.6- 2.0	0.08-0.12	3.6- 5.5	---	HIGH	MODERATE	HIGH
				45-60	SHALE										
49B	TUTHILL	>60	>6.0	0-10	FINE SANDY LOAM	A-4	20-35	NP-10	0.6- 6.0	0.14-0.17	6.1- 7.8	---	LOW	LOW	LOW
				10-24	FINE SANDY LOAM, SANDY CLAY LOAM	A-4, A-6	25-40	5-15	0.6- 2.0	0.09-0.18	6.1- 7.8	---	MODERATE	MODERATE	LOW
				24-60	FINE SANDY LOAM, SANDY LOAM	A-4	20-30	NP-10	0.6- 6.0	0.09-0.15	6.1- 8.4	---	LOW	MODERATE	LOW

Appendix B

Archaeological Clearance Material

HISTORICAL
PRESERVATION
CENTER
University of South Dakota
Vermillion, SD 57069
Phone (605) 677 5314

SOUTH DAKOTA Department of
Education and Cultural Affairs

August 30, 1978

Mr. Maxwell D. Ramsey
Recreation Program Coordinator
Tennessee Valley Authority
Norris, Tennessee 37828

Re: Edgemont Uranium Mining Project
Fall River and Custer Counties

Dear Sir:

This office has been notified of your intention to undertake the above federally involved action. To assist your compliance with Section 106 of the National Historic Preservation Act (PL 89-665); Executive Order 11593, Protection and Enhancement of the Cultural Environment; 36 CFR 800; and other laws and regulations pertinent to the protection of historic, archaeological or culturally significant properties, the State Historic Preservation Officer makes the following comment:

The above project has been reviewed and determined to have no effect on significant cultural sites. However, should archaeological, historical or cultural materials be discovered in the course of the undertaking, work disturbing those materials shall cease immediately, and the State Historic Preservation Officer notified of their existence. An immediate assessment of their importance will follow, and appropriate mitigation recommendations issued.

Additional comments:

This office wishes to extend its gratitude to the TVA for its efforts to protect the cultural resources of the area in question.

Your cooperation in this matter is most appreciated.

Yours truly,

Steven L. Ruple

for John J. Little
State Historic Preservation Officer

jla

cc: Robert Alex

The Office of Cultural Preservation of the Department of Education and Cultural Affairs coordinates South Dakota's archaeological research, museums, historical preservation and historical resource in a program designed to preserve our natural and cultural heritage.