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HEALTH IMPLICATIONS OF COAL RELATED ENERGY DEVELOPMENT: MINING IMPACTS

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The purpose of this project was to establish a method for prospective epidemiological analysis of the health effects associated with the development of western coal sites. Particular emphasis was placed on potential community health effects related to mining, especially mining effluents which may enter drinking water supplies in hazardous quantities. The study area is defined as United States EPA Region VIII which includes Colorado, Utah, Montana, Wyoming, and the Dakotas. This research effort involved: (1) development of criteria for selecting communities suitable for future in-depth study and selection of several such communities; (2) characterization of health and environmental quality in the region as a whole; (3) formulation of data requirements for a prospective epidemiological study; and (4) evaluation of the quality of environmental, health, and demographic data currently available for such a study in these communities.

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FOREWORD

The United States is increasingly aware of the need to depend on its own resources for energy production. Also apparent is the necessity of protecting the environment and the health of the population. In pursuit of means to concurrently achieve these ends, the Health Effects Research Laboratory supports a variety of programs designed to identify and characterize potential health effects associated with different forms of energy production. Since coal is a relatively abundant resource in the United States, much of the research effort has focused on energy production from this source.

The report that follows focuses specifically on potential health effects due to mining of western coal reserves. It addresses issues related to community health rather than occupational health hazards and focuses on the identification and evaluation of environmental, health, and demographic data necessary to evaluate mining effects on health through prospective study.

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Acting Director
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ABSTRACT

The purpose of this project was to establish a method for prospective epidemiological analysis of the health effects associated with the development of western coal sites. Particular emphasis was placed on potential community health effects related to mining, especially mining effluents which may enter drinking water supplied in hazardous quantities. The study area is defined as United States EPA Region VIII which includes Colorado, Utah, Montana, Wyoming, and the Dakotas. This research effort involved: (1) development of criteria for selecting communities suitable for future in-depth study and selection of several such communities; (2) characterization of health and environmental quality in the region as a whole; (3) formulation of data requirements for a prospective epidemiological study; and (4) evaluation of the quality of environmental, health, and demographic data currently available for such a study in these communities.

The selection of communities for in-depth study included an analysis of current and planned or projected expansion of coal mining, demographic description, and consideration of public water supply. Criteria were established, based on this work, for considering a community a potential site for further in-depth study. Any community was included if it was located within 20 miles of a currently operating, new, or expanding mine; had between 1,000 and 30,000 residents; and was supplied with public water through a single-source surface water supply.

Each community so identified was assigned to one of two categories depending on whether or not its water supply was likely to be impacted by mining activities. The purpose of this was to identify one set of communities expected to exhibit water-mediated health effects due to mining and another set of similar communities expected to show effects due to mining exclusive of the water-mediated effects. Comparison of suitable health status indicators between study communities (water impacted) and control communities will yield an estimate of the magnitude of health effects attributable to contamination of public water supplies by mining activities. The distinction between study and control communities was based upon the location of mining activity in relation to the location of the intake for the community's public water system. It was required for those communities categorized as study (water-impacted) sites that (1) coal mining exist within 20 miles upstream from the community water intake, and (2) drinking water be drawn from the impacted river downstream from the mine.

Craig, Hayden, and Rangely (all located in Colorado) were identified as possible study sites. Potential control sites are Canon City and Steamboat

Springs in Colorado and Green River, Kemmerer, Rock Springs, and Sheridan in Wyoming. These candidates for study and control communities are characterized according to quantity of coal mining, relative importance of coal mining to the community's economy, validity of the community's designation as a study or control site, quality of water monitoring, presence of air monitoring, proximity to other control and/or study sites, availability of other information, and presence of coal-utilizing facilities, such as electric power generating facilities.

Characterization of health and environmental quality in the region as a whole involved obtaining and assembling baseline data on demographic trends, health status, community health and sanitation services, and environmental quality. A cursory examination of aggregate data was performed to identify trends in environmental quality and any unusual patterns of morbidity and mortality. One important activity in this task was the calculation and analysis of standardized mortality ratios for the region by county. The only cause of death category which showed any geographical relationship to mining activity was deaths due to motor vehicle accidents. This was expected since mining activities tend to increase the amount of traffic in mining areas. Failure to find additional effects is not surprising considering county (rather than community) rates were studied to demonstrate effects that would be expected in only a small proportion of the county residents. Moreover, mortality may not be the most appropriate indicator for detecting the effect of mining activity on health status. While the results suggest that there are no blatantly unusual patterns of mortality in the region, more information on health status must be obtained in order to examine water-mediated health effects due to coal mining in specific communities.

A critique of the quality of existing environmental, health, and demographic data for use in a prospective epidemiological study is presented in the report along with recommendations for the type of data needed and methods by which it can be secured.

This report was submitted in fulfillment of Grant No. R805700-01 by Battelle's Columbus Laboratories under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period January 1, 1978, to April 30, 1980, and work was completed as of April 30, 1980.

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OVERVIEW: ENERGY DEVELOPMENT AND HUMAN HEALTH

Energy production is, and will continue to be, a major concern of society. While one facet of that interest must concern technological development necessary to discover and harness new sources of energy, clearly there must be a concomitant consideration of the environmental and human health effects of developing these resources. Although it is unreasonable to expect or demand "zero risk" or no health costs associated with energy production, scientific definition and measurement of the health costs and the degree to which they may be predicted and ameliorated through sound energy development policy merits intensive investigation. In examining the potential health impacts of the rapid expansion of mining activities in the western coal region, the present program explores but one facet of the energy production picture in the United States. Nevertheless, the sheer magnitude of projected increases in mining activity and the relative paucity of knowledge concerning nonoccupational, environmentally mediated health effects of mining activities underscore the need for careful epidemiologic studies in mining communities. Only then can the nature and magnitude of potential health effects be ascertained and the indirect effects of the current energy development policy be discovered. Ultimately, insights gained from this program and subsequent epidemiologic studies regarding the human costs of energy development may be used to establish a more informed bases for future decisions regarding the development and/or expansion of energy resources.

Projected Coal Energy Development in the U.S

Coal is abundant in most parts of the United States and, along with petroleum and natural gas, it has contributed significantly to our industrial and economic growth. Of the three fuels, coal is by far the most abundant with recoverable resources of coal containing about ten times as much heat value as the combined recoverable reserves of petroleum and natural gas.

Since the mid 1930's, the United States has experienced a fourfold increase in the use of energy. Most of this increased demand was met by increased use of petroleum and natural gas (Averitt, 1975). This growth was further accelerated after World War II by: (1) a prolonged period of industrial and economic growth, (2) increased rate of population growth, and (3) considerable increase in per capita use of energy. Accompanying the increased use of petroleum and natural gas was a surge in imports of petroleum, beginning in the late 1950's, followed by a decline in domestic petroleum production in the late 1960's and early 1970's. About the same time, it became apparent that reserves of both fuels were smaller than formerly believed. Throughout the long period prior to OPEC (Organization of Petroleum Exporting Countries) the unit costs of petroleum and natural gas were relatively low, and these fuels were more convenient to use and more environmentally acceptable than coal. Higher prices for petroleum and natural gas will undoubtedly encourage the use of atomic energy, coal, and other sources of fuel for the generation of electricity and lead to increased use of coal, oil shale, and bituminous sands as sources of synthetic fuels and pipeline gas (Averitt, 1975). Faced with the above conditions, namely, depleting reserves and increasingly negative cost factors associated with petroleum and natural gas, and a relative abundance of coal, the United States has become firmly committed to the development of new coal-based energy technologies such as coal gasification, coal liquefaction, and fluidized-bed combustion.

Besides these new markets, the electric utility industry has established a trend toward the increased use of coal. During the past 20 years, the utility industry (which is the largest single consumer of coal) has increased its use of coal at an extremely rapid rate. Further, rapid proliferation of coal-fired power plants is expected to continue throughout the next 20 years due to:

(1) Anticipated steady growth of the electric utility industry--recent EPA projections forecast a 226 percent increase in coal-fired generating capacity between 1976 and 1986 for the six states of EPA Region VIII (U.S. EPA, 1976). Other regional analyses predict similar trends.

(2) Construction of coal-fired generating plants in areas previously served by natural gas and/or conversion orders directing large industrial users of natural gas to switch over to coal. In 1977, the Federal Energy Administration issued coal conversion directives to 56 major industrial plants presently burning oil or gas. Earlier in 1977, similar directives were sent to 74 utility companies and similar notices were sent to 32 planned industrial sites requiring that the plants be built with coal burning capability. Other industries targeted for future directives include chemical, food, fabric, metal, film, and refined oil products manufacturers (Anonymous, 1977).

(3) Gradual phase-out of older gas-fired generating plants. Taken together, the trends outlined above forebode vast increased in demand for coal, particularly the low sulfur coals from the western United States. Various governmental and private agency projections are consistent with this forecast (Asbury et al., 1977; Corsentino, 1976; U.S. EPA, 1976; Averitt, 1975).

In response to the increasing demand for coal, rapid expansion of coal mining activity is anticipated. Important determinants of the location of this expansion include the location of proven coal reserves, characteristics of the coal (rank, grade, specific gravity), thickness of the beds, thickness of the overburden, and a variety of commercial factors including labor, equipment, and transportation costs.

Table I shows the distribution of the coal reserves base and total remaining identified coal resources of the United States as of January, 1974. Reliable projections indicate that the majority of future mining expansion will take place in the western United States (Corsentino, 1976). As is evident from Table 1, Regions 6 and 7, the northern and southern Rocky Mountain regions, together account for nearly one-half of the "demonstrated reserve base" and approximately 60 percent of "resources in thin beds and inferred resources" and "total remaining identified resources". The very large reserve base in Region 6, the northern Rocky Mountains, represents 41 percent of the total in column 1. This large tonnage and percentage reflect the fact that the coal beds are very thick. Numerous and closely spaced, the coal-bearing rocks lay nearly flat and the topography is relatively flat over thousands of square miles in North Dakota, eastern Montana, and northeastern Wyoming. Thus, much of the coal in Region 6 is within reach using strip mining methods. The more modest reserve base in Region 7 as compared with that of Region 6 reflects the fact that in most of Region 7 the coal-bearing rocks are on the edges of moderate to steeply dipping structural basins. This coal is less accessible; underground or drift mining methods must be used in these settings (Averitt, 1975).

High rank bituminous and anthracite coal in the continental United States lies almost exclusively in the eastern half of the country. About 99 percent of the subbituminous coal and lignite lies in the western half of the country. In large part these differences are due to differences in geologic age (Pennsylvanian in the east and Cretaceous or Tertiary in the west). The younger western coals attain high rank only where there has been deformation and alteration by mountain building processes or by the intrusion of igneous rock. Subbituminous coals and lignite of the western states are lower in heat value and are somewhat more difficult to ship and store than the more widely used bituminous coals of the eastern states. However, the low rank coals of the western states are well suited to the production of electric power and the production of synthetic gas and liquid fuels.

Receiving much attention today is the sulfur content of coal. Sulfur in coal has several undesirable effects. First, it lowers the quality of coke and the resulting iron and steel products. It contributes to corrosion, formation of boiler deposits, and more importantly to air pollution. Sulfur impurities in coal spoils (in the eastern United States) inhibit growth of vegetation. Leaching of sulfuric acid from mines contributes directly to the pollution of streams, while sulfur oxides emitted into the atmosphere from combustion of high sulfur coal contribute to both air pollution and acid rain formation. Averitt (1975) states that about 65 percent of the identified coal resources in the United States are low in sulfur

TABLE 1. DISTRIBUTION, BY BASIN OR REGION, OF THE COAL RESERVE BASE AND OF TOTAL REMAINING IDENTIFIED COAL RESOURCES OF THE UNITED STATES, JANUARY 1, 1974[a,b,c]

Basin or Region	Overburden 0-3,000 ft: Demonstrated Reserve base, 0-1,000 ft overburden: Tons	Percent	Resources in thin beds inferred resources, 0-1,000 ft overburden; and identified resources in all beds 1,000-3,000 ft overburden	Total remaining identified resources
1) Northern Appalachian basin (PA, OH, WV, and MD)	93	21	132	225
2) Southern Appalachian basin (eastern KY, VA, TN, NC, GA, and AL)	20	5	36	56
3) Michigan basin	--	--	--	--
4) Illinois basin (IL, IN, & western KY)	89	20	126	215
5) Western Interior basin (IA, KS, MO, OK, AR, & TX)	19	4	63	82
6) Northern Rocky Mountains (ND, SD, MT, WY, & ID)	175	41	606	781
7) Southern Rocky Mountains (CO, UT, AZ, & NM)	24	6	211	235
8) West Coast (AK, WA, OR, & CA)	14	3	123	137
TOTAL	434	100	1,297	1,731

(a) Source: Adopted from Averitt, 1975.

(b) In billions (10^9) of short tons. Dashes (--) indicate negligible amount of coal. Figures are for reserves and resources in the ground. At least half of the reserve base is recoverable.

(c) Includes coal in the measured and indicated (demonstrated) category in beds 28 in or more thick for bituminous coal and anthracite, and 5 ft or more thick for subbituminous coal and lignite. Maximum overburden is 1,000 ft for subbituminous coal, bituminous coal, and anthracite, and 120 ft for lignite. May include coal outside these parameters if such coal is being mined or is considered to be commercially minable.

(0-1.0 percent). Much of this low-sulfur coal is subbituminous coal and lignite concentrated in the Rocky Mountains and Northern Great Plains. The remaining 35 percent of coal reserves are of medium (1.1-3.0 percent) and high sulfur (over 3.0 percent) content. In contrast, much of the remaining medium and high-sulfur coal occurs in the bituminous coal of the central and eastern United States.

Until recently, when the electric utilities were confronted with the problem of complying with sulfur dioxide control regulation, western coal supplied only local markets. Due to its relatively low thermal value and high delivery costs, western coal could not successfully compete against eastern and midwestern coals in their respective market areas. Today the market structure has shifted due to increasing specific demand for low-sulfur coals. Utilities view substitution of lower sulfur western coals for eastern coals as one potential means of forestalling the addition of costly emissions control equipment. Rapid increases in production costs of eastern and midwestern coals relative to the cost of transporting western coal and, as mentioned, the higher prices and reduced availability of alternative fuels further increase demand. In view of this situation, the general feeling now is that western coals will become a principal source of energy for United States utilities.

By convention, the United States is usually divided into three coal-producing regions--western, eastern, and midwestern. The geographical boundaries of these regions are depicted in Figure 1. The western coal region includes two great coal provinces: the Northern Great Plains province covering eastern Wyoming, and the Rocky Mountain province which includes western and southern Wyoming, most of Colorado and Utah, and northeastern New Mexico. The Hanna Region and the Powder River Basin of Wyoming and Montana are currently the most important exporters to distant markets. The Williston Basin (part of the Northern Great Plains Region) and the Unita Region represent secondary sources (Asbury et al, 1977). Due to superior export opportunities, a great deal of attention is being focused on the future development of huge coal reserves located in the Powder River Basin.

As of May, 1976, 154 new mines or expansions of existing mines were planned, proposed, or under development. Forty-five new mines were to be located in Colorado, 33 in Wyoming, 30 in Utah, and the balance in ten other states. If all of these future western mines were developed according to present plans, an additional 472.1 million tons of coal per year would be realized. Future mines in Wyoming alone would increase production by 139.8 million tons per year, while 77.7 million tons per year and 64.5 million tons per year are anticipated for Utah and New Mexico, respectively. The remainder of the production increase is distributed among the other states. Considering both the location of coal reserves (see Table 1) and the specific areas slated for greatest expansion, it is clear that the bulk of the increase in mining activities will take place in the states of Montana,

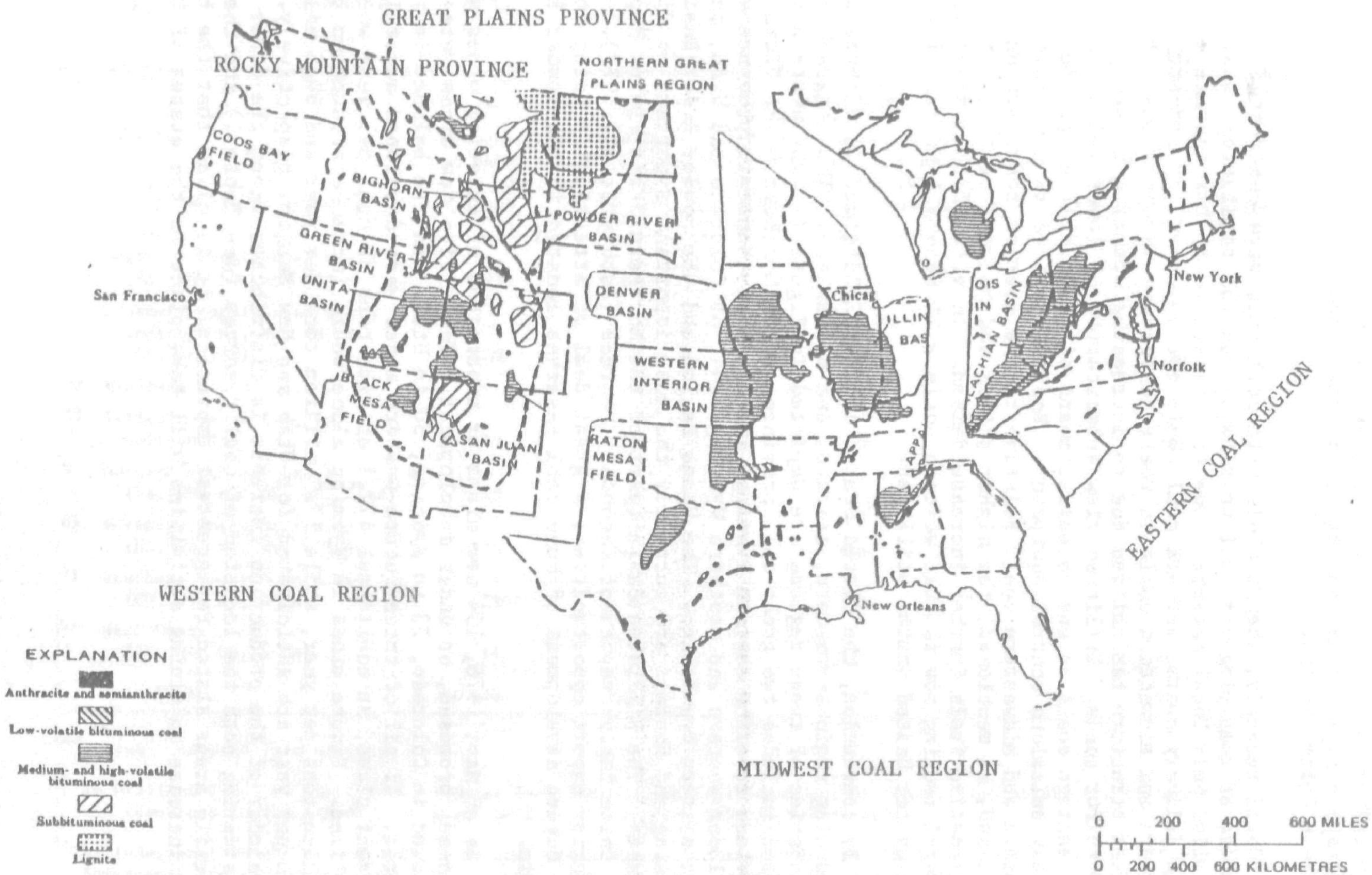

Figure 1. Coal fields of the conterminous United States.

Wyoming, North Dakota, South Dakota, Colorado, and Utah. The focus of the present program has been confined to a geographic area consisting of these six states.

Assessment of Health Effects Related to Increased Mining

Assessment of the potential social and environmental costs of energy development includes a wide range of concerns, such as public health, occupational health and safety, environmental stability and diversity, and social stability. These concerns have prompted the development of a great variety of methods for measuring impacts and costs (U.S. FEA, 1977; Bozzo et al., 1978; Morris and Novak, 1977; University of California, 1978). Unfortunately, these reports outline general approaches which have not been applied to specific communities as yet. In attempting to quantify and/or project the impacts of energy development in terms of human mortality, morbidity, or changes in health status (either positive or negative), detailed empirical studies of health status of residents in specific impacted communities are essential.

Two different sets of health effects must be considered in evaluating the causal effects of energy development on health status. First, the possible etiologic significance of the products and processes employed in the various industrial activities must be investigated. Another set of effects arising as a result of boom town conditions (e.g., increases in population, inadequate housing, crowding, unmet demand for health and sanitation services) need to be examined as well. Three generic types of health problems can be anticipated: the first set is related to the occupational environment; such problems are primarily the province of industrial hygiene. These problems have been studied elsewhere and will not be considered in the present program. Second are the potential problems which can be traced to pollution of the environment by industrial activity itself. Third, many significant health and social problems are related to the rapid and unplanned community growth which accompanies intensive development of coal resources. Problems arising from these "boom town conditions" include excess demands on community environmental and sanitation services (e.g., inadequate water supplies, sewage systems, and solid waste disposal systems). Other boom town phenomena which impact on the individual or family level include higher rates of physical illness and injuries, mental illness, various types of social disruption, and shortages of needed medical services at both primary (physicians, dentists) and secondary (hospital, clinic, nursing home) levels of care.

This report primarily addresses impacts of the second type above. However, problems of the third type are also examined to the extent that they represent bona fide health, rather than sociological, problems. Because of the extensive breadth of health impacts outlined above, the current program focuses on a limited set of impacts, namely those resulting specifically from increases in mining activity. It was recognized from the outset, however, that industrial activities connected with construction of highways, commercial establishments (especially electric power plants), and housing inevitably accompany increases in mining, and produce health effects of their own which must be considered as part of the overall costs of development. It is essential to realize that changes in health status subsequent to mining expansion reflect these indirect effects in addition to direct mining-related impacts.

This report summarizes work in the areas of: (1) identifying those communities most likely to be impacted by the development of western coal, (2) examining existing environmental data in and around these communities, and (3) assembling available data on health status and community health and environmental services in the impacted areas. These data provide valuable "baseline" characterization of these populations. When coupled with periodic reassessment of the relationships among health and environmental parameters in the form of prospective epidemiologic studies, needed information concerning the potential health impacts of mining could be generated.

GENERAL OUTLINE OF THE PROJECT

The purpose of this project was to establish a method for prospective epidemiological analyses of the health effects associated with the development of western coal sites. Particular emphasis in the program was placed upon potential health effects related to mining activities, especially mining effluents which may enter drinking water supplies in hazardous quantities. Specific tasks include the following:

(1) Identifying and characterizing potentially impacted communities, including an analysis of planned and projected expansion of coal mining;

(2) Obtaining and assembling baseline data (ca. 1975-1978) on the above communities with respect to demographic trends, health status, community health and sanitation services, and environmental quality;

(3) Performing a cursory examination of aggregate data (regional, state, or county levels) for trends in environmental quality, compliance with relevant standards, and unusual patterns of morbidity and mortality;

(4) Evaluating the adequacy of existing environmental, health, and demographic data as a basis for future prospective epidemiologic studies;

(5) Formulating data requirements for prospective studies and searching for methods by which the requisite data (or suitable alternatives) can be secured;

(6) Developing criteria for selecting specific individual communities for in-depth studies. Priorities for this task include:

(a) volume of projected expansion (coal tonnage)
(b) amount of projected community growth (population, jobs, etc.)
(c) location with respect to mining
(d) size and representativeness of the community
(e) absence of major sources of pollution unrelated to mining
(f) quality of existing health and environmental data.

These topics are addressed individually in subsequent sections of the report. Much supplementary data is also contained in the appendix.

SECTION 2

ISSUES AND POTENTIAL IMPACTS

Investigators concerned with estimating the type and potential magnitude of impacts from western coal development have identified several key areas of concern. Many of the national energy policy concerns are reflected in the report of the Rall Commission (Rall, 1977). Examples of area-specific issues are addressed in the various Environmental Impact Statements alluded to later in this section. In general, there seems to be a consensus that impacts are expected in at least six generic areas, including: (1) water quality; (2) air quality; (3) social environment; (4) sanitation and public health (due to rapid population influx); (5) economic structure; and (6) transportation. An overview of each of these types of impacts is given in this section.

WATER QUALITY

Introduction

The chemical quality of surface water in the western United States is highly variable due to diversity in geology, size of drainage basin, aridity, and seasonality of streamflow. Few generalizations applicable to the entire region can be made. Also, there are limitations on the distribution and amount of available data, particularly with respect to groundwater. There is a critical need for longitudinal studies of water quality comparing values of various parameters pre- and post-mining in order to assess the trends in quality of surface water and groundwater that may be related to mining and reclamation activities (NAS, 1974).

Mine development generally progresses in three distinct phases: (1) construction of the associated facilities; (2) mining of coal (and perhaps other materials, e.g., clinker and gravel for roads) and concurrent reclamation; and (3) abandonment of the mine upon completion of mining. Each of these phases has associated with it a series of environmental impacts which must be considered in order to have a total picture of mining impacts. The construction phase precedes the actual mining activities. It includes construction of the coal handling facilities, railroad spur and loop, access and haulage roads, warehouse, administrative offices, maintenance buildings, explosive materials storage, water pumping, waste disposal systems, stream diversion, communication lines, power transmission lines, and electric utilities. At many sites, construction activities also include the quarrying of clinker for use as road building materials, stream diversion lining, and railroad subgrade construction materials. All of these activities create disturbances of the local terrain (USGS, 1978a).

During the mining operation, surface waters are impacted as a disruption of the existing drainage patterns. The amount of disruption varies in that surface drainage systems can be built to store and/or route produced water, runoff, and sanitary sewage. The degree to which the quality of surface water will be impacted will depend to some degree on the design of the storage and routing system. The chemical quality of intermittent streams is often proportional to the magnitude of the flow. Thus, changes in flow due to diversions and altered topography may have varying impacts. Concentration of sediment increases as flow increases, whereas, concentration of dissolved solids decreases as flow increases (USGS, 1978b).

One parameter which gives a general indication of suitability of surface water for industrial use is total dissolved solids (TDS). TDS varies with discharge during periods of high flow and is lowered by dilution. TDS increases in areas where rivers are underlain by highly soluble materials such as shale (NAS, 1974).

Groundwater varies in quality principally because of geological diversity in the west. Water recovered from sedimentary rocks varies from brackish in deeply buried marine shales to very pure in shallow aquifers. Groundwater in valley alluvium is derived mainly from local recharge and the quality varies according to the rock type in the drainage basin. Again, as with surface water, quality is highly variable and governed by local conditions. To be reliable, observations must be specific to the mine site (NAS, 1974).

The effects of the mining on groundwater are: (1) removal of the coal aquifer; (2) a change in the recharge-discharge relationships; (3) a possible change in the quality of water in some aquifers; (4) an increase in the consumptive use of groundwater which decreases the supply available for other uses; and (5) lowering of water levels in local aquifers.

Coal seams are frequently aquifers. Hence, interception and removal of the coal is bound to have both quantitative and qualitative effects on groundwater. Disturbances in aquifers will undoubtedly occur because spoil material would be expected to have different hydrologic characteristics than the original material; spoil will probably transmit water more readily than the coal it replaces, leading to increased quantities of groundwater in some localities and decreases in others (USGS, 1978b).

Water changes in quality as it moves through various strata. Mining of the coal and disturbance of the overburden alter the chemical quality of the water by changing the sources of constituents, the rock material and biosphere, the hydraulic, thermal, and chemical gradients, and the rates of ion exchange and sorption. The net result of these changes cannot be predicted, but the quality of the groundwater reservoir formed by the spoil is likely to be of significantly poorer quality than the water in the undisturbed local aquifer. Specific changes will depend on constituents of the rock material and biosphere which is disrupted. Alteration in hydraulic, thermal, and chemical gradients and rates of ion exchange and sorption will affect water quality (USGS, 1978b).

In general, the quality of surface and groundwater in the upper Colorado River Basin is very good in the mountainous and headwater areas but gradually worsens as one moves downstream. Sediment loads are generally high in the streams that drain the Colorado Plateau. TDS concentrations may reach 2,000-3,000 mg/l in some streams. The variation in water quality among the western rivers also implies a variation in the withdrawal rates that each can tolerate without causing excess salinity downstream. Sedimentation and salinity present serious problems in many of the areas under consideration for expansion of mining. These and other specific impacts are described more fully in the next section.

Surface Water Impacts

Location of Water Impacts--

In characterizing the various potential water quality impacts from mining, it is useful to distinguish between impacts which occur at the location of the mine (on-site impacts) from those which occur at some distance from the site (off-site impacts). The National Academy of Sciences first suggested this classification scheme for coal mining impacts, and their findings are summarized here (NAS, 1974).

On-Site Impacts--The primary on-site impacts include the effects of soil erosion, channel erosion, and disruption of surface drainage and groundwater aquifers. Channel erosion and sedimentation may become problematic if mining activities result in the addition of significant quantities of water to surface discharge. Downcutting and widening initiated by the augmented flow of storm water runoff may produce a channel to which the normal runoff is not adjusted. Tributary channels may no longer be used if the base level of the main channel to which they are graded is lowered. Channel deepening and enlargement, unless checked, can cause production and transport of large quantities of sediment to downstream channels or reservoirs.

Surface mining operations disrupt the channels of ephemeral streams and damage upland slopes. Altered drainage patterns create two major problems: a change in the channel slope and increased flow velocity resulting in increased bed and bank erosion; and a decrease in runoff volume and loss of recharge to alluvial aquifers in the downstream valleys. Either of these problems can be serious in an arid or semi-arid environment.

In most of the western coal fields, the coal beds that lie close to the surface are also aquifers. Removal of the coal by mining operations often intersects the aquifer which is the source for hundreds of local wells. Consequently, flow patterns in the aquifer are changed and some parts undoubtedly would be dewatered. Also, as the coal/aquifer is removed, the groundwater is discharged into the mine pit, necessitating the pumping of the unwanted water into nearby surface streams. Additional flow into these ephemeral channels can cause both erosion and changes in water quality.

Presently, the extent to which the aquifer characteristic of the stratum formerly occupied by the coal might be restored is unknown.

Off-Site Impacts--The primary hydrologic impacts of surface mining which occur away from the site are: (1) changes in the volume of surface flow (both increases and decreases); (2) loss of groundwater; (3) deterioration of water quality; (4) channel erosion caused by increased sediment loads; (5) destruction of aquatic habitats; and (6) possible increases in endemic diseases among users of water contaminated by mining.

Changes in land configuration as they apply to stream channels (see above) could possibly impact streams at some distance from the site of mining. Sustained increases in flow could cause severe bank erosion and sedimentation problems in the major valleys of the western coal region. Major decreases in flow caused by consumptive uses of water at the mine will serve to decrease recharge to aquifers and lower groundwater levels.

Industrial water requirements for surface mining operations are relatively small and do not generally present serious problems of aquifer depletion or competition with existing uses (except for mining in conjunction with mine-mouth electric generating facilities). The principal consumptive use of water in mining operations is in dust control on access and haulage roads. The most common source of this water is the surface and groundwater that accumulates in mine sumps. Auxiliary water requirements for domestic and sanitation purposes at a typical mining operation (e.g., Decker, Montana) seldom exceed 5000 gallons per day (SCPRL, 1974).

Restoration of surface-mined lands requires inputs of large quantities of water. Rehabilitation practices which consume water include irrigation of vegetation planted on reshaped spoil piles, on-site use of water for retaining stockpiles of topsoil and mine spoil banks (interruption of surface flow causes internal drainage), permanent irrigation on some rehabilitated mine areas, and replacement of water supplies diminished in quality or quantity by prior mining activities with alternate sources.

Serious political conflicts can arise to the extent that expansion of mining activities (directly or indirectly) reduces the amount of water available to downstream users. Many of these users have established rights to these waters over a period of years prior to mining and are engaged in operations contingent on the continued availability of water. For example, much runoff is used for flood irrigation of meadows and stored for livestock use. Although this flow probably accounts for only five to ten percent of the flow reaching perennial streams, it takes on great significance in the arid west, for it supports the productive use of over 50 percent of the land (NAS, 1974).

Physical and Chemical Impacts--

Coal extraction can result in a variety of physical and chemical impacts to aquatic systems. Physical impacts from mining activities can include collapse of stream beds overlying older mines, diversion of water to a different surface drainage system or subsurface aquifer (resulting in loss of flow in the original stream and/or contamination of an aquifer), and erosion of spoil and refuse areas with subsequent sedimentation in aquatic systems. Potential chemical impacts to surface waters can be grouped into three general categories, namely, suspended solids (siltation), alkaline mine drainage, and nutrient enrichment (Dvorak et al., 1977).

Suspended Solids--Coal deposits in the west are located in arid and semi-arid areas characterized by frequent and extended periods of drought which are interrupted by brief, intense storms. These factors encourage erosion, making erosion rates on western rangeland among the highest in the United States on noncultivated land. Disturbance of these areas during mining and the lengthy period required for revegetation provide considerable potential for accelerating erosion and sediment loading to aquatic systems. The actual extent of aquatic degradation from suspended solids is dependent on the extent of area disturbed, its distance from a water body, and amount, form, and intensity of precipitation (Dvorak et al., 1977). Sediment transport in mining areas can be as much as 1000 times greater than that in undisturbed land. This, in turn, causes clogged reservoirs, premature aging of lakes from eutrophication and siltation, and direct and indirect toxic effects on aquatic biota (Dvorak et al., 1977).

Alkaline Mine Drainage--Western coals, by virtue of their generally low content of sulfur and pyrite, tend not to produce acid mine drainage problems of the type seen in the eastern and midwestern United States. Due to geologic and climatic characteristics, overburden and deposits between coal seams in the west frequently contain high concentrations of one or more soluble constituents. The most common of these include sodium, calcium, magnesium, carbonate, bicarbonate, sulfate, and occasionally chloride. Likewise, due to edaphic and climatic features, ground and surface waters in the southwest (Black Mesa) and Northern Great Plains (Powder River Basin) usually contain comparatively high concentrations of varying combinations of these constituents. (Data on the actual concentrations of these and other constituents in surface waters near mining areas are presented in a later section.) Generally, however, water in these areas is classified as hard (high in calcium and magnesium), and alkaline (high in carbonate and/or bicarbonate). If the dominant cation is sodium, the water is considered saline.

Results of available research indicate that leaching of soluble salts from mine spoils and their transport into receiving surface waters by precipitation, runoff, or pumping constitutes one of the most significant water quality problems expected in both the southwest and Northern Great Plains coal regions (Dvorak et al., 1977).

Reported effects of mine discharges from western coal mines upon receiving waters are site-specific, but viewed from a regional perspective, the effects most commonly reported are increases in: (1) hardness (due to increases in calcium and magnesium); (2) alkalinity (especially due to bicarbonate); (3) sodium; (4) sulfate; and (5) total dissolved solids (TDS). The effects of these changes on biota are variable and depend on such factors as relative amount of pollutant present, sensitivity of the species present, and degree of dilution as determined by flow rate (Dvorak et al., 1977). Effects on humans depend on the extent to which these changes in surface water are reflected in drinking water supplies.

Nutrient Enrichment--Nutrient enrichment of receiving waters occurs when nitrogen and phosphorus contained in chemicals used for mining are carried away from the site as runoff. Discharge of these compounds can result in algal blooms and decreased oxygen levels. These changes in turn cause alteration in biotic community structure. Oxygen depletion can also promote the production of toxic chemicals such as ammonia (by reduction of nitrates) or hydrogen sulfide (by reduction of sulfates) (Dvorak et al., 1977).

Groundwater Impacts

Impacts of groundwater resources from surface mining are less direct than the physical and chemical impacts on surface water described above. The most frequent groundwater impact appears to be the interception of groundwater aquifers as coal and overburden are removed. Both quantitative and qualitative changes can result. Interception of aquifers and subsequent lowering of the water table is serious in the west because precipitation rates are not usually sufficient to insure recharge of the aquifer. As indicated earlier, often the coal bed itself is an aquifer. While this water may not be of good enough quality for domestic use, significant use is made of these waters by livestock. Also, the groundwater normally carried by the aquifer (coal bed) may be discharged into the mine pit after the coal has been extracted. This water is sometimes removed by pumping it into nearby streams where the alkaline or saline characteristics of this waste may alter water quality or affect aquatic organisms in the streams. Finally, after completion of mining, spoils used to refill the pit may generate highly mineralized leachates as groundwater percolates through them. These leachates could subsequently contaminate surface and groundwater systems (Dvorak et al., 1977).

Summary

Water concerns are among the most visible and politically charged of all the problems which have been identified and discussed in connection with energy development in the western United States. Competition for water and concerns for its quality are long-standing traditions in this energy-rich but water-poor area. Availability of water for development or expansion of mining seems to dominate the issues addressed in the Environmental Impact Statements for proposed new facilities in the western coal area. Moreover, most of the attention has been focused on the quantity of water available for use rather than the quality of the water postdevelopment.

Several assessments have concluded that the energy developments being proposed for this region do not create new problems as much as they exacerbate existing ones (White et al., 1977; USGS, 1978b). It is generally agreed that water quality impacts of western energy resource development could include some of all of the following: (1) runoff from mines, spoils piles, facilities, and urban areas; (2) increasing concentration of various salts in surface waters due to consumptive uses of water; (3) accidental introduction of pollutants from evaporative ponds to surface water; and (4) contamination of groundwater springs and ponds.

As either point or nonpoint sources, energy resource developments apparently will not create as much of a salinity problem as would some other uses, particularly agricultural irrigation. In general, the amount of water consumed (i.e., withdrawn and not returned) by such developments should not have much of a salt concentrating effect on area surface streams. These findings are important for policy decisions regarding choices between alternative development schemes (U.S. EPA, 1977).

AIR QUALITY

Introduction

The extraction of millions of tons of coal annually from the western coal region will result in deterioration in air quality. Maximal air quality impacts are expected to occur when the developing mines reach their full production capacity, and to taper off over the remaining years of coal production at each site. Both direct impacts of the mining operation itself and indirect impacts due to population influx, increased vehicular traffic, and coal transportation are anticipated. This section provides a general overview of the relationships between various aspects of the mining operation and their impacts on air quality.

General Impacts

Air quality impacts are expected to vary directly with the number of acres of nonvegetated land at a given time. At most of the mining sites, hundreds of nonvegetated acres will be exposed to wind action at some point over the course of mining activities.

Undoubtedly, particulates in the form of fugitive dust will be the primary threat to air quality (USGS, 1978b). Gaseous emissions including sulfur dioxide, oxides of nitrogen, and carbon monoxide are expected to pose problems, but to a lesser extent. Activities of the mining operation which emit air pollutants include: (1) removal, transport, and storage of topsoil; (2) blasting, removal, deposition, and storage of overburden; (3) blasting, extraction, and transport of coal to storage areas; (4) coal processing (crushing, etc.); (5) transport of coal by unit train to utilization site; (6) replacement of overburden, topsoil, revegetation, and other reclamation processes; and (7) transport of people and material in and around the mine area (USGS, 1978a). Enlargement of the labor force produces an influx of population, which in turn, generates air quality deterioration due to increased vehicular traffic, home heating, power generation, etc.

Annual baseline total suspended particulates (TSP) near major traffic routes and coal handling facilities could be increased by a factor of 3.5 (USGS, 1978a). In some cases, the increments in TSP will be enough to cause violation of state guidelines and/or federal primary ambient air quality standards. Increases of thousands of tons of particulates annually (as projected by many mines) are expected to produce substantial reduction of visibility in the vicinity of the mines. Likewise, dustfall will increase significantly (USGS, 1978a).

Gaseous emissions from mining operations will probably have a lesser impact on air quality than particulates, and violations of air quality standards are not expected. NO_x fumes from blasting and coal bank fires could create acute pollution episodes which would harm organisms downwind of the mine and produce visibility reduction as well. These, however, are expected to be temporary and intermittent problems (USGS, 1978a).

The air quality of mining areas will also be impacted by two other activities, namely, the transport of coal via unit train and the increase in population due to coal mining development. Not only will the unit trains emit gaseous and particulate pollutants from the diesel engines, but also there would be approximately a two percent loss of coal to the atmosphere in the form of dust from open coal cars.

Specific Projected Impacts

Air pollutant emissions associated with the projected ten million ton/yr mining operation at Coal Creek Mine have been projected using various source factors and estimated emission rates (USGS, 1978b). For example, stripping operations are expected to produce 1.5 tons of fugitive dust for each acre of land disturbed per year. Soil erosion by wind is expected to contribute 0.08 tons of fugitive dust for each acre of land reclaimed for five years post-reclamation (0.02 due to natural soil erosion by wind). On-site unit train exhaust emissions were modeled based on an assumed fuel consumption rate of 1,800 gallons of diesel fuel per million ton-miles, with estimated EPA emission factors for locomotives. Off-site unit train exhaust emission estimates were similarly derived based on 1,000 unit trains per year carrying ten million tons of coal per year over the productive life of the mine, with train emission rates as above. Estimated coal dust emission along the railroad corridor from the Coal Creek mine was placed in the vicinity of 200,000 tons annually (USGS, 1978b). Population-related emissions were projected based on an estimated population increase of 1,650 people combined with EPA per capita emission factors for population increases.

Combining the estimated impacts from the various sources above, emissions from proposed new mining operations or expansions of existing mines can be projected. Similar estimates have been made for total emissions in the eastern Powder River Basin coal mining region under various development scenarios. The air quality impacts of new mining activities are expected to be substantial. One estimate, for example, placed emissions from the anticipated development of the coal deposits in the Powder River region at from ten to 12 percent of total emissions for the state of Wyoming (USGS, 1978b).

Summary

It is not possible to accurately predict the effects of the above emissions on local and regional air quality unless atmospheric dispersion patterns peculiar to the site are known. Then, atmospheric effects can be simulated using dispersion models. Nevertheless, it is known that in areas of high coal mining activity, particulate concentrations can often exceed 1,000 mg/m^3. Most projections indicate that applicable annual air quality standards for particulates (60–75 $\mu g/m^3$) will probably not be exceeded through 1985, but that it is very likely that 24-hour standards will continue to be violated regularly, as they are now under undisturbed conditions. There is some indication that oxidants may violate standards, but modeling data are not available. Carbon monoxide, nitrogen oxides, and sulfur dioxide are not expected to violate standards.

THE SOCIAL ENVIRONMENT

The rapid growth in population that is experienced by many western communities as a result of coal mining expansion creates some potentially serious social problems. These problems are aggravated by the unique characteristics of the area. The area is very sparsely populated, thus many interpersonal relationships (financial and other) are based on an informal system of trust. This system must be replaced by a more impersonal and formal mode of interaction as longtime residents of a community cope with the large influx of newcomers (Richards, 1977; Hanks et al., 1977).

One of the major problems in these communities is inadequate housing. Because the mining companies are able to pay relatively high wages to compete for labor, construction costs must increase. Newcomers, who tend to be primarily young adults with young children, are finding it difficult, if not impossible, to purchase their own homes (Brown, 1977; Uhlmann, 1977). As a result, trailer and rental living are accepted as the only alternatives, with crowded housing conditions developing rapidly.

Another problem these communities are facing is the inability to provide recreational facilities suitable to the new patterns of living. Traditionally, camping, fishing, and hunting have been the preferred forms of recreation for the slow-paced, rural lifestyle. The more regimented eight-hour day, 40-hour week lifestyle demands more immediately accessible types of recreation such as bowling, swimming, and theaters (Uhlmann, 1977; Brown, 1977).

A third difficulty is the inability of community services, both public and private, to meet the rapidly increasing demand. Most community services such as water and sewer facilities, schools, and health care can meet a five to ten percent annual increase in demand (University of Wyoming, 1978; Hanks et al., 1977). Some of the mining impacted communities are, however, doubling or tripling in size in two to three years (University of Wyoming, 1978).

These three conditions, which result from the mining boom, appear to be increasing the incidence of a multitude of social and mental health problems. There is much depression and child abuse, especially among the female population. This is most likely a result of the crowded living conditions and inadequate recreational opportunities (Uhlmann, 1977; Brown, 1977). The unsettled home life and crowded schools, which cannot provide sufficient extracurricular activities, are contributing to childhood social and behavioral disorders (Uhlmann, 1977; Brown, 1977). Likewise, the law enforcement agencies are not prepared to deal with juvenile delinquency (Uhlmann, 1977; Brown, 1977; Hanks et al., 1977). The predominantly male working population is turning to alcohol, prostitution, and gambling for relaxation due in part to the lack of more acceptable social and recreational outlets (Brown, 1977; Hanks et al., 1977). The population of senior citizens, whose social network has been based on family relationships, is forced into isolation as social networks shift from a family to a peer orientation. Also, their fixed incomes are no longer sufficient because of massive inflation (Uhlmann, 1977; Brown, 1977; Hanks et al., 1977). In considering these problems, it is important to keep in mind that the discussions in the above citations are not based on empirical data; increases in social problems may be proportional to increases in population size; actual rates may not be changing (Hanks et al., 1977).

It is necessary to point out that there are some social advantages to the boom conditions as well as the many disadvantages listed above. Hanks et al. (1977) point out two such advantages:

(1) Financially, business entrepreneurs and high ranking mining company employees reap tremendous profits.

(2) There is a substantial decrease in unemployment and poverty levels. Richards (1977) also suggests that the boom communities may be attracting attention that will produce government financial support for schools, health facilities, and other areas where there is, and has been, a need.

COMMUNITY ECONOMIC STATUS

A rapid increase in the population of a community such as that initiated by the opening of a new mine or expansion of an old one can create some serious financial problems for the community involved. Gilmore et al. (1976) conceptualize these problems as a mutually reinforcing triangle with three components. These three problem categories are discussed briefly with a cursory analysis of factors which influence their respective magnitudes.

Inadequate Local Services

Local services provided by both public and private sectors may not be able to accommodate the rapid increase in population. This results mainly from two conditions: (1) employment in community services may be unable to compete effectively with comparatively higher paying opportunities with the mining companies; and (2) capital for investments, from both public and private sources lags far behind the generated needs (Gilmore et al., 1976; Denver Research Institute, 1975). For example, expensive labor for housing construction may lead to complete dependence upon trailer dwellings. This form of housing tends to cluster on the fringes of communities where it is difficult to provide adequate water and sewer facilities (Gilmore et al., 1976; Uhlmann, 1977). Tax revenues do not rise proportionately to the population, since few of the newcomers are able to purchase property. This is especially troublesome since many of the migrants are young families with children and thus place a heavy burden on local schools, roads, etc., without contributing the tax dollars needed to improve such services (Uhlmann, 1977; Denver Research Institute, 1975). Other community services which may lack adequate support are health care facilities, community protection agencies, and recreational facilities (Gilmore and Duff, 1975; Denver Research Institute, 1975; Uhlmann, 1977).

Lowered Quality of Life

The lack of community services, as described above, can create a situation in which a large part of the community is living under unsatisfactory conditions. The original inhabitants share the now limited resources with the newcomers. Because residents must share limited tangible commodities, intangible qualities also suffer. The feeling of community deteriorates, and the two groups, original inhabitants and newcomers, become competitive, neither accepting the other (Gilmore et al., 1976; Denver Research Institute, 1975).

Decreased Productivity and Profitability

Residents dissatisfied with the quality of their personal lives can lead to lower employee productivity. This appears in the form of high rates of absenteeism and turnover, lowered production per shift, and difficulty in recruiting labor. Due to these labor problems, companies' profits suffer which, in turn, causes decreasing tax revenues for the local community. Capital for investment in private sectors of community services such as hospitals is also decreased. Consequently, the series of problems has become a mutually reinforcing triangle (University of California, 1978; Gilmore et al., 1976).

Factors Influencing the Magnitude of the Problems

The above description is a superficial view of this issue, since each of the issues raised has many facets. Gilmore et al. (1976) and University of California (1978) address the following factors which could influence the magnitude of the various problems discussed. (1) The problem of insufficient public revenues can be exacerbated when the increase in population is in one taxing jurisdiction and the increase in assessed valuation due to the energy developments is in another jurisdiction. (2) The permanence and rate of population growth affect the whole gamut of problems. In general, the faster the growth rate, the more severe the problems. (3) Often there is a large amount of uncertainty regarding development. Greater certainty of development increases the willingness of public officials to incur public debts and may also lower lending rates. (4) Communities which have revenue sources such as income or sales tax that reflect the population increase more rapidly may avoid some of the lag time involved with property tax as a source of revenue. (5) The basis of the community's economy prior to the establishment of mining and other industries in the area may affect the availability of labor, the attractiveness of the area to newcomers, and the degree of antagonism between newcomers and established residents. Power generating plants will increase the competition with agriculture for water resources. This competition further strains the relationship between newcomers and the original inhabitants. A community with a large tourist economy may be very attractive to prospective employees. The tourist trade itself, however, may be severely damaged by the aesthetic degradation of the area that accompanies strip mining.

In conclusion, the problem triangle as described here is only a superficial view of the issue. The economic and financial problems resulting from boom town growth are much more complex and involved. While the scope of this report does not provide for further analysis of this particular problem, detailed studies of the problem have been undertaken by the University of California (1978); and Gilmore et al. (1976).

TRANSPORTATION

Coal development affects transportation by two distinct mechanisms. First, the influx of population inevitably causes increased motor vehicle traffic, and the residents' new housing generates the need for additional or upgraded roads. This issue is one of many facets of rapid community development, and is not specific to the expansion of coal mining activities. The general problem of meeting the public's transportation needs is addressed from an economic perspective in the previous section.

The second transportation concern is the impact of coal movement in the area. Shipping coal by truck or rail has the potential to produce accidents and injuries to both transportation workers and the general public. Collisions involving coal trucks or trains fall clearly in the realm of health impacts of coal development.

Several attempts have been made to determine the national health costs of coal transportation. Sagan (1974) estimated that ten percent of the 2,300 annual railroad-related deaths are a result of coal transportation to electricity generating facilities, or 230 deaths annually. An additional 2,000 injuries were estimated also as an impact of coal transportation by rail. This calculation ignores truck and barge transportation of coal, and any transportation of coal for uses other than electricity generation. Similar (crude) methods have been employed by others to estimate the loss of life due to coal transportation for electricity. A synthesis of these studies by Comar and Sagan (1976) indicates that 0.55 to 1.3 deaths occur annually in transporting coal to supply a 1,000 megawatt power plant.

Studying transportation in the small western communities locally impacted by coal mining is somewhat more difficult than national analyses, and the above calculations are not easily extrapolated. The coal produced at western mines is either hauled by truck to its end-use site, truck to train to end-use site, or directly by train to end-use site. The local effect of coal transportation would be in the form of motor vehicle or pedestrian accidents involving the trucks or trains. In order to extrapolate the national averages cited earlier to a community, it would be necessary to compute deaths/injuries per mile traversed by train or truck, and the number of train or truck miles traversed in the vicinity of the community. This cannot be done accurately. A more reasonable approach to the study of coal-related transportation injuries in small communities would be a search of hospital admissions and death certificates for all transportation injuries. Then, a case-by-case consideration of the identified incidents would determine which were coal-related.

In summary, effects of train and truck traffic on coal mining impacted communities are nearly inevitable. There is some probability that the vehicles shipping coal will kill or injure some community residents. Unfortunately, there is no readily available quantitative data on such risks at the community level, and national estimates are not very useful for such purposes.

HEALTH

The health of the populations impacted by coal mining is the ultimate focus of this study. The preceding five issue areas are deserving of concern in their own right, but it is their role as mediators of a coal mining/health relationship which is of special concern. In this section, the manner in which the changes in the social, economic, and physical environment engendered by mining could affect health is described. The specific health parameters expected to change as a result of environmental impacts will be noted when possible. In this way, the reader can compare these anticipated health changes with the readily available health indices (described in a later section) to evaluate the adequacy of routinely reported health measures as indicators of coal mining impacts.

Effects of Changes in Water Quality

Although the link from mining-impacted surface and groundwater to tap water is tenuous, for discussion purposes, the chemical alterations in the water sources will be assumed to be qualitatively similar. One expected effect is a general increase in the chemical material in the water as reflected by total dissolved solids (TDS), conductivity, and hardness. There is a speculative link of TDS and conductivity with decreased cancer mortality (Burton and Cornhill, 1977), but this has not been replicated. A better established association is that between water hardness and (decreased) cardiovascular disease (Neri et al., 1974).

It is interesting to note that while the above nonspecific water factors are associated with decreased disease rates, a variety of specific ions are linked to negative health outcomes. Increased sodium and/or nitrate may produce hypertension (Calabrese and Tuthill, 1977; Morton, 1971). Furthermore, toxic metals (which may be increased due to coal mining) are associated with a broad range of illnesses (NAS, 1977). These include gastrointestinal and urinary tract cancers (Berg and Burbank, 1972), hypertension (Perry, 1972), and other cardiovascular diseases (Neri et al., 1974). Although a listing of the health effects speculatively associated with water quality alterations does not narrow the scope of inquiry substantially, several health outcomes are pinpointed as essential for consideration, including hypertension and other cardiovascular diseases and cancers in organs exposed to ingested water (gastrointestinal and urinary tracts).

Effects of Changes in Air Quality

The major air quality concern is with increased particulates as a consequence of coal mining and related activities. Particulates are associated with a variety of respiratory impairments, including chronic bronchitis (U.S. DHEW, 1969). In addition to this nonspecific effect, selected components of particulate matter may have other respiratory and nonrespiratory impacts (e.g., cadmium and hypertension, polycyclic organic matter and lung cancer). Precise suggestions of health impacts other than chronic respiratory disease would require chemical characterization of the particulate matter in the mining area of concern.

Effects of Changes in the Social Environment

The negative social changes characteristic of boom towns might be expected to exert a strong influence on the health of community residents. The most obvious effects would be anticipated on traditional "social ills". including alcohol and drug abuse, violence (homicide, suicide), and psychological disorders. The physical effects consequent to these behaviors are numerous (e.g., cirrhosis of the liver, hepatitis, venereal disease).

In addition, the social transformation might produce physical health changes in more subtle ways (Cassel et al., 1960; Cassel, 1976). There are potential effects on hypertension and other cardiovascular diseases, as well as the generalized detrimental effects of stressors on health (Eyer, 1977).

Effects of Changes in Economic Status

The major concern in regard to the community's economic condition is the effect of inadequate social, medical, and public health services on health status. With rapid population growth there is a risk that community environmental services will not expand quickly enough to meet the increasing demand. As a result, environmental contamination could occur. Inadequate sewage disposal could lead to contamination of drinking water supplies with fecal wastes (NGPRP, 1974). Communicable diseases caused by enteric pathogens such as typhoid and infant diarrhea could be spread rapidly under such conditions. Personal hygiene would suffer if the water supply were insufficient, thus increasing the risk of person-to-person transfer of intestinal pathogens. Where solid wastes are not disposed of properly, disease carrying rodents and insect vectors can find favorable breeding grounds.

Rapid population growth can also create conditions in which supply of and access to primary health care is limited. This would result in inadequate school immunization programs, poor follow-up of identified health problems, and less ability to screen the population for latent problems, leading to more serious manifestations of disease conditions. There are some positive changes in health to be anticipated by the few members of the community reaping financial benefit which may be accompanied by improved access to medical care.

Increased traffic is a direct consequence of rapid community growth. Increased vehicular emissions contribute to carbon monoxide and hydrocarbons in the air, thus increasing the risk of cardiorespiratory ailments and other problems related to these chemicals. Also, traffic accidents would be expected to increase in boom town situations with their substantial economic and health tolls. In addition to accidents resulting from transporting coal (discussed earlier), the increased number and concentration of residents would be predicted to compound this problem.

Effects of Changes in Transportation Networks

Transporting coal by truck or train entails risks of accidents. Residents of the coal-impacted communities are placed at some risk of injury or death as a result of the movement of coal transporting vehicles in their vicinity.

SECTION 3

RESEARCH METHODOLGY

DEFINING EXPOSURE

Before setting out to measure changes in health status which may be associated with increased mining, it is essential to select appropriate measures of exposure ("dose") and response. Levels of exposure in a community are usually determined through sampling and analyses of environmental media (e.g., air, water) or human tissues and fluids (e.g., blood, urine, hair). Response, on the other hand, is commonly measured by changes in health status as reflected in rates of mortality, morbidity, hospital usage, or community health surveys.

The first part of this section describes our efforts to identify specific communities which are already being impacted by the development of the western coal fields, or by virtue of their location, are likely to be impacted in the near future. The types and sources of demographic data on these communities are outlined. Next, available monitoring data are given such that environmental quality in the vicinity of the impacted communities can be characterized. The final part of this section describes some of the major indices of community health status, the type of data required to calculate each measure and the degree of availability of the requisite data for various communities in the western coal area.

DATA ACQUISITION AND CHARACTERIZATION

Coal Mining Activities

Mapping of Current Mines--

In order to identify potential effects of coal mining on human populations, it was first necessary to characterize the current status of mining activities in the areas of interest. The most up-to-date information available was obtained from the U.S. Department of the Interior's Mineral Industry Location System (MILS). This service of the Bureau of Mines maintains a current computer file on mining which was searched for information on coal mining in all six EPA Region VIII states. Each coal mine was listed by name with identification of its county, type (surface or underground), current production status, and precise location (latitude/longitude).

For mapping purposes, all mines listed as "current producers" were included. It should be noted that there was no indication of annual production tonnage provided, so that some of the mines listed on the map may be quite small. In addition, L. R. Rice of the U.S. Bureau of Mines in Denver (personal communication) stated that some of the mines undergo frequent changes in production status. That is, short-term variations in the price of coal and transportation costs cause some mines to terminate and others to commence production. Keeping these imperfections in mind, all currently active mines were denoted on a map of EPA Region VIII, according to their latitude/longitude coordinates. Appendix A contains a listing of those mines currently producing coal (as well as planned mines which are discussed in the following section). The mine name, location, and type were obtained from the MILS printouts.

When available, supplementary data from the Keystone Coal Industry Manual (Nielson, 1977) were used as a source of coal analysis, past production, and current employment data. The MILS mine listing was more extensively used, however, since it is a more current source of data.

Figure 2 is a reproduction of the results of this mapping process (i.e., the mines listed in Appendix A). One of the most noteworthy features of western coal mining is the type of mining (surface or underground) as a function of geography. The mines in North Dakota, Montana, and Wyoming are nearly all surface, whereas those in Utah are nearly all underground. In Colorado, both types coexist with about twice as many underground as surface mines. It should be kept in mind in examining Figure 2 that the extreme variability in mine production (with greater quantities from surface mines) makes the number of mines an imperfect reflection of actual tonnage mined. In fact, the apparent concentration of mines in Utah, Colorado, and North Dakota, with sparse mining in Montana and Wyoming is inverse to actual coal production.

Mapping of Future Mines--

The information required for locating and quantifying coal mining development was obtained from a variety of sources, but primarily from the Bureau of Mines Information Circular 8772 (Rich, 1978). This document is a compilation of all energy-related expansion in western states, including coal mine development, updated as of August, 1977. It should be noted that mine development is often contingent on such factors as water availability and is thus subject to unpredictable changes. For that reason, the future coal mine information provided in Appendix B should be viewed as the current best conjecture of development and expansion plans.

The mine name, location, coal analysis, and future production were compiled by Rich (1978), and supplemented as needed with the information in Bureau of Mines Information Circular 8719 (Corsentino, 1976), and the MILS printouts (USBM, 1978). In order to determine the degree of expansion (increase), the baseline production for 1975 or 1976 was obtained from the Keystone Coal Industry Manual (Nielson, 1977).

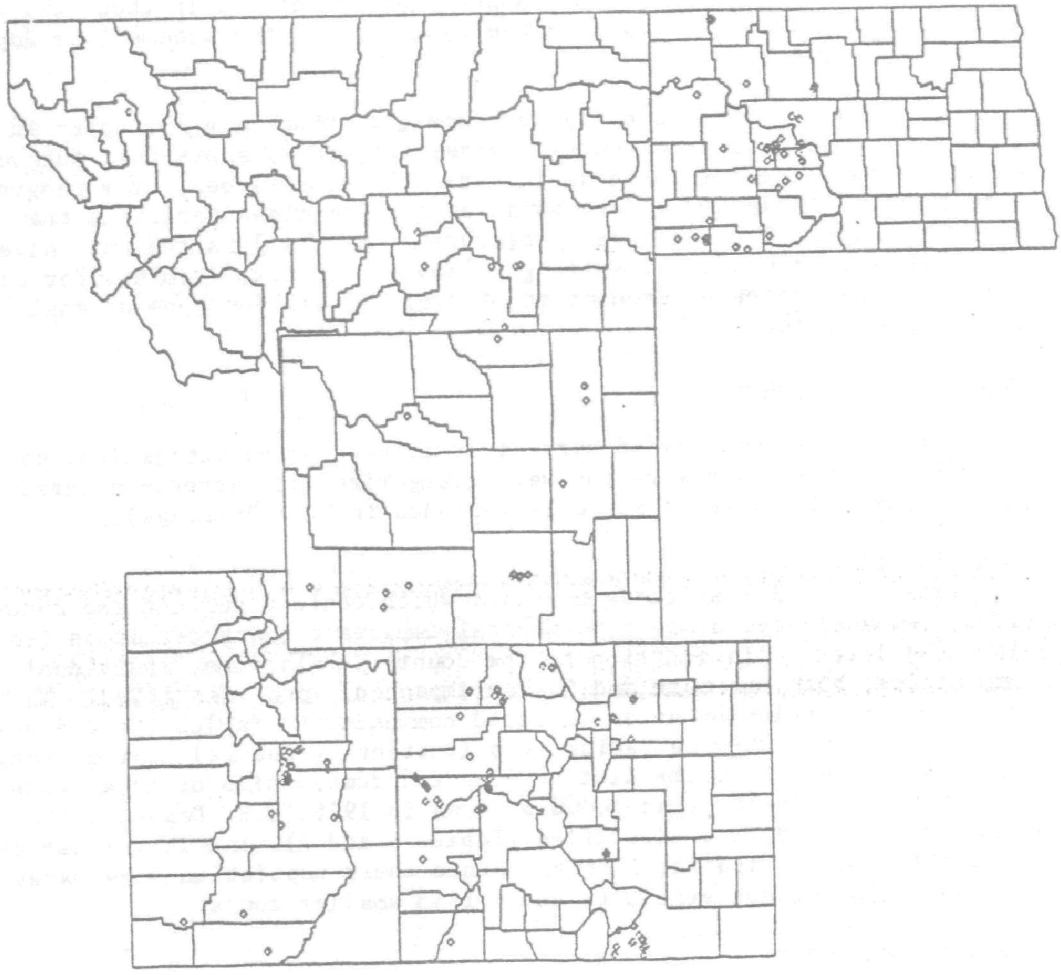

Figure 2. Geographic distribution of current mining activity in EPA Region VIII.

Mines were included on the map shown in Figure 3 if they had a projected tonnage in 1980 or later and could be located with latitude/longitude coordinates, township/range coordinates, or detailed descriptions of proximity to towns or rivers. Current production was noted as the production for 1976 or, if unavailable, 1975, as indicated in the Keystone Coal Industry Manual (Nielson, 1977). The absence of any current value was interpreted to mean no current production. The future level was taken as the maximum projected value supplied by Rich (1978), or, if a range was projected, the midpoint of that range. The difference in these two values (current and future) was used in the symbolic mapping scheme (see Appendix B, Footnote b).

The locations of developing and expanding mines are indicated in Figure 3. Comparison with current mines (Figure 2) shows that much of the expansion is projected to occur in currently mined areas. The geographic distribution of planned underground and surface mines parallels the current mining pattern. The outstanding feature of Figure 3 is the extensive development in Montana and Wyoming. Campbell County, Wyoming, for example, has plans for increased production of over 100 million tons of coal per year by the mid 1980's.

Impacted Communities

Based on the presence of current or future mining activities, coal-impacted counties in the region were categorized as current-impacted or future-impacted (counties could be included in both listings).

Identification--

Tables 2 and 3 list those counties which contain current and future mines, respectively, along with several important characteristics (to be discussed later). In addition to the county tabulations, individual communities, both current- and future-impacted, were identified. The only criterion for inclusion as an impacted community in Tables 4 and 5 was location within a 20-mile radius of a (current or future) mining site.[1] Finally, a subset from the list of impacted communities of those with populations of greater than 1,000 persons in 1975 (U.S. Department of Commerce, 1977 a-e) was identified (Tables 6 and 7). The latter set of communities was of special interest since their population size makes them more suitable for epidemiologic study than smaller towns.

Characterization--

Information on the impacted areas was obtained on both county and community levels. This information is described in detail below.

[1]Categorization of communities was independent of the status of its home county; mines near county borders often result in impacted communities outside the mining county.

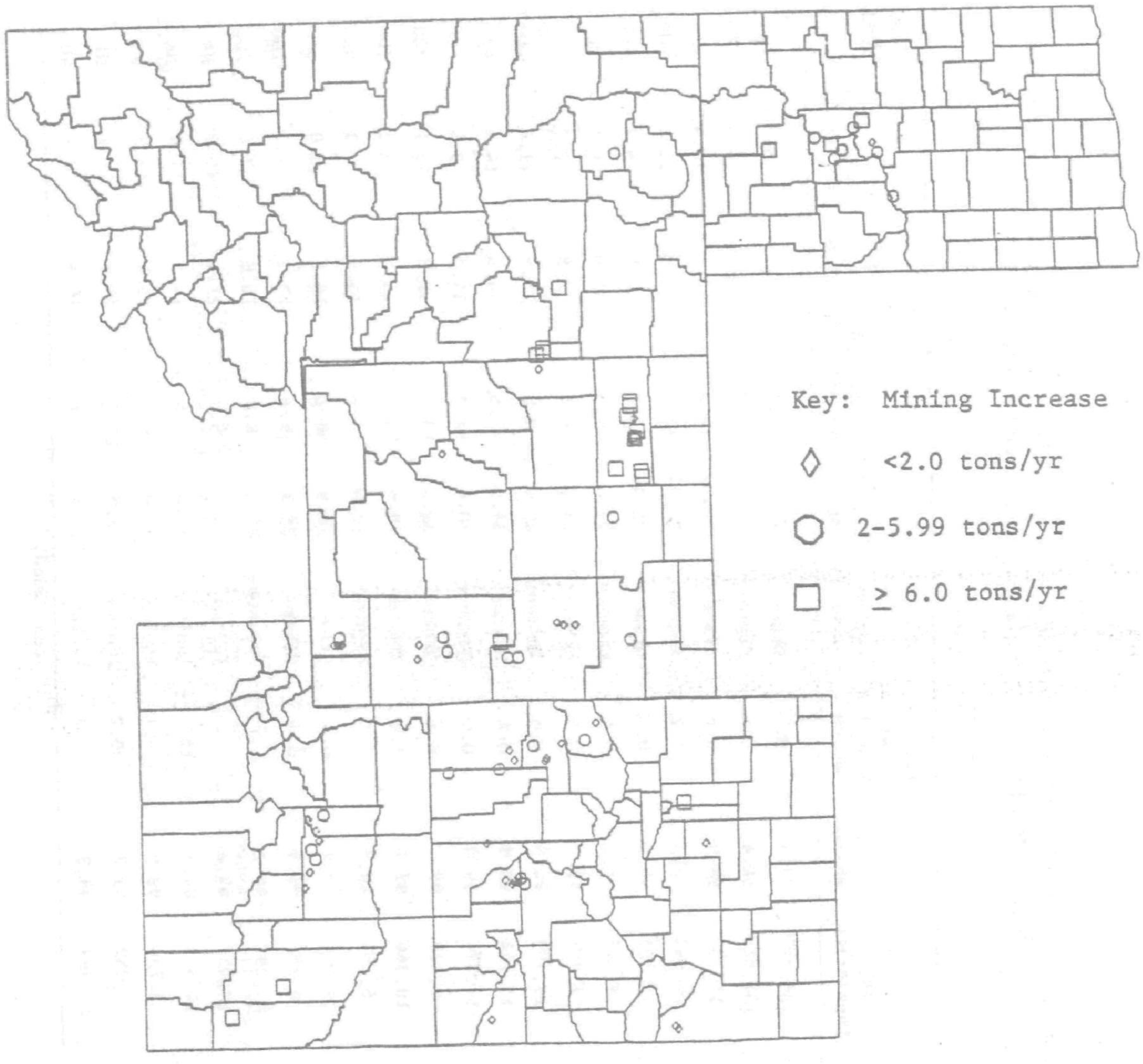

Figure 3. Geographic distribution of developing mining activity in EPA Region VIII.

TABLE 2. SELECTED DEMOGRAPHIC CHARACTERISTICS OF COUNTIES IN EPA REGION VIII WHICH CURRENTLY HAVE COAL MINING OPERATIONS[(a)]

State	County	1970 Population	Percent White	Percent In Largest Nonwhite Group	Group Identity	Median Age	Percent Over 65	Birth Rate Per 1000	Death Rate Per 1000	Employment in Mineral Industry[(b)] Number	Employment in Mineral Industry[(b)] Percent Population
Colorado	Adams	185,789	97.7	0.7	Negro	23.0	3.6	19.1	4.3	NA[(c)]	
	Boulder	131,889	98.4	0.5	Negro	24.2	7.0	16.2	6.2	200	0.2
	Delta	15,332	98.9	0.6	Other	39.0	18.5	12.6	13.4	NA	
	Fremont	21,942	98.2	1.2	Negro	35.9	17.6	12.0	15.1	200	0.9
	Garfield	14,821	99.5	0.2	Other	30.4	11.3	14.9	9.7	400	2.7
	Gunnison	7,578	98.8	0.4	Other	21.5	4.8	15.9	6.1	NA	
	Jackson	1,809	99.2	0.5	Other	25.9	4.9	18.8	7.7	NA	
	La Plata	19,199	94.6	4.8	Indian	26.4	9.9	15.9	11.4	100	0.5
	Las Animas	15,744	98.8	0.6	Negro	31.9	15.5	14.6	14.3	NA	
	Mesa	54,374	99.0	0.4	Negro	30.4	11.9	14.9	9.6	500	1.0
	Moffat	6,332	99.4	0.4	Other	31.1	10.5	17.9	10.1	200	3.2
	Montrose	18,366	97.7	1.6	Indian	28.9	10.1	16.5	9.3	700	
	Pitkin	6,185	98.7	0.7	Negro	27.0	3.9	15.9	4.2	NA	
	Rio Blanco	4,842	98.9	0.4	Other	26.9	8.2	18.1	8.0	600	12.7
	Routt	6,592	99.4	0.4	Other	28.5	9.7	13.9	7.8	100	1.5
	Weld	89,297	98.2	0.7	Japanese	24.4	8.8	16.8	7.6	200	0.2
Montana	Big Horn	10,057	59.8	38.9	Indian	23.5	6.9	21.5	10.0	NA	
	Lake	14,445	84.5	15.2	Indian	29.8	13.5	14.5	11.8	NA	
	Musselshell	3,734	99.9	0.1	Indian	38.0	16.3	13.4	13.3	NA	
	Rosebud	6,032	69.7	30.2	Indian	26.5	10.2	20.8	11.1	NA	
	Yellowstone	87,367	98.2	1.2	Indian	26.3	8.1	16.8	8.1	400	0.5

(continued)

TABLE 2. (Continued)

State	County	1970 Population	Percent White	Percent In Largest Nonwhite Group	Group Identity	Median Age	Percent Over 65	Birth Rate Per 1000	Death Rate Per 1000	Employment in Mineral Industry(b) Number	Percent Population
North Dakota	Adams	3,832	99.8	0.2	Indian	31.0	12.8	17.4	11.6	NA	
	Bowman	3,901	100.0			28.5	11.0	14.7	11.0	NA	
	Burke	4,739	99.6	0.3	Indian	33.4	12.4	16.8	12.2	200	4.2
	Dunn	4,895	91.7	8.1	Indian	25.3	8.3	18.1	9.6	NA	
	Grant	5,009	99.7	0.2	Indian	28.9	9.0	13.5	8.4	NA	
	McHenry	8,977	99.8	0.1	Indian	30.6	12.4	15.1	9.5	NA	
	McKenzie	6,127	90.7	9.0	Indian	28.4	9.9	13.4	9.5	200	3.3
	McLean	11,251	95.0	4.8	Indian	12.1	31.7	12.1	9.3	NA	
	Mercer	6,175	98.8	1.2	Indian	32.0	10.8	17.6	11.6	200	3.2
	Morton	20,310	99.4	0.5	Indian	25.6	10.2	15.7	8.0	NA	
	Montrail	8,437	90.8	9.1	Indian	29.9	11.7	15.7	10.7	NA	
	Oliver	2,322	99.4	0.6	Indian	25.6	6.3	17.8	4.3	NA	
	Slope	1,484	99.9	0.1	Filipino	18.9	6.9	18.2	8.6	NA	
	Stark	19,613	99.7	0.3	Indian	22.1	8.9	20.1	7.2	100	0.5
	Ward	58,560	96.7	2.1	Negro	23.2	6.9	22.0	6.2	NA	
	Williams	19.301	97.9	1.9	Indian	26.9	9.6	17.1	9.3	400	2.1
Utah	Carbon	15,647	98.7	0.4	Other	30.8	10.9	16.2	8.1	1,000	6.4
	Emery	5,137	99.4	0.3	Indian	27.6	11.2	16.2	8.7	300	5.8
	Garfield	3,157	99.2	0.8	Indian	26.4	9.8	14.9	9.1	NA	
	Iron	12,177	98.1	1.6	Indian	22.4	7.6	24.7	6.8	200	1.6
	Kane	2,421	99.0	1.0	Indian	27.3	9.8	19.6	8.2	NA	
	Sevier	10,103	98.9	0.9	Indian	29.7	12.7	14.9	9.6	NA	

(continued)

TABLE 2. (Continued)

State	County	1970 Population	Percent White	Percent In Largest Nonwhite Group	Group Identity	Median Age	Percent Over 65	Birth Rate Per 1000	Death Rate Per 1000	Employment in Mineral Industry[b] Number	Employment in Mineral Industry[b] Percent Population
Wyoming	Campbell	12,957	99.0	0.7	Indian	23.2	4.9	16.8	6.7	700	5.4
	Carbon	13,354	98.5	0.7	Negro	30.0	9.5	13.1	9.1	300	2.2
	Converse	5,938	99.2	0.5	Indian	31.4	12.8	11.0	10.2	200	3.4
	Hot Springs	4,952	97.0	2.6	Indian	35.0	16.5	8.9	13.2	200	4.0
	Lincoln	8,640	99.5	0.2	Indian	26.7	9.3	18.4	8.0	400	4.6
	Sheridan	17,852	98.9	0.4	Indian	35.5	15.8	14.5	13.7	NA	
	Sweetwater	18,391	97.5	1.3	Negro	29.0	9.6	15.6	10.8	1,100	6.0

[a] List of counties is based on Bureau of Mines Information Circular 8772 (Rich, 1978).

[b] This is the mineral industry employment for the year 1967 (U.S. Department of Commerce, 1973).

[c] NA = Not Available.

TABLE 3. SELECTED DEMOGRAPHIC CHARACTERISTICS OF COUNTIES IN EPA REGION VIII WHICH ARE SLATED FOR EXPANSION OF COAL MINING OPERATIONS(a)

State	County	Population	Percent White	Percent In Largest Nonwhite Group	Group Identity	Median Age	Percent Over 65	Birth Rate Per 1000	Death Rate Per 1000	Employment in Mineral Industry(b) Number	Percent of Population
Colorado	Adams	185,789	97.7	0.7	Negro	22.8	3.6	19.1	4.3	NA(c)	
	Delta	15,286	98.9	0.6	Other	39.6	18.5	12.6	13.4	NA	
	Elbert	3,903	99.3	0.3	Indian	33.6	14.0	8.7	10.8	NA	
	Gunnison	7,578	98.8	0.4	Other	22.3	4.8	15.9	6.1	NA	
	Jackson	1,811	99.2	0.5	Other	27.3	6.6	18.8	7.7	NA	
	La Plata	19,199	94.4	4.8	Indian	26.3	9.9	15.9	11.4	100	0.5
	Las Animas	15,744	98.8	0.4	Other	32.0	15.5	14.6	14.3	NA	
	Mesa	54,374	99.0	0.4	Negro	30.2	12.0	14.9	9.6	500	0.9
	Moffat	6,525	99.4	0.4	Other	29.7	10.2	17.9	10.1	200	3.1
	Rio Blanco	4,842	98.9	0.3	Other	26.9	8.2	18.1	8.0	600	12.4
	Routt	6,592	99.4	0.4	Other	28.4	9.8	13.9	7.8	100	1.5
Montana	Big Horn	10,057	59.8	38.9	Indian	23.4	6.9	21.5	10.0	NA	
	McCone	2,875	99.4	0.6	Indian	28.5	10.0	11.6	8.9	NA	
	Rosebud	6,032	69.7	30.2	Indian	26.2	10.2	20.8	11.1	NA	
North Dakota	Burleigh	40,714	98.8	1.1	Indian	25.2	7.9	19.0	7.3	NA	
	Dunn	4,895	91.7	8.1	Indian	25.5	8.3	18.1	9.6	NA	
	McLean	11,251	95.0	4.8	Indian	31.7	12.1	12.1	9.3	NA	
	Mercer	6,175	98.8	1.2	Indian	31.5	10.8	17.6	11.6	200	3.2
South Dakota											
Utah	Carbon	15,647	98.7	0.4	Japanese	30.8	10.9	16.2	8.1	1000	6.4
	Emery	5,137	99.4	0.3	Indian	28.0	11.2	16.2	8.7	300	5.8
	Garfield	3,157	99.2	0.8	Indian	26.6	9.8	14.9	9.1	NA	
	Kane	2,421	99.0	1.0	Indian	27.5	10.0	19.6	8.2	NA	

(continued)

TABLE 3. (Continued)

State	County	Population	Percent White	Percent In Largest Nonwhite Group	Group Identity	Median Age	Percent Over 65	Birth Rate Per 1000	Death Rate Per 1000	Employment in Mineral Industry[(b)] Number	Percent of Population
Wyoming	Albany	26,431	97.8	0.7	Negro	23.2	6.2	20.2	6.4	NA	
	Campbell	12,957	99.0	0.7	Indian	23.4	4.8	16.8	6.7	700	5.4
	Carbon	13,354	98.5	0.7	Negro	29.7	9.6	13.1	9.1	300	2.2
	Converse	5,938	99.2	0.5	Indian	31.3	12.8	11.0	10.2	200	3.4
	Hot Springs	4,952	97.0	2.6	Indian	36.5	16.5	8.9	13.2	200	4.0
	Lincoln	8,640	99.5	0.2	Indian	26.7	9.2	18.4	8.0	400	4.6
	Sheridan	17,852	98.9	0.4	Indian	36.8	15.9	14.5	13.7	NA	
	Sweetwater	18,391	97.5	1.3	Negro	28.9	9.6	15.6	10.8	1100	6.0

(a) List of counties is based on Bureau of Mines Information Circular 8772 (Rich, 1978).

(b) This is the mineral industry employment for the year 1967 (U.S. Department of Commerce, 1973).

(c) NA = Not Available.

TABLE 4. COMMUNITIES WITHIN 20 MILES OF CURRENTLY OPERATING MINES[a]

State	County	Community
Colorado	Adams	Aurora, Bennett, Brighton, Commerce City, Eastlake, Federal Heights, Henderson, Northglenn, Thornton, Watkins, Westminster
	Arapahoe	Englewood, Strasburg
	Boulder	Allenspark, Boulder, Eldora, Gold Hill, Hygiene, Jamestown, Lafayette, Longmont, Louisville, Lyons, Marshall, Nederland, Nivot, Pinecliffe, Ward
	Costilla	Chama, San Pedro
	Custer	Greenwood, Rosita, Silver Cliff, Westcliffe, Wetmore
	Delta	Bowie, Crawford, Grand Mesa, Hotchkiss, Lazear, Paonia
	Denver	Denver
	Fremont	Canon City, Florence, Hillside, Parkdale, Penrose, Portland, Texas Creek
	Garfield	Carbondale, Cardiff, Glenwood Springs, New Castle, Rifle, Silt
	Gilpin	East Portal, Idaho Springs, Rollinsville
	Gunnison	Marble, Somerset
	Huerfano	Cuchara, La Veta, Maitland, Walsenburg
	Jackson	Coalmont, Cowdrey, Kings Canyon, Rand, Walden
	Jefferson	Arvada, Golden, Wheat Ridge
	La Plata	Durango, Hesperus, Kline, Marvel, Mayday, Redmesa, Trimble
	Larimer	Berthoud, Campion, Glendebey
	Las Animas	Aguilar, Boncarbo, Culnare, Hoehne, Jansen, Ludlow, Model, Stonewall, Trinidad, Valdez, Weston
	Mesa	Cameo, DeBeque, Fruitvale, Glade Park, Grand Junction, Loma, Mack, Mesa, Molina, Palisade, Whitewater
	Moffat	Axial, Craig, Hamilton, Lay, Moffat
	Montezuma	Mancos, Mesa Verde National Park
	Montrose	Bedrock, Naturita, Nucla, Redvale, Uraban, Vincorum
	Pitkin	Basalt, Redstone, Snowmass
	Pueblo	Beulah, Stone City

(continued)

TABLE 4. (Continued)

State	County	Community
Colorado	Rio Blanco	Meeker, Rio Blanco
	Routt	Hayden, Milner, Oak Creek, Phippsburg, Steamboat Springs, Toponas, Yampa
	San Miguel	Norwood
	Weld	Ault, Cornish, Eaton, Erie, Evans, Frederick, Fort Lupton, Galeton, Gilcrest, Gill, Greeley, Hudson, Ione, Johnstown, Keenesburg, Kersey, LaSalle, Lucerne, Masters, Mead, Platteville, Roggen, Severance, Vollmar, Wattenburg, Windsor
Montana	Big Horn	Decker
	Lake	Rollins, Swan Lake
	Musselshell	Delphia, Klein, Roundup
	Rosebud	Brandenberg, Colstrip, Lame Deer
	Yellowstone	Ballantine, Billings, Huntley, Pompeys Pillar, Shepherd, Worden
North Dakota	Adams	Bucyrus, Haynes, Hettinger, Reeder
	Bowman	Bowman, Gascoyne, Haley, Rhame, Scranton
	Burke	Columbus, Larson, Lignite, Portal
	Divide	Crosby, Noonan
	Dunn	Dodge, Dunn Center, Halliday, Killdeer, Manning, Marshall, New Hradec
	Grant	Elgin, Heil, Leith, New Leipzig
	Hettinger	Burt, Havelock, New England
	McHenry	Granville, Karlsruhe, Simcoe, Velva, Voltaire
	McKenzie	Arnegard, Keene, Mandaree, Watford City
	McLean	Butte, Falkirk, Garrison, Max, Raub, Riverdale, Roseglen, Ruso, Underwood, Washburn
	Mercer	Beulah, Golden Valley, Hazen, Pick City, Stanton, Zap
	Morton	Almont, Glen Ullin, Hebron, Judson, Mandan, New Salem
	Mountrail	Belden, New Town, Palermo, Parshall, Plaza, Stanley
	Oliver	Center, Fort Clark, Hannover, Hensler

(continued)

TABLE 4. (Continued)

State	County	Community
North Dakota	Slope	Amidon, DeSart
	Stark	Dickinson, Gladstone, Richardton, Taylor
	Ward	Douglas, Minot, Sawyer, Surrey
	Williams	Epping, McGregor, Trenton, Wheelock, Williston
Utah	Carbon	Castle Gate, Clear Creek, Columbia, Dragerton, Helper, Hiawatha, Mutual, Price, Scofield, Spring Glen, Sunnyside, Wattis, Wellington
	Emery	Castle Dale, Cedar, Clawson, Cleveland, Elmo, Emery, Ferron, Huntington, Moore, Mounds, Orangeville, Woodside
	Garfield	Bryce Canyon, Cannonville, Henrieville, Rubys Inn, Tropic
	Iron	Cedar City, Enoch, Hamiltons Fort, Iron Springs, Kanarraville, Summit
	Kane	Glen Canyon
	Sanpete	Ephraim, Fairview, Indianola, Mayfield, Milburn, Mount Pleasant, Spring City
	Utah	Colton, Gilluly
	Wasatch	Soldier Summit
	Washington	New Harmony, Pintura
Wyoming	Campbell	Gillette, Recluse, Rocky Point, Rozet, Weston, Wildcat, Wyodak
	Carbon	Elk Mountain, Hanna, Kortes Dam, Leo, Medicine Bow, Seminoe Dam, Walcott
	Converse	Glenrock, Parkerton
	Crook	Stroner
	Hot Springs	Grass Creek, Hamilton Dome,
	Lincoln	Diamondville, Elkol, Frontier, Kemmerer, Opal, Sage
	Park	Meeteetse
	Sheridan	Acme, Big Horn, Dayton, Parkman, Ranchester, Sheridan, Wolf, Wyarno
	Sweetwater	Bitter Creek, Green River, Hallville, Monell, Peru, Point of Rocks, Quealy, Reliance, Rock Springs, Superior, Thayer Junction, Winton

(a) USBM, 1978.

TABLE 5. COMMUNITIES WITHIN 20 MILES OF EXPANDING MINES[a]

State	County	Community
Colorado	Adams	Aurora, Bennett, Brighton, Commerce City, Eastlake, Federal Heights, Henderson, Northglenn, Thornton, Watkins, Westminster
	Arapahoe	Byers, Englewood, Littleton, Strasburg
	Delta	Bowie, Cedaredge, Crawford, Delta, Grand Mesa, Hotchkiss, Lazear, Orchard City, Paonia
	Denver	Denver
	Douglas	Parker
	Elbert	Elbert, Elizabeth, Kiowa, Matheson, Simla
	El Paso	Calhan, Ramah
	Garfield	Grand Valley, Rifle
	Gunnison	Marble, Somerset
	Jackson	Coalmont, Cowdrey, Kings Canyon, Rand, Walden
	La Plata	Bondad, Durango, Hesperus, Kline, Marvel, Mayday, Redmesa, Trimble
	Larimer	Glendevey
	Las Animas	Aguilar, Boncarbo, Gulnare, Jansen, Ludlow, Noehne, Stonewall, Trinidad, Valdez, Vigil, Weston
	Mesa	Cameo, Collbran, DeBeque, Mesa, Molina, Palisade
	Moffat	Axial, Blue Mountain, Craig, Dinosaur, Elk Springs, Hamilton, Lay, Massadona, Moffat
	Montezuma	Mancos
	Rio Blanco	Meeker, Rangely
	Routt	Hayden, Milner, Oak Creek, Phippsburg, Steamboat Springs, Yampa
	Weld	Wattenburg
Montana	Big Horn	Busby, Decker, Kirby, Lodge Grass, Wyola
	McCone	Brockway, Circle, Weldon
	Rosebud	Brandenberg, Colstrip, Lame Deer
North Dakota	Billings	Fairfield
	Burleigh	Baldwin, Bismark, McKenzie, Wilton
	Dunn	Dodge, Dunn Center, Halliday, Killdeer, Manning

(continued)

TABLE 5. (Continued)

State	County	Community
North Dakota (Cont'd)	McKenzie	Grassy Butte
	McLean	Falkirk, Garrison, Max, Mercer, Raub, Riverdale, Roseglen, Ruso, Turtle Lake, Underwood, Washburn
	Mercer	Beulah, Golden Valley, Hazen, Pick City, Stanton, Zap
	Morton	Mandan, St. Anthony
	Oliver	Center, Fort Clark, Hannover, Hensler
	Ward	Douglas
Utah	Carbon	Castle Gate, Clear Creek, Helper, Hiawatha, Mutual, Price, Scofield, Spring Glen, Wattis, Wellington
	Emery	Castel Dale, Clawson, Cleveland, Elmo, Emery, Ferron, Huntington, Moore, Orangeville
	Garfield	Boulder, Escalante, Hatch
	Kane	Alton, Glendale, Mount Carmel, Orderville
	Sanpete	Fairview, Indianola, Milburn, Moroni, Mount Pleasant, Spring City
	Utah	Colton, Ciliuly
	Wasatch	Soldier Summit
Wyoming	Albany	Bosler, Wyoming
	Campbell	Echeta, Gillette, Recluse, Rozet, Savageton, Weston, Wildcat, Wyodak
	Carbon	Elk Mountain, Hanna, Kortes Dam, Leo, Medicine Bow, Rawlins, Seminoe Dam, Sinclair, Walcott
	Converse	Bill, Glenrock, Parkerton, Verse
	Hot Springs	Crass Creek, Hamilton Dome
	Laramie	Farthing
	Lincoln	Diamondville, Elkol, Frontier, Kemmerer, Opal, Sage
	Park	Meeteetse
	Sheridan	Acme, Big Horn, Dayton, Parkman, Ranchester, Sheridan, Ulm, Wolf, Wyarno
	Sweetwater	Bitter Creek, Brian, Frewen, Green River, Harririle, Latham, Monell, Peru, Point of Rocks, Reliance, Riner, Rock Springs, Muperior, Table Rock, Thayer Junction, Wamsutter, Wingon
	Uinta	Carter

(a) USBM, 1978.

TABLE 6. DEMOGRAPHIC INFORMATION ON COMMUNITIES WITH MORE THAN 1000 RESIDENTS IN 1975 WHICH ARE LOCATED WITHIN 20 MILES OF A CURRENTLY OPERATING MINE[a]

State	County	Community	Population 1975	Population 1973	Population 1970	Annual Percent Change in Population 1970-1975	Per Capita Income ($) 1974	Annual Percent Change In Per Capita Income 1969-1974
Colorado	Adams	Aurora	118,060	107,586	76,477	10.4	5,146	11.1
		Brighton	11,132	10,560	8,309	6.5	4,745	11.8
		Commerce City	16,258	17,026	17,407	-1.3	3,845	11.4
		Federal Heights	6,350	6,001	1,502	61.5	5,960	10.8
		Northglenn	35,318	33,781	29,259	3.9	4,685	11.5
		Thornton	24,757	19,905	15,329	11.7	4,403	13.3
		Westminster	24,008	22,573	19,877	4.0	4,635	10.8
	Arapahoe	Englewood	35,870	36,923	33,695	1.2	4,892	10.1
	Boulder	Boulder	78,560	75,904	66,870	3.3	4,919	9.1
		Lafayette	4,686	4,505	3,498	6.5	4,430	10.8
		Longmont	31,831	29,092	23,209	7.1	4,821	10.8
		Louisville	3,134	2,996	2,409	5.7	4,487	12.4
		Lyons	1,193	1,144	958	4.7	3,483	9.7
	Delta	Paonia	1,331	1,143	1,161	2.8	4,162	12.1
	Denver	Denver	484,531	515,358	514,678	-1.1	5,585	11.6
	Fremont	Canon City	12,791	11,853	11,011	3.1	3,658	13.3
		Florence	3,153	3,277	2,846	2.1	3,763	12.8
	Garfield	Carbondale	1,128	875	726	10.6	4,049	10.1
		Glenwood Springs	5,351	4,370	4,106	5.8	4,732	11.3
		Rifle	2,016	2,046	2,150	-1.2	4,836	11.3
	Huerfano	Walsenburg	4,018	4,132	4,329	-1.4	4,432	15.1

(continued)

TABLE 6. (Continued)

State	County	Community	Population 1975	Population 1973	Population 1970	Annual Percent Change in Population 1970-1975	Per Capita Income ($) 1974	Annual Percent Change In Per Capita Income 1969-1974
Colorado	Jefferson	Arvada	74,254	61,701	49,844	9.3	5,177	12.0
		Golden	12,864	11,658	9,817	5.9	5,645	11.4
		Wheat Ridge	29,437	30,169	29,778	-0.2	6,119	10.3
	La Plata	Durango	11,771	11,212	10,333	2.6	4,149	11.5
	Larimer	Berthoud	2,653	2,251	1,446	15.9	4,310	11.0
	Las Animas	Trinidad	10,063	9,952	9,901	0.3	3,409	14.0
	Mesa	Grand Junction	27,729	25,661	20,170	2.9	4,395	11.4
	Moffat	Craig	5,426	4,497	4,205	5.5	4,833	14.5
	Rio Blanco	Meeker	1,986	1,798	1,597	4.6	4,206	16.2
	Routt	Hayden	1,338	992	763	14.4	5,492	17.6
		Steamboat Springs	3,013	2,552	2,340	5.5	6,219	19.1
	Weld	Eaton	1,629	1,464	1,389	3.3	4,560	15.1
		Erie	1,662	1,233	1,090	10.0	3,651	10.8
		Evans	3,455	3,218	2,570	6.6	4,147	10.8
		Fort Lupton	3,041	2,830	2,489	4.2	3,582	10.4
		Greeley	47,362	45,018	38,902	4.1	4,554	11.9
		Johnstown	1,580	1,481	1,191	6.2	3,950	9.2
		La Salle	1,780	1,501	1,227	8.6	5,311	12.8
		Platteville	1,024	944	683	9.5	3,670	10.3
		Windsor	2,426	2,049	1,564	10.5	4,077	10.5
Montana	Musselshell	Roundup	2,235	2,294	2,116	1.1	4,375	15.2
	Yellowstone	Billings	68,987	66,887	63,205	1.7	4,910	12.8

(continued)

TABLE 6. (Continued)

State	County	Community	Population 1975	Population 1973	Population 1970	Annual Percent Change in Population 1970-1975	Per Capita Income ($) 1974	Annual Percent Change in Per Capita Income 1969-1974
North Dakota	Adams	Hettinger	1,609	1,551	1,655	-0.5	6,971	28.4
	Bowman	Bowman	2,014	1,838	1,762	2.7	7,390	32.7
	Divide	Crosby	1,487	1,536	1,545	-0.7	5,278	22.9
	McHenry	Velva	1,240	1,194	1,241	0	4,927	20.8
	McLean	Garrison	1,574	1,608	1,614	-0.5	4,592	15.5
	Mercer	Beulah	1,421	1,390	1,344	1.1	5,707	21.9
		Hazen	1,549	1,341	1,240	4.7	5,690	19.9
	Morton	Hebron	1,082	1,054	1,103	-0.4	2,960	9.9
		Mandan	12,560	11,370	11,093	2.5	4,099	17.2
	Mountrail	New Town	1,671	1,695	1,428	3.2	3,715	13.5
		Parshall	1,009	1,036	1,246	-3.6	3,874	15.4
		Stanley	1,831	1,638	1,581	3.0	4,728	17.9
	Ward	Minot	32,790	32,452	32,290	0.3	5,047	14.8
	Williams	Williston	11,364	11,178	11,280	0.1	4,773	15.6
Utah	Carbon	Helper	2,198	1,983	1,964	2.3	4,156	12.6
		Price	7,391	6,884	6,218	3.6	4,442	14.2
		Wellington	1,146	1,011	922	4.6	3,079	11.9
	Emery	Huntington	1,303	1,072	857	9.9	3,650	22.0
	Iron	Cedar City	10,349	9,908	8,946	3.0	3,553	9.0
	Sanpete	Ephraim	2,380	2,306	2,127	2.3	2,836	7.8
		Mount Pleasant	1,743	1,644	1,516	2.9	2,976	9.3

(continued)

TABLE 6. (Continued)

State	County	Community	Population 1975	Population 1973	Population 1970	Annual Percent Change in Population 1970-1975	Per Capita Income ($) 1974	Annual Percent Change in Per Capita Income 1969-1974
Wyoming	Campbell	Gillette	8,215	7,801	7,763	1.1	5,793	12.0
	Converse	Glenrock	2,071	1,868	1,515	7.0	4,057	11.8
	Lincoln	Kemmerer	2,658	2,315	2,292	3.0	4,578	11.6
	Sheridan	Sheridan	11,617	11,088	10,856	1.3	4,551	10.2
	Sweetwater	Green River	7,423	5,201	4,196	14.6	4,937	14.8
		Rock Springs	17,773	14,091	11,657	10.0	5,358	16.5

(a) Source: U.S. Department of Commerce (1977a-e).

TABLE 7. DEMOGRAPHIC INFORMATION ON COMMUNITIES WITH MORE THAN 1000 RESIDENTS IN 1975 WHICH ARE LOCATED WITHIN 20 MILES OF A DEVELOPING MINE[(a)]

State	County	Community	Population 1975	Population 1973	Population 1970	Annual Percent Change in Population 1970-1975	Per Capita Income ($) 1974	Annual Percent Change in Per Capita Income 1969-1974
Colorado	Adams	Aurora	118,060	106,586	76,477	10.4	5,146	11.0
		Brighton	11,132	10,560	8,309	6.5	4,745	11.0
		Commerce City	16,258	17,026	17,407	-1.3	3,845	11.3
		Federal Heights	6,350	6,001	1,502	61.5	5,960	10.8
		Northglenn	35,318	33,781	29,259	3.9	4,685	11.4
		Thornton	24,757	19,905	15,329	11.7	4,403	13.3
		Westminster	24,008	22,573	19,877	3.9	4,635	10.7
	Arapahoe	Englewood	35,870	36,923	33,695	1.2	4,892	10.1
		Littleton	28,125	29,385	26,466	1.2	5,503	9.7
	Delta	Delta	3,632	3,560	3,694	-0.3	3,519	11.6
		Paonia	1,331	1,143	1,161	2.8	4,162	12.1
	Denver	Denver	484,531	515,358	514,678	-1.1	5,585	11.6
	Elbert	Elizabeth	1,069	876	493	22.2	3,906	10.3
	Garfield	Rifle	2,016	2,046	2,150	-1.2	4,836	11.3
	La Plata	Durango	11,771	11,212	10,333	2.6	4,149	11.5
	Las Animas	Trinidad	10,063	9,952	9,901	0.3	3,409	14.0
Colorado	Moffat	Craig	5,426	4,497	4,205	5.5	4,833	14.5
	Rio Blanco	Meeker	1,986	1,798	1,597	4.6	4,206	16.2
		Rangely	1,792	1,610	1,591	2.4	4,526	14.2
	Routt	Hayden	1,338	992	763	14.4	5,492	17.6
		Steamboat Springs	3,013	2,552	2,340	5.5	6,219	19.1
Montana	McCone	Circle	1,003	973	964	0.8	6,646	20.6
North Dakota	Burleigh	Bismarck	38,378	37,562	34,703	2.0	4,914	14.1

(continued)

TABLE 7. (Continued)

State	County	Community	Population 1975	Population 1973	Population 1970	Annual Percent Change in Population 1970-1975	Per Capita Income ($) 1974	Annual Percent Change in Per Capita Income 1969-1974
North Dakota (Cont'd)	McLean	Garrison	1,574	1,608	1,614	-0.5	4,592	15.5
	Mercer	Beulah	1,421	1,390	1,344	1.1	5,707	21.9
		Hazen	1,549	1,341	1,240	4.7	5,690	19.9
	Morton	Mandan	12,560	11,370	11,093	2.5	4,099	17.2
Utah	Carbon	Helper	2,198	1,983	1,964	2.3	4,156	12.6
		Price	7,391	6,884	6,218	3.6	4,442	14.2
		Wellington	1,146	1,011	922	4.6	3,079	12.0
	Emery	Huntington	1,303	1,072	857	9.9	3,650	22.0
	Sanpete	Mount Pleasant	1,743	1,644	1,516	2.9	2,976	9.3
Wyoming	Campbell	Gillette	8,215	7,801	7,763	1.1	5,793	12.0
	Carbon	Rawlins	9,592	8,685	7,855	4.2	4,697	14.0
	Converse	Glenrock	2,071	1,868	1,515	7.0	4,057	11.8
	Lincoln	Kemmerer	2,658	2,315	2,292	3.0	4,578	11.6
	Sheridan	Sheridan	11,617	11,088	10,856	1.3	4,551	10.2
	Sweetwater	Green River	7,423	5,201	4,196	14.6	4,937	14.8
		Rock Springs	17,773	14,091	11,657	10.0	5,358	16.5

(a) Source: U.S. Department of Commerce (1977a-e).

Information on Counties--All 224 counties in the region (both mining and nonmining counties) were characterized by a set of socioeconomic and demographic parameters. A comprehensive listing was desired as a broad description of the entire region and to establish a background from which any unique characteristics of mining counties could be discerned.

A variety of parameters were tabulated from the U.S. Bureau of the Census and other sources. Population as of 1970, 1975, annual growth rate from 1970-1975, and percent urban were obtained for each county from the Current Population Survey (CPS) (U.S. Department of Commerce, 1977 a-e) and City and County Data Book (U.S. Department of Commerce, 1973). Employment characteristics obtained from the CCDB (1973) include percent of population employed; percent of work force in agriculture, mining, manufacturing, entertainment, and hospitals and health services; and percent of land area in farms. Economic and housing characteristics examined were median family income, median level of schooling, percent of housing owner-occupied, and percent of housing lacking some plumbing facilities. Tables 2 and 3 contain selected items from the complete list.

These data were obtained for several purposes. A major use was simply to describe the nature of the region as a whole, and the special features of mining counties compared to the region. Another concern was the impact of these parameters on health phenomena. In order to effectively study coal's impact on health, simultaneous consideration of socioeconomic and occupational influences is essential.

Overall, as Tables 2 and 3 show, the region is sparsely populated, except for the Denver and Salt Lake City metropolitan areas. The only summary statement to be made for most social and demographic characteristics is that there is extreme variability. On the county level, for example, annual percentage population growth rate ranged from -3.6 to 20.6 percent. Similarly, employment and economic/housing characteristics are difficult to summarize for the region as a whole. It is of interest in this report to characterize mining counties relative to nonmining counties. Such comparisons convey some notion of the cluster of social and demographic characteristics related to coal mining in the west. Mining and nonmining counties are very similar on most demographic parameters (percent urban, employment profile, etc.). One of the few differentiating characteristics of mining counties is a higher rate of population growth (3.0 versus 2.0 percent annually). This would be expected due to the ongoing increase in coal utilization in the United States. Another (somewhat cruder) measure which was studied in relation to social and demographic variables was "percent of work force in mining." Although this includes all forms of mining, coal mining is one of the major contributors. Employment in mining was positively associated with total employment, median income, and median years of schooling, but negatively correlated with percent of land in farms; employment in agriculture, manufacturing, or hospitals; percent of housing lacking some plumbing; and total population. Overall, counties with mining seem to be more rural, with fewer competing employment activities such as agriculture.

Information on Communities--The communities of 1000 or more residents within 20 miles of a current or future mine are of special importance because of their potential usefulness in an epidemiologic study. The only readily available comprehensive data source was the U.S. Bureau of the Census's Current Population Survey (U.S. Department of Commerce, 1977a-e). This provided the population figures for 1970, 1973, 1975, and the per capita incomes in 1969 and 1974. From these data, the annual percent changes in population and per capita income were calculated. Tables 6 and 7 present this information.

Mining-impacted communities have a wide range of growth rates and population sizes. Most of the communities (except metropolitan Denver) are quite small, with populations less than 15,000. The limited data makes further discussion of these communities difficult without addressing them individually.

Water Quality

Introduction--

This section describes efforts to obtain and analyze readily accessible (i.e., from state and Federal agencies) environmental monitoring data from the vicinity of mining-impacted communities. Three types of water quality data were examined: data on surface water, groundwater, and public drinking water supplies. In each case, an attempt was made to match mining-impacted communities (see Figure 3) with any water quality measurements taken during the past seven to eight years. To the extent possible, levels of specific constituents of water have been tabulated for each of the relevant monitoring sites.

Data on groundwater supplies are extremely scant with respect to analysis of specific constituents. Although various special studies have sampled thousands of wells in the western coal region, the emphasis has been on determining the quantity of water available rather than its quality. Consequently, little can be said regarding human exposure levels from groundwater except in cases where wells are the source of public water supplies.

Finished water from public water supplies is routinely analyzed for chlorine, fluoride, and bacteria in accordance with quality control procedures of the water treatment plants and state health department requirements. Turbidity, pH, color, iron, hardness, and alkalinity are also monitored by most water treatment plants. Substances in drinking water such as heavy metals and organic compounds, which are important to human health, are spot-checked at infrequent intervals according to most of the municipal suppliers surveyed. Consequently, the bulk of the discussion of water quality is concerned with surface water, since they are more often monitored for the parameters of interest. However, measurements of water parameters before the water is treated for public consumption provide only indirect information regarding potential human health hazards. Inferences must be made regarding the impact of treatment on levels of these parameters. If the discussion concerns measures of finished water it will be so stated.

Surface Water--

Water quality impacts are best determined by documenting changes in various water quality tests or biological samples taken at pertinent locations with respect to the site of mining operations. The most commonly measured parameters used to indicate water quality can be grouped into the following general categories: (1) physical - including pH, temperature, dissolved and/or suspended solids, and stream bottom conditions; (2) chemical - including nutrients (nitrate, phosphate, etc.), "trace" metals (copper, zinc, etc.), salinity (sulfate, chloride, etc.), and organic material [commonly measured as biochemical oxygen demand (BOD) which may produce a depletion of dissolved oxygen (DO) in the water as organics are reduced by bacteria]; and (3) biological - bacteria and other aquatic life (NGPRP, 1974).

At present, water quality in the western coal region is measured only at selected locations and for selected parameters. In general, most water quality data are from the U.S. Geological Survey, U.S. EPA, and state water quality sampling stations. The specific locations of monitoring sites and the parameters measured at each are shown in Table 8. The sites tabulated include all sites designated as energy impacted by U.S. EPA Region VIII. In addition, any site located within 20 miles of active or expanding mining operations was included, bringing the total to approximately 60 sites. Sampling frequency at most sites is either monthly or biweekly.

Table 9 presents a tabulation of water quality data for each of the monitoring locations listed in Table 8, and the information is summarized in Table 10. Observations associated with each site represent the mean or average of a variable number of samples taken during the period 1971-1978. For most parameters and sites, the figures given are based on 30-100 samples. Entries of -0.99 in Table 9 indicate that data was missing or that the parameter was not measured at the site(s) noted. Although there is substantial variability in the data, several general observations can be made from Table 10. Water in the impacted areas is alkaline (pH ranges from 7.47 to 8.44) and very hard (total hardness ranges from 100.0 to 2521.8; over 300mg/l total hardness is usually regarded as very hard). There is also a noticeable deterioration of chemical, physical, and biological parameters as one moves downstream from the headwaters of individual rivers. This degradation is the result of hydrologic, geologic, and anthropogenic influences. Except for a few limited areas, however, the water quality is satisfactory for irrigation, livestock watering, recreation, and municipal and industrial purposes (NGPRP, 1974).

Wide variations in the mineral quality of water may be noted in individual streams throughout the western coal region. High quality water is found in the Yellowstone River. Dissolved solids in the Yellowstone near its mouth range from a low of 230 mg/l to a high of 655 mg/l with an average of 460 mg/l. In contrast, the Powder River contains poorer quality water. Dissolved solids in the Powder River near Moorhead average 1552 mg/l with highs and lows of 4080 and 676 mg/l, respectively. Suspended sediment concentrations and loads vary widely at a given site both throughout the region and throughout the year. The sediment load is normally light

TABLE 8. SITE SPECIFIC HISTORY OF WATER QUALITY MONITORING ACTIVITIES: ENERGY IMPACTED AREAS

Monitoring Site Code Number	Location	Field Measurements	Chemical	Nutrients	TOC	Metals	BOD (5-day)	Suspended Sediments	Turbidity	#309	#310	Bacteriological
Colorado												
09244410	Yampa River, below diversion, near Hayden	1975→	1975→	1975→	1975→	1975→	1975→	1975→	1975→	1975→	1975→	--
09246550	Yampa River below confluence with Elkhead Cr.	1975→	1975→	1975→	1975→	1975→	1975→	1975→	1975→	--	--	--
09247600	Yampa River, below Yampa Project Diversion	1975→	1975→	1975→	1975→	1975→	1975→	1975→	1975→	1975→	1975→	--
09249750	Williams Fork River, below Hamilton	1975→	1975→	1975→	1975→	1975→	--	1975→	1975→	1975→	1975→	1975→
09093000	Parachute Creek, near Grand Valley	1975→	1975→	1975→	1975→	1975→	--	1975→	1975→	1975→	1975→	1975→
09304800	White River near Meeker	1975→	1975→	1975→	1975→	1975→	--	1975→	1975→	1975→	1975→	1975→
09306300	White River above Rangely	1975→	1975-	1975→	1975→	1975→	--	1975→	1975→	1975→	1975→	1975→
09095300	Logan Wash near DeBeque[1] (1975-76)	?	?	?	?	?	?	?	?	?	?	?
Montana												
06205200	Yellow Stone River at Laurel	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	--	--
06217500	Yellowstone River at Huntley	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	--	--
06294840	Yellowstone River at Myers	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→
06295000	Yellowstone River and Forsyth	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	--	--
06296120	Yellowstone River near Miles City	1974→	1974→	1974→	1974→	1974→	1975→	1974→	1974→	1974→	1974→	1974→
06307610	Tongue River below Hanging Woman Creek	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→
06326530	Yellowstone River near Terry	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→	1974→
12355500	N. Fork Flathead River near Columbia Falls[2]	--	--	--	--	--	--	--	--	--	--	--
06179500	West Fork Poplar River at International Boundary[2]	--	--	--	--	--	--	--	--	--	--	--
06180400	West Fork Poplar River near Bredette[2]	--	--	--	--	--	--	--	--	--	--	--
06178000	Middle Fork Poplar River at International Boundary[2]	--	--	--	--	--	--	--	--	--	--	--
06178150	Middle Fork Poplar River near Scoby[2]	--	--	--	--	--	--	--	--	--	--	--
06179000	East Poplar River at Scoby[2]	--	--	--	--	--	--	--	--	--	--	--
06179200	Poplar River above West Fork near Bredette[2]	--	--	--	--	--	--	--	--	--	--	--
06294700	Big Horn River at Bighorn[1]	(1974-75)	?	?	?	?	?	?	?	?	?	?
06307830	Tongue River at Brandenburg Bridge[1]	(1974-75)	?	?	?	?	?	?	?	?	?	?
06308500	Tongue River near Miles City[1]	(1974-75)	?	?	?	?	?	?	?	?	?	?

(continued)

TABLE 8. (Continued)

Monitoring Site Code Number	Location	Field Measurements	Chemical	Nutrients	TOC	Metals	BOD (5-day)	Suspended Sediments	Turbidity	#309	#310	Radiochemical
North Dakota												
06330000	Missouri River at Williston	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974
06338490	Missouri River at Garrison	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974
06342500	Missouri River at Bismark	1975	1975	1975	--	--	--	1975	1975	1975	--	--
06349700	Missouri River at Schmidt	1975	1975	1975	1975	1975	1975	1975	1975	1975	--	--
06340000	Spring Creek at Zap	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974
06340500	Knife Creek near Hazen	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974
Utah												
09302000	Duchesne River near Randlett	1975	1975	1975	1975	1975	--	1975	1975	1975	1975	--
09306900	White River upstream confluence with Green River	1975	1975	1975	1975	1975	--	1975	1975	1975	1975	(Bacteriological) 1975
09314500	Price River at Woodside	1975	1975	1975	1975	1975	--	1975	1975	1975	1975	--
09328500	San Rafael River near Green River	1975	1975	1975	1975	1975	--	1975	1975	1975	1975	--
Wyoming												
06298000	Tongue River near Dayton	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974	--
06299980	Tongue River at Monarch	1974	1974	1974	1974	1974	1974	1974	1974	--	--	--
06305500	Goose River below Sheridan	1974	1974	1974	1974	1974	1974	1974	1974	--	--	--
06306300	Tongue River at State Line	1974	1974	1974	1974	1974	1974	1974	1974	1974	1974	--
06313000	South Fork Powder River at Kaycee	1975	1975	1975	1975	1975	--	--	1975	(Flow) 1975	(Fecal coli-forms) 1975	
06323500	Piney Creek at Ucgross	1975	1975	1975	1975	1975	--	--	1975	(Flow) 1975	(Fecal coli-forms) 1975	
06324000	Clear Creek near Arvada	1974	1974	1974	1974	1974	1974	1974	1974	--	--	--
06324970	Little Powder River and Dry Creek near Weston[3]	1975	1975	1975	1975	1974	1975	1975	1975	(Flow) 1975	(Fecal coli forms) 1975	
06332800	Little Missouri at New Haven	1975	1975	1975	1975	1975	1975	1975	1975			
06386500	Cheyenne River near State Line	1975	1975	1975	1975	1975	1975	1975	1975			
06426500	Belle Bourche River below Moorecroft	1975	1975	1975	1975	1975	1975	1975	1975			
06247850	Belle Fourche River at Devil's Tower	1974	1974	1974	1974[4]	1974[4]	1974	1974	1974	1974	1974	
06209400	Green River near Labarge	1975	1975	1975	1975	1975	1975	1975	1975			
09211200	Green River below Fontenelle Reservoir	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	

TABLE 8. (Continued)

Monitoring Site Code Number	Location	Field Measurements	Chemical	Nutrients	TOC	Metals	BOD (5-day)	Suspended Sediments	Turbidity	#309	#310	Radiochemical
Wyoming												
09216000	Big Sandy below Eden	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	
09216810	Killpecker Creek at mouth (Rock Springs)	1975	1975	1975	1975	1975	1975	1975	1975[4]	1975	1975	
09216880	Bitter Creek below Little Bitter Creek	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	
09217000	Green River near Green River	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	
09217010	Green River below Green River	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	
09224050	Hams Fork near Diamondville	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	
10027000	Twin Creek at Sage	1975	1975	1975	1975	1975	1975	1975	1975	1975	1975	
06324985	Powder River at State Line--only for 1974 to 1975, no record of what data obtained.											

[1]Site listed as operational, but no years of operation or monitoring activities reported.

[2]Site only operated years shown; no information as to monitoring activities reported.

[3]Two numbers given: 06324970 and 96324900.

[4]Data for that year only.

TABLE 9. SITE SPECIFIC SURFACE WATER QUALITY DATA FOR THE "ENERGY FUNDED SITES" AS DESIGNATED BY EPA REGION VIII PLUS OTHERS LOCATED WITHIN 20 MILES OF COAL MINES[a]

			mg/l						
Monitoring Site Code Number	Turbidity Units (Jackson)	pH (Standard Units)	Bicarbonate	Carbonate	Nitrate	Total Hardness	Dissolved Calcium	Dissolved Magnesium	Dissolved Sodium
COLORADO									
09244410	-0.99[b]	7.87	108.40	0.15	-0.99	101.00	26.14	8.55	16.65
09246550	-0.99	7.96	124.90	0.28	0.01	122.03	30.25	11.21	22.58
09247600	-0.99	8.02	130.70	0.70	0.01	122.90	30.62	11.27	25.86
09249750	-0.99	8.18	199.70	0.68	0.01	200.90	43.54	22.29	20.43
09093000	-0.99	8.30	353.30	2.32	1.02	288.57	55.21	36.61	60.50
09304800	18.21	8.17	178.32	1.45	0.19	262.94	71.50	20.18	36.32
09306300	-0.99	8.29	226.93	0.33	-0.99	284.55	71.52	25.38	66.59
09093500	-0.99	8.15	456.29	0.26	0.61	502.63	92.79	65.34	127.97
09093700	-0.99	7.89	155.21	0.11	0.17	229.54	66.18	15.52	105.91
09095000	-0.99	8.07	484.80	1.09	0.72	439.14	73.86	61.66	110.03
09246500	-0.99	8.29	233.67	-0.99	0.11	215.00	49.00	22.00	49.00
09304550	-0.99	8.15	136.67	1.80	0.92	182.00	53.67	11.43	16.33
09306380	-0.99	7.86	316.07	1.23	1.48	1279.50	234.17	189.57	562.91
MONTANA									
06205200	14.54	8.06	126.31	0.16	0.02	106.32	28.43	8.72	16.83
06217500	27.52	8.02	152.85	0.18	0.14	151.46	38.55	13.82	27.17
06294840	44.23	8.25	165.98	0.41	0.29	204.88	51.27	18.98	47.51
06295000	39.83	8.17	170.47	0.67	0.35	217.17	53.34	19.44	58.43

(continued)

TABLE 9. (Continued)

Monitoring Site Code Number	Turbidity Units (Jackson)	pH (Standard Units)	mg/l						
			Bicarbonate	Carbonate	Nitrate	Total Hardness	Dissolved Calcium	Dissolved Magnesium	Dissolved Sodium
MONTANA									
06296120	56.60	7.99	169.85	0.59	0.20	206.96	51.84	18.86	51.55
06307610	9.32	8.30	249.39	1.05	0.11	315.00	59.09	41.04	38.80
06326530	137.56	8.30	177.20	0.71	0.19	226.20	54.80	21.66	60.39
12355500	3.10	8.08	115.00	-0.99[b]	-0.99	100.97	28.82	6.98	0.92
06180400	27.94	8.44	589.77	13.47	-0.99	126.82	22.35	17.24	246.47
06178000	10.89	8.21	609.15	6.90	-0.99	295.90	46.00	43.53	212.74
06178150	51.74	8.31	637.04	13.16	0.88	275.77	42.23	41.42	240.08
06179000	20.61	8.43	665.50	16.11	0.17	324.15	41.92	53.17	266.19
06179200	25.05	8.36	655.21	15.21	-0.99	301.05	40.74	48.53	281.05
06294700	32.85	7.85	213.14	0.34	0.24	329.06	78.70	28.37	92.93
06307830	25.47	8.17	262.80	0.82	-0.99	326.05	60.55	42.34	48.76
06308500	107.14	7.96	272.20	0.68	0.12	327.36	63.14	44.04	62.44
NORTH DAKOTA									
06330000	85.90	7.72	186.92	0.01	-0.99	226.92	57.49	20.62	55.71
06338490	1.97	8.17	183.26	0.47	0.15	210.60	51.33	20.13	57.69
06342500	8.57	8.30	185.65	0.73	0.15	218.33	53.39	20.54	57.59
06349700	10.97	8.29	187.92	0.18	0.18	215.40	52.24	20.89	58.57
06340000	19.86	8.08	482.34	0.37	-0.99	387.56	76.53	47.75	222.18
06340500	62.40	8.08	460.58	0.24	0.21	307.66	64.66	35.43	233.68

(continued)

TABLE 9. (Continued)

Monitoring Site Code Number	Turbidity Units (Jackson)	pH (Standard Units)	mg/l Bicarbonate	Carbonate	Nitrate	Total Hardness	Dissolved Calcium	Dissolved Magnesium	Dissolved Sodium
UTAH									
09302000	-0.99[b]	8.12	282.65	1.00	0.17	482.10	107.99	64.69	195.69
09306900	182.31	8.19	242.06	2.25	0.12	277.83	66.39	26.91	80.33
09314500	-0.99	7.86	316.07	1.23	1.48	1279.50	234.17	189.57	562.91
09328500	-0.99	7.80	281.74	0.19	0.47	1213.40	249.76	145.72	405.12
WYOMING									
06298000	3.24	7.97	146.56	0.90	-0.99	127.11	33.36	10.44	1.79
06299980	11.91	7.90	212.84	0.13	0.05	213.42	48.00	22.72	16.01
06305500	14.52	7.80	265.60	0.64	-0.99	317.52	59.57	40.97	28.83
06313000	990.24	7.76	191.92	0.01	-0.99	1043.30	292.83	76.81	394.53
06323500	3.75	7.97	183.43	0.59	-0.99	220.06	49.94	22.99	28.44
06324000	32.08	7.91	232.11	0.71	-0.99	486.38	105.22	54.08	73.08
06324970	388.25	8.15	373.55	0.26	-0.99	794.80	158.79	96.24	362.04
06332800	41.67	7.47	140.00	-0.99	-0.99	493.33	100.00	59.33	172.67
06386500	78.06	8.04	311.62	0.38	-0.99	926.21	222.83	90.62	570.04
06426500	121.83	7.89	467.79	0.03	-0.99	478.97	95.90	58.76	331.97
06427850	23.24	7.91	226.20	0.30	-0.99	688.28	182.29	57.42	86.26
09211200	2.43	8.09	161.10	1.24	0.05	174.75	46.85	14.01	19.22
09216000	14.98	7.95	246.40	0.08	-0.99	885.75	220.23	86.17	335.41

(continued)

TABLE 9. (Continued)

Monitoring Site Code Number	Turbidity Units (Jackson)	pH (Standard Units)	mg/l						
			Bicarbonate	Carbonate	Nitrate	Total Hardness	Dissolved Calcium	Dissolved Magnesium	Dissolved Sodium
WYOMING									
09216810	93.03	8.00	623.04	0.93	-0.99[b]	2521.80	285.71	437,86	1302.90
09216880	575.94	8.05	403.28	0.18	-0.99	602.81	104.19	82.91	470.00
09217000	20.38	8.04	180.15	1.05	0.98	231.02	57.04	21.18	48.51
09217010	26.50	8.26	177.60	1.34	0.08	233.40	56.52	22.44	55.34
09224050	4.91	7.69	194.70	0.21	-0.99	250.00	69.85	-0.99	16.27
10027000	29.36	8.06	269.42	0.13	-0.99	379.11	81.54	42.59	46.28

(continued)

TABLE 9. (Continued)

Monitoring Site Code Number	Chloride (mg/l)	Total Sulfate (mg/l)	Dissolved Fluoride (mg/l)	Dissolved Silica (mg/l)	Dissolved Iron (mg/l)	Dissolved Lead (mg/l)	Fecal Coliforms (ct/100 ml)	Dissolved Solids (mg/l)	Suspended Sediments (mg/l)
COLORADO									
09244410	8.19	33.68	0.21	9.29	97.35	5.70	-0.99[b]	160.63	47.74
09246550	9.99	53.11	0.23	7.88	114.24	1.40	-0.99	200.03	15.00
09247600	10.12	62.79	0.23	6.77	107.09	1.63	-0.99	213.86	49.22
09249750	4.29	88.77	0.17	10.26	86.55	2.00	-0.99	282.69	144.00
09093000	6.07	107.89	0.57	16.36	22.00	2.91	36.40	464.89	20.17
09304800	33.99	137.65	0.24	14.46	164.67	2.50	224.86	406.41	116.86
09306300	39.76	174.00	0.31	13.48	105.00	4.66	14.20	513.67	340.34
09093500	12.53	354.53	0.80	17.94	46.67	1.91	-0.99	918.14	212.89
09093700	146.07	123.98	0.28	8.18	38.41	-0.99	-0.99	547.43	513.50
09095000	9.17	253.51	0.70	15.34	45.00	2.16	-0.99	784.67	-0.99
09246500	13.00	101.00	0.30	5.15	52.00	1.00	-0.99	367.00	41.25
09304550	18.43	78.08	0.33	12.40	61.99	-0.99	-0.99	261.50	550.99
09306380	36.75	666.25	0.53	9.01	206.67	10.00	-0.99	1273.90	-0.99
MONTANA									
06205200	6.22	32.55	0.47	14.36	48.67	5.40	82.72	173.30	90.71
06217500	6.65	81.56	0.46	12.98	100.30	5.27	1540.90	263.43	137.85
06294840	7.89	158.88	0.42	10.62	35.83	2.33	-0.99	381.07	218.33
06295000	10.26	180.07	0.42	10.59	44.15	5.62	-0.99	396.07	295.17
06296120	8.02	166.66	0.42	11.24	59.26	2.45	198.27	397.17	401.21
06307610	3.38	185.91	0.29	4.65	54.75	3.15	-0.99	459.30	57.82
06326530	11.93	191.96	0.41	9.55	26.50	3.33	-0.99	442.33	514.11
12355500	0.44	8.56	0.11	4.70	21.70	0.90	3.33	107.62	107.00
06180400	7.49	149.65	0.48	8.81	54.11	0.20	-0.99	761.77	-0.99
06178000	7.88	222.00	0.52	8.05	62.94	0.83	-0.99	896.18	57.37

(continued)

TABLE 9. (Continued)

Monitoring Site Code Number	Chloride	Total Sulfate	Dissolved Fluoride	Dissolved Silica	Dissolved Iron	Dissolved Lead	Fecal Coliforms	Dissolved Solids	Suspended Sediments
	mg/l						ct/100 ml	mg/l	
MONTANA									
06178150	10.27	245.15	0.56	7.99	51.92	1.33	-0.99[b]	921.27	-0.99
06179000	9.28	328.88	0.33	5.47	43.85	2.20	-0.99	1062.30	-0.99
06179200	17.20	323.16	0.51	7.14	31.05	0.33	-0.99	1068.20	-0.99
06294700	11.12	323.26	0.44	9.86	52.65	2.36	60.42	582.37	2327.30
06307830	3.98	211.46	0.31	5.25	40.26	6.11	-0.99	509.73	-0.99
NORTH DAKOTA									
06330000	9.59	177.01	0.54	10.80	107.27	2.00	-0.99	440.07	440.92
06338490	8.82	172.37	0.50	7.50	21.74	1.84	0.96	415.56	-0.99
06342500	9.15	170.69	0.52	7.82	18.33	1.90	6.59	415.88	152.93
06349700	9.06	171.35	0.53	7.47	20.00	1.50	106.03	417.14	166.67
06340000	6.10	469.43	0.47	10.44	148.00	2.36	-0.99	1086.10	119.96
06340500	4.42	366.50	0.40	11.76	116.43	3.47	425.39	1056.90	273.81
UTAH									
09302000	89.59	499.02	0.57	12.10	29.06	3.44	-0.99	1144.00	262.08
09306900	39.17	192.18	0.34	12.40	26.67	1.60	71.65	542.36	2777.40
09314500	65.54	2039.10	0.40	8.94	31.03	3.00	-0.99	3001.40	4281.10
09328500	52.78	1726.70	0.33	9.60	85.17	3.58	-0.99	2800.50	5760.50
WYOMING									
06298000	2.00	5.58	0.15	7.10	80.59	1.85	18.06	134.96	-0.99
06299980	2.00	66.76	0.20	6.56	49.43	1.60	-0.99	269.36	-0.99
06305500	5.71	148.05	0.36	9.56	108.57	2.14	30344.00	410.88	78.17
06313000	175.66	1459.50	1.43	13.24	76.80	2.78	478.30	2531.50	22995.00

(continued)

TABLE 9. (Continued)

Monitoring Site Code Number	Chloride	Total Sulfate	Dissolved Fluoride	Dissolved Silica	Dissolved Iron	Dissolved Lead	Fecal Coliforms	Dissolved Solids	Suspended Sediments
	mg/l						ct/100 ml	mg/l	
WYOMING									
06323500	2.38	125.29	0.17	7.73	79.71	2.75	283.07	331.43	15.50
06324000	4.67	447.21	0.37	8.24	119.43	1.81	138.40	798.11	138.69
06324970	10.50	1234.90	0.58	7.85	61.23	3.10	267.62	2076.30	835.89
06332800	4.07	706.67	0.57	6.10	63.33	1.00	-0.99[b]	1129.00	-0.99
06386500	71.00	1751.30	0.87	9.72	41.25	1.78	605.50	2882.30	2296.40
06426500	47.73	733.79	0.65	7.82	89.31	2.20	-0.99	1519.30	2317.30
06427850	7.76	672.15	0.63	6.74	58.86	2.38	65.53	1132.50	-0.99
09211200	5.34	73.15	0.30	6.94	43.05	4.09	13.31	248.40	5.50
09216000	60.51	1294.30	0.89	11.96	70.61	3.22	47.50	2055.90	166.78
09216810	1365.00	2899.60	0.84	5.19	332.50	5.70	6114.70	6673.90	-0.99
09216880	435.00	711.56	0.76	8.98	84.69	3.10	518880.00	2030.60	-0.99
09217000	8.15	167.80	0.30	8.14	50.58	2.82	100.75	398.91	985.20
09217010	10.92	183.34	0.27	5.33	43.13	6.45	681.94	425.14	-0.99
09224050	7.72	112.67	0.29	3.25	54.85	1.90	3204.00	326.67	-0.99
10027000	28.77	211.94	0.46	9.84	35.63	5.60	69.47	558.58	81.77

(a) Observations tabulated are means based on a variable number of observations at each site. In most cases, values reported were based on 30 to 100 samples.

(b) -0.99 indicates no data reported or few observations (i.e., <10).

TABLE 10. DESCRIPTIVE STATISTICS FOR 18 SELECTED WATER QUALITY PARAMETERS AT 58 SURFACE WATER MONITORING SITES IN MINING AREAS

Parameter	Geometric Mean	Range	95 Percent Confidence Interval
Turbidity (Jackson units)	28.317	1.970 - 990.24	18.693 - 42.895
pH	8.070[a]	7.470 - 8.44	8.020 - 8.120
Bicarbonate (mg/l)	245.443	108.400 - 665.50	216.247 - 278.581
Carbonate (mg/l)	0.530	0.010 - 16.11	0.352 - 0.797
Nitrate (mg/l)	0.177	0.010 - 1.48	0.112 - 0.277
Total Hardness (mg/l)	208.025	100.970 - 2521.80	259.091 - 366.201
Calcium (mg/l)	67.169	22.350 - 292.83	57.444 - 78.540
Magnesium, dissolved (mg/l)	32.298	6.980 - 437.86	26.083 - 39.993
Sodium, dissolved (mg/l)	74.183	0.920 -1302.00	52.601-104.620
Chloride (mg/l)	12.800	0.440 - 1365.00	9.035 - 18.134
Sulfate, total (mg/l)	215.128	5.580 - 2899.60	157.709 - 293.452
Fluoride, dissolved (mg/l)	0.402	0.110 - 1.43	0.355 - 0.455
Silica, dissolved (mg/l)	8.696	3.250 - 17.94	7.956 - 9.504

(continued)

TABLE 10. (Continued)

Parameter	Geometric Mean	Range	95 Percent Confidence Interval
Iron, dissolved (μg/l)	55.787	4.390 - 332.50	46.735 - 66.594
Lead (μg/l)	2.435	0.200 - 10.60	2.023 - 2.932
Fecal Coliform (per 100 ml)	176.132	0.690 - 5118.00	68.149 - 455.215
Dissolved Solids (mg/l)	608.429	107.620 - 6673.90	488.426 - 757.917
Suspended Solids (mg/l)	236.477	5.500 - 22995.00	140.526 - 397.944

(a) Arithmetic means.

in the upper reaches of a given stream. Sediment concentrations have historically been detrimental to consumptive uses of water as well as to fisheries and recreation in some stream reaches. The average sediment loads at the mouths of the Yellowstone and Powder Rivers are 0.27 and 0.40 AF/sq. mi./year (NGPRP, 1974).

Biological quality of surface water, characterized by nutrients, dissolved oxygen, and bacterial concentrations, is considered good except for some localized problems. Some areas are considered to be deficient in nutrients to support aquatic life. On the other hand, some areas contain quantities of nutrients at such levels as to indicate the potential for problems from overgrowth of aquatic plants if further stimulation occurs. The dissolved oxygen level of streams ranges from excellent to satisfactory throughout most of the year. However, a marked reduction in oxygen levels may be found during the summer below some municipal and industrial wastewater outfalls and in some reaches with low flows resulting from diversions and natural conditions. Bacterial concentrations are generally low due to low levels of population and industrial activity in the region. The effect of diversions and return flows on stream temperatures is more noticeable in summer months because of the increased demand at that time for domestic, irrigation, and industrial water (NGPRP, 1974).

Only sparse data are available to describe the radiological quality of streams. Concentrations of radioactivity in the samples that have been taken are below limits generally recognized as safe. Data on the biological water quality in the region are scarce. While fishery information is generally available, data for plankton, benthos, and other aquatic organisms are particularly limited (NGPRP, 1974).

For the group of sites designated as mining impacted, we calculated descriptive statistics for the 18 water quality parameters shown in Table 9. Literature reviews indicated that these were likely to be the most sensitive indicators of water quality impacts in the west. In all, 58 sites were examined in the mining-impacted group. Because other nonmining factors were not taken into account, the figures presented serve merely to give a general impression of the levels of various parameters at the sites; they should not be taken as indicator of human exposure levels in the various mining-impacted communities.

Our data confirmed the fact that surface water in the area was indeed hard (over 300 mg/ℓ being regarded as very hard) and alkaline. Various salts were abundant as shown in Table 10. Sodium was quite high; in several locations it was over 1000 mg/ℓ. Similarly, while most of the sites recorded less than the U.S. PHS Drinking Water Standard of 250 mg/ℓ for chloride, many sites registered mean chloride levels above 1000 mg/ℓ. Sulfates were also quite high; the mean sulfate level, 418.30 mg/ℓ, was above the U.S. PHS standard for drinking water of 250 mg/ℓ . Although it is not really reasonable to compare drinking water standards to surface water, such comparisons may convey a rough impression of potential human exposures for those substances such as sulfates which are not removed from water by any common treatment process.

Heavy metals including iron and lead were low to moderate at the sites. Means for iron were below the 0.3 mg/ℓ U.S. PHS Drinking Water Standard at all but one of the 58 monitoring locations. Similarly, none of the sites had a mean lead concentration over 10.6 mg/ℓ (the U.S. PHS Drinking Water Standard is 50 mg/ℓ). Turbidity, dissolved solids, and suspended sediments showed such marked variation (both within and between sites) that general trends could not be discerned.

Plotting the geographical distribution of the various constituents of water is a useful way of looking at the data. Preliminary analyses for hardness, total dissolved solids, sodium, and lead provided evidence that high levels of these constituents often occur downstream from older mining areas (as defined in Section 3: Research Methodology), but the converse is not always true. To further clarify the matter, detailed analysis of potential nonmining sources of these constituents would have to be done for each monitoring site. In view of the fact that surface water quality data have limited value in documenting human exposure through drinking water, such detailed analysis (on a regional basis) would not appear warranted.

Groundwater--

Although groundwater is not used as extensively as surface water in the western coal region, there is sufficient reliance on shallow groundwaters for human consumption and other uses to make the potential impact of coal development on groundwater supplies important. Although numerous samples of groundwater have been assayed throughout the recent decades, no comprehensive regional analysis of groundwater has been published or, to our knowledge, even initiated (NGPRP, 1974). As indicated, many states (especially Montana) have extensive sampling programs for wells. Unfortunately, these do not shed much light on the nature of human exposures via drinking water because: (1) they concentrate almost exclusively on the quantity of water (hydrologic and aquifer characteristics) rather than its chemical constituents and (2) sampling is nearly always done on a once-only basis, with no provision for repeated sampling in the same location. Consequently, it is not possible to generate much of an impression about the quality of groundwater in the area as a whole.

After requesting all available groundwater quality data from 1970-78 in the six western coal states, we discovered that chemical data was available for only a small minority of the sites listed in the NAWDEX Site Directory (USGS, 1978c). In the state of Utah, for example, chemical data was available for only ten wells. No repeat samples were taken at any of the locations. In Montana, chemical data was available for only two of the NAWDEX sites; again only one sample per well was analyzed. In Wyoming, only 11 sites reported data on chemical constituents of groundwater with no repeat samples at the same locations. Data on groundwater quality was much more extensive for the state of Colorado; 116 sites reported results of chemical analysis of groundwater samples. Unfortunately, however, each of the wells was sampled only once. No recent data (1970 to present) was available for the states of North and South Dakota.

With the exception of Colorado, most of the existing chemical data have been obtained from the shallower aquifers of the Northern Great Plains. These aquifers include alluvium or relatively recent alluvial and terrace deposits. They have been utilized to a high degree for domestic and agricultural purposes since they require only shallow drilling (NGPRP, 1974). The quality of water drawn from the alluvial and terrace aquifers in the Northern Great Plains is highly variable due to: (1) the varied occurrences of alluvial material in proximity to different bedrock formations, (2) the relatively short distances of travel from areas of recharge to areas of withdrawals, and (3) the increasing tendency of surface waters that recharge the alluvial aquifers to become contaminated by activities such as agricultural irrigation and urban water use (NGPRP, 1974). In other words, shallower aquifers respond more quickly to contamination of surface and near-surface waters than do aquifers located in deeper bedrock. Similarly, alluvial aquifers are exposed to greater opportunities for evaporation, which tend to concentrate any salts present.

Water flowing through bedrock aquifers usually deteriorates in quality as it progresses down-gradient through the formation. The deterioration is caused by weathering of minerals contained in the formations, with weathering or "leaching" taking place continuously as the water moves through the formation. One exception to this, noted by NGPRP (1974), is that in some cases, water is actually purified as it passes through coal aquifers. The coal apparently acts as a filter and water quality (in terms of dissolved gases and organics) could actually be improved, although there do not appear to be any published reports of this occurring.

Even within a single aquifer, there is a high degree of variability in water quality. Several factors account for this, including the typically shallow depth of many aquifers, the varied distance from areas of recharge and withdrawals, and lateral changes in lithology. Together, these factors make it exceptionally difficult to describe regionwide groundwater quality in terms of averages.

Studies of Specific Locations--The NGPRP Water Quality Subgroup Report (1974) summarizes various studies which have examined water quality for various aquifers in the Northern Great Plains. Water quality characteristics for samples taken from principal aquifers in the Yellowstone River, the Powder River Valley (Montana), Rosebud County (Montana), the Little Bighorn Valley, principal aquifers in North Dakota (including the area near Beulah and Hettinger in Adams County), and principal aquifers in South Dakota are tabulated in the NGPRP (1974) report. Much of this data is from the 1920's through the early 1960's.

More recently, special studies have examined groundwater conditions in three major mining areas in the Northern Great Plains: the Gasgoyne area in North Dakota, the Gillette, Wyoming, area, and the Birney-Decker area in Montana. A brief summary of the NGPRP findings for these three areas is presented below:

The Gasgoyne area is on the western edge of the Williston Basin. Groundwater movement is generally northeastward toward discharge areas along the Missouri River Valley. Major constituents in the water are calcium, magnesium, sodium, bicarbonate, and sulfate. Dissolved solids range from about 1,500 to 2,000 mg/ℓ. Concentrations of calcium and magnesium generally decrease with increasing depth as sodium and bicarbonate become the dominant ions.

The Gillette area is near the eastern edge and the Birney-Decker area is in the north-central part of the Powder River Basin. Groundwater in the deepest of the shallow aquifers--Basal Hill Creek-Fox Hills in Montana, or Lance-Fox Hills in Wyoming--flows generally northward and discharges by upward leakage along the Yellowstone River Valley and along the lower reaches of the Tongue River and Powder River Valleys. The direction of groundwater movement in the Fort Union and Wasatch Formations is controlled largely by the local topography. Water enters the system along the interstream divides and moves downward and laterally toward the nearby valleys. Much of the water is discharged by springs, seeps, or wells, but some enters the alluvium along the stream valleys where it augments streamflow.

Major constituents in water from bedrock aquifers in both the Gillette and Birney-Decker areas are calcium, magnesium, sodium, bicarbonate, and sulfate. Dissolved solids average about 2,000 mg/ℓ in the Gillette area and about 1,500 to 2,000 mg/ℓ in the Birney-Decker area. As in the Gasgoyne area, amounts of calcium and magnesium decrease with depth and the amount of sodium increases.

Detailed and specific information on the areas investigated is contained in the report by the Groundwater Subgroup entitled Shallow Groundwater in Selected Areas in the Fort Union Coal Region (NGPRP, 1974).

Recent study has indicated that substantial amounts of water may be available from deep aquifers in some areas of the coal region. Near the Black Hills this groundwater has less than 1,000 mg/ℓ dissolved solids but in much of the coal region TDS ranges between 1,000 and 2,000 mg/ℓ. The water may be suitable for energy development, but is marginal to unsatisfactory for irrigation or other specialized uses demanding water of good quality.

Further information in deep groundwater is contained in the Ground-Water Subgroup report entitled Possible Development of Water from Madison Group and Associated Rocks in Powder River Basin, Montana-Wyoming (NGPRP, 1974).

Summary--

Activities directly associated with coal mining, land reclamation, and domestic water uses which increase as a result of population growth will probably cause some degradation in groundwater quality in the western coal area. Examples of specific cases of groundwater pollution of contamination caused by these activities are available (NGPRP, 1974). Less obvious sources of contamination of groundwater supplies also occur with mining development, however. Often overlooked is the fact that saline and sodium-rich soils occur in many parts of the region. Construction activities may disturb the soil sufficiently to enhance leaching of salts and precipitation of the salts on the ground surface. According to the NGPRP (1974) report, the adverse effect on land quality by evaporation of salts can be seen near areas of road construction, especially in Montana and eastern Wyoming. Additional salinity in soils is bound to have adverse impacts on groundwater quality in these localities.

Air Quality

Air quality monitoring stations near coal mines in the west are listed in Table 11 and a detailed description of the station (including the pollutants monitored and an indication of the distance from the pertinent mines) can be found in Table 12. A fairly large number of sites are within 20 miles of coal mines, although few of those monitors are actually at the mine sites. Almost all sites analyze total soluble particulates (TSP), and many in Colorado also analyze benzene-soluble organic fraction (BSOF). A few monitoring stations provide more detailed data on such pollutants as sulfur dioxide, nitrogen dioxide, and ozone.

Health Status

This section of the report describes the efforts and products of a search for an adequate intraregional indicator of the health status of the population. Such an indicator is needed to compare and contrast small geographical units within the region with one another as well as with the region as a whole. Since communities will be the units of study for more detailed analyses, they would be the ideal units for comparison within the region. Therefore, communities were considered the optimal units with counties the second most desirable units. The type of information sought can be arranged into three categories: health services information, morbidity data, and mortality data. These three categories are each addressed below in terms of the data desired, agencies contacted to obtain that information, and the data actually received from the agencies. A description of the ideal data to suit our needs is presented in Table 13. The contrast between ideal data and that which was actually available (Table 14) is significant.

Health Services Information--

The data in this category include the following measures (see Table 13): (1) the type, number, capacity, and accessibility of health services facilities by county or community (e.g., the number of hospital beds, size of population served, and percent occupancies); (2) the type, number, and location of personnel to provide health services (e.g., the number of obstetricians by community or by county); and (3) secular trends in the use of treatment facilities categorized by discharge diagnosis.

TABLE 11. SITE SPECIFIC HISTORY OF AIR QUALITY MONITORING ACTIVITIES: ENERGY IMPACTED AREAS

Monitoring Site Code Number		Location	Total Suspended Particulate Hi-Vol	Total Suspended Particulate Membrane	SO_2 - NO_x Bubbler	SO_2 - NO_x Continuous	Ozone Continuous	Other
South Dakota	(43)							
0760001	F03	Buffalo	(Dual Site)	--	1974	1977	--	
0760002	F03	Buffalo	1974	--	--	--	--	
0980001	F03	Belle Fourche	1974	--*FY 1977	1975	--	--	
1320001	F03	Lemmon	1974	--	--	--	--	
Utah	(46)							
0280004	F03	Castle Dale	1977	--	--	1977	--	
0140001	F02	Huntington	1975	--	--	1974	--	(Escalante to monitor TSP Hi-Vol and membrane and NO_x and SO_2 continuous monitoring 1977; Kanab to monitor Hi-Vol TSP and continuous SO_2, NO_x, 1977)
0780001	F01	Price	1975	--	--	SO_2 only 1975	--	
0160001	F01	Cedar City	1975	--	--	SO_2 only 1975	--	
0400001	F03	Bullfrog Basin	1975	--	--	SO_2 only 1975	--	
0400002	F03	Wahweap Marina	1974	--	--	SO_2 only 1975	--	
1280003	F02	Hurricane	1977	--	--	1977	--	
--	--	Vernal	*FY 1977	--	--	*FY 1977	--	
--	--	Caineville	*FY 1977	--	--	*FY 1977	--	
Wyoming	(52)							
0060001	F03	Buffalo	1974	--*FY 1977		--	--	
0080001	F03	Gillette	1974	--*FY 1977	1974	1974	--*FY 1977	
0300001	F03	Lusk, (A) Dual Site	1974	--*FY 1977	1975	--	--	
0300002	F03	Lusk, (B) Dual Site	1974	--	--	--	--	
0820001	F03	New Castle	1974	--	--	--	--	
0620001	F01	Rock Springs	1974	--	--	--	--	
0440002	F01	Afton	1975	--	--	--	--	
0220002	F01	Irene Ranch	1975	--	--	--	--	
0180001	F03	Burks Ranch	1974	--	--	--	--	
0480001	F01	New Castle	1975	--	--	--	--	
0180004	F03	Bill	--	--	1976	--	--	
0440003	F03	Kemmerer	1976	--	1976	--	--	
0540001	F03	Wheatland	1976	--	1976	--	--	
0180006	F03	Douglas	1977	--	1976	--	--	
0700016	F03	Patrick Draw	1976	--	--	1976	--	
Colorado	(06)							
0880001	F01	Rifle	1970	--	--	--	--	
0880003	F01	Grand Valley	1974	--	--	--	--	
0980010	F01	Grand Junction	1975	--	--*FY 1977	--		
1520001	F01	Fruita	1974	--	--	--	--	
1520002	F01	Palisade	1974	--	--	--	--	
0480001	F01	Craig	1974	--	--*FY 1977	--	--	
1860001	F01	Meeker	--	1974	--	--	--	
1860002	F01	Rangely	1974	--	--*FY 1977	--	--	
1860003	F03	Black Sulfur Creek	1973	--	--	--	--	

(continued)

TABLE 11. (Continued)

Monitoring Site Code Number		Location	Total Suspended Particulate Hi-Vol	Total Suspended Particulate Membrane	SO_2 - NO_2 Bubbler	SO_2 - NO_x Continuous	Ozone Continuous	Other
Montana	(27)**							
0200001	F03	Ekalaka	1975	--	--	--	--	
0360001	F03	Glendive	1974	--*FY 1977	--	--	--	
0980001**	F03	Ft. Peck	1974	--*FY 1977	--FY 1977	--	--	
1240009	F03	Broadus	1974	--	--	--	--	
1340001	F03	Wolf Point	1974	--	--	(NO_2 only) 1974	1974	
1360003	F03	Lame Deer	1974	--	1975	--	--	
0060009	F03	Decker	1975	--	--	--	--	
0300004	F03	Miles City	1976	--	--	--	--	
0060010	F03	Hardin	1976	--	--	--	--	
0340001	F03	Scobey-3	1976	--	1976	--	--	(Scobey 1, 2 to begin 1977 Hi-Vol TSP only)
1360027	F03	Colstrip (B.N. Site)	1974	--	1974-75	1974-75	1975	
1360028	F03	Colstrip (Macrae Site)	1974	--	1974	1974-75	1974-74	
		(Dual Site at Lindsay to begin FY 1977, no site number given, to monitor TSP, Hi-Vol)						
North Dakota	(35)							
0080001	F03	Medora	1974	--	--	--	--	
0160001	F03	Bowman	1974	--	--	--	--	
0560001	F03	Mott	1974	--	1975	--	--	
0720001	F03	Garrison	1974	1975	--	--	--	
0720002	F03	Washburn	1974	--	1975	--	--	
0820001	F03	Parshall	1974	--	--	--	--	
1060001	F03	McClusky (dual site)	1974	--	--	--	--	
0860001	F03	Stanton	1974	--	1975	1974	1976	

*No data received, site to begin operation in late 1977.
**All Mt. (22) except Ft. Peck.

TABLE 12. AIR QUALITY MONITORING SITES NEAR MINES/MINE EXPANSIONS

Site Number	Location	Pollutants Monitored	Estimated Proximity to Mining Area
Colorado (06)			
0020001 F01	4301 E. 72nd St. Adams (City) Adams Co.	TSP, BSOF	< 20 mi. from Commerce City mining area
0120001 F01	7622 Grandview Ave. Arvada Jefferson Co.	TSP only	~ 20 mi. from older mines near Boulder Frederick Lafayette
0120002 F01	W. 57th Ave. & Garrison St. Arvada Jefferson Co.	Soiling Index, CO, SO_2, THC, O_3 Windspeed, Direction	< 20 mi. from older mines Boulder Frederick Lafayette
0140001 F01	1633 Florence St. Aurora Adams Co.	TSP only	< 15 mi. from Commerce City mining
0240001 F01	15 S. Main St. Brighton Adams Co.	TSP, BSOF	< 25 mi. from Commerce City, Lafayette Frederick mining areas
0300001 F01	Courthouse, Macon & 7th St. Canon City Fremont Co.	TSP, BSOF	~ 5 mi. north of older mining area at Florence
0480001 F01	Courthouse Craig Moffat Co.	TSP, BSOF	< 5 mi. from mining areas Craig Hamilton Moffat Axial
0680003 F01	Fire Station, 10th and 2nd Ave. Durango La Plata Co.	TSP, BSOF	~ 15 mi. from mining area near Hesperus
0800001 F01	101 Main St. Florence Fremont Co.	TSP, BSOF	At site of several old mines near Florence
0880001 F01	111 E. 3rd Ave. Rifle Garfield Co.	TSP, BSOF	< 10 miles from mine at New Castle
0920001 F01	8th and Colorado Ave. (Courthouse) Greenwood Springs Garfield Co.		

(continued)

TABLE 12. (Continued)

Site Number	Location	Pollutants Monitored	Estimated Proximity to Mining Area
Colorado (continued)			
0980010 F01	5th and Rood Sts. Grand Junction Mesa Co.	TSP, BSOF	Within 25 mi of ~ 20 older mines
1000003 F01	6th St. and 10th Ave. Greeley Weld Co.	TSP, BSOF	~ 15 mi. N of several older mines
1000004 F01	1st Ave. and 10th St. Greeley Weld Co.	TSP, BSOF	< 15 mi. from mining near Evans, Gill, etc.
1120001 F01	North Park High School Jackson Co.	TSP, BSOF	< 25 mi. from Coalmont and Walden
1300001 F01	Gillen Dairy Red Mesa La Plata Co.	TSP, BSOF	At site of mining in Red Mesa
1420002 F01	Centennial Wells Littleton Arapahoe	TSP, BSOF	~ 30 mi. from Commerce City mining area
1520001 F01	100 W. Pabor St. Fruita Mesa Co.	TSP, BSOF	At site of old mines in the north central Mesa Co. area
1520002 F01	15 Lakes Park Palisade Mesa Co.	TSP, BSOF	Same as above
1530002 F03	Mesa Verde National Park Montezuma Co.	TSP	< 10 mi. from La Plata Co. sites Hesperus and Mayday
1530003 F03	Fire lookout Station Monte Verde Park Montezuma Co.	TSP, BSOF	Same as above
1860003 F03	Black Sulphur Creek Rio Blanco Co.	TSP, BSOF	Northeast of Meeker near older mines
1860001 F01	Courthouse Meeker Rio Blanco Co.	TSP, BSOF	At Meeker

(continued)

TABLE 12. (Continued)

Site Number	Location	Pollutants Monitored	Estimated Proximity to Mining Area
Colorado (continued)			
1860002 F01	Water Treatment Plant Rangely Rio Blanco Co.	TSP, BSOF	At Rangely near two expanding mines
1920003 F01	136 6th St. (Courthouse) Steamboat Springs Routt Co.	TSP, BSOF	< 5 miles from mines at Steamboat Springs Also fairly close to Milner-Hayden mining
2200003 F01	City Hall Johnstown Weld Co.	TSP, BSOF	~ 10 mi. from Gilcrest-Platteville mines
2200004 F01	La Salle Weld Co.	TSP	Located at minesite. (4 mi.) in LaSalle
2200005 F01	Platteville Weld Co.	TSP	Located within 1 mi. of mine
2240002 F01	70th and Utica Westminster Adams Co.	TSP, BSOF	~ 20 mi from Commerce City mine area
Montana (27)			
0080006 F05	Lockwood School Billings Yellowstone Co.	SO_2	Within 2 mi. of older mines near Billings
0080006 G02	Lockwood School Billings Yellowstone Co.	TSP	Same as above
0080007 G01	Radio Station KGHL Billings Yellowstone Co.	TSP	Same as above
0080008 G01	City Hall Billings Yellowstone Co.	TSP	Same as above
0080009 G01	Grand Ave. School Billings Yellowstone Co.	TSP	Same as above

(continued)

TABLE 12. (Continued)

Site Number		Location	Pollutants Monitored	Estimated Proximity to Mining Area
Montana (continued)				
0080035	G01	Hi-ball Trucking Billings Yellowstone Co.	SO_2	Within 2 mi. of older mines near Billings
0080052	F05	Division and Grand Billings Yellowstone Co.	CO, SO_2, NO_2, NMHC, O_3	Same as above
0080053	F01	27th and Montana Billings Yellowstone Co.	Same as above	Same as above
0080054	F01	11th and S. 27th Sts. Billings Yellowstone Co.	CO	Same as above
1360003	P03	Lame Deer Mountain Rosebud Co.	TSP, SO_2, NO_2	Within 20 mi. of Colstrip and Brandenberg Lame Deer
1360026	P03	Ashland Ranger District Rosebud Co.	TSP	Same as above
1360027	F02	BN Site Ravalli Rosebud Co.	TSP, SO_2, NO_2, THC, NMHC, Methane, O_3	Near Colstrip, Lame Deer, Brandenberg
1360027	F03	BN Site Rosebud Co.		
1360028	F02	McCrae Site Rosebud Co.	TSP, SO_2, NO_2, O_3	Near Colstrip, Lame Deer, Brandenberg
1360028	F02	McCrae Site Rosebud Co.	TSP, CO, SO_2, NO_2, O3	Near Colstrip, Lame Deer, Brandenberg
North Dakota (35)				
0100001	F01	213 6th St., N. Bismarck Burleigh Co. (may be too urban)	TSP, Soiling Index, Beta, Fluoride Nitrate, Sulfate Hydrogen Ion, SO_2 Sulfation, NO_2	< 5 mi. from mining at Bismarck
0100001	P01	215 N. 6th St. Bismarck Burleigh Co.	TSP	Same as above

(continued)

TABLE 12. (Continued)

Site Number		Location	Pollutants Monitored	Estimated Proximity to Mining Area
North Dakota (continued)				
0100002	F01	220 S. 19th St. Bismarck Burleigh Co.	TSP, Beta, Fluoride. Nitrate, Sulfate Hydrogen Ion, Sulfation	< 5 mi. from mining at Bismarck
0160001	F03	Folske Angus Ranch Bowman Co.	TSP, Beta, Fluoride, Nitrate Sulfate	Within 25 mi of mines at Scranton, Gasgoyne
0720001	F03	Radio Tower north of town McLean Co.	TSP, Beta, Fluoride, Sulfate Hydrogen Ion, Sulfation	Close to Garrison mining area
0720002	F03	3 miles NW of Washburn McLean Co.	TSP, Beta, Fluoride, Nitrate, Sulfate, Hydrogen, SO_2, Sulfation, NO_2	< 1 mi. from Washburn mine site. Close to Underwood
0740001	F01	210 2nd Ave., NW Mandan Morton Co.	TSP, Beta, Fluoride, Nitrate, Sulfate Hydrogen Ion, SO_2, Sulfation, NO_2	~ 2 mi. from mining activity Mandan and Bismarck
0760001	F01	Water Treatment Plant Mercer Co.	Same as above	Near Hagen
0760002	F01	Woodward Envicons Tower Mercer Co.	Same as above	~ within 10 mi. of Golden Valley and Zap
0820001	F03	Tower at Parshill Mountrail Co.	Same as above	Within 10 mi. of mines in Parshill-Belden area
0860001	F03	Warren Rockenback farm Oliver Co.	Same as above	Within 3 mi. of mines at Center
1360001	F01	205 E. Broadway Williston Williams Co.	Same as above	In town but near older Williston mine
South Dakota		None		
Utah (46)				
0140001	F02	Huntington Carbon Co.	TSP, SO_2	Within 10 mi. of mining complex at Kelper Castle Green, etc.
0160001	F01	Cedar City Iron Co.	TSP, SO_2	Near site of older mines at Cedar City

(continued)

TABLE 12. (Continued)

Site Number	Location	Pollutants Monitored	Estimated Proximity to Mining Area
Utah (continued)			
0280003 F03	Emery County TV Tower Emery Co.	TSP	Near mines at Helper and Price
0400001 F03	Green Canyon Kane Co.	TSP, SO_2	Near older mines near Green Canyon
0400001 F03	Glen Canyon Kane Co.	TSP, SO_2	Near older mines near Green Canyon
0780001 F01	Price Carbon Co.	TSP, SO_2	Near Helper, Price, Spring Green mining areas
Wyoming (52)			
0080001 F03	Collins Transmitter Campbell Co.	TSP, SO_2, NO, NO_2	Within 10 mi. of many mines in the Wyodak area
0080002 F03	Reno Junction Campbell Co.	TSP	Within 10 mi. of mining complex in SE corner Campbell Co.
0280001 F01	400 S. Gillette Ave. Gillette Campbell Co.	TSP	Within 10 mi of mining complex near Gillette
0320001 F01	Green River Sweetwater Co.	TSP	Within 5 miles of mines near Rock Springs and Green River
0580001 F01	Private residence Rawlins Carbon Co.	TSP	Within 20 miles of mining complex at Rawlins-Sinclair-Wolcott
0620001 F01	416 Bridge Ave. Rock Springs Sweetwater Co.	TSP, SO_2	Close to mines at Rock Springs
0620002 F01	104 Bellview Rock Springs Sweetwater Co.	TSP,	Same as above
0620003 F01	1516 Sublette Rock Springs Sweetwater Co.	TSP	Same as above

(continued)

TABLE 12. (Continued)

Site Number		Location	Pollutants Monitored	Estimated Proximity to Mining Areas
Wyoming (continued)				
0660001	F01	Story Wyarno Sheridan Co.	TSP	~ 25 mi from mines at Wyarno
0700001	F01	212 2nd St. Granger Sweetwater Co.	TSP	~ 40 mi. W of Rock Springs mining area
0700002	J02	FMC Plant Sweetwater Co.	TSP	Within 10-20 mi. of Rock Springs mining area
0700003	J02	FMC Plant Sweetwater Co.	TSP	Same as above
0700004	J02	FMC Plant Sweetwater Co.	TSP	Same as above
0700005	J02	FMC Plant Sweetwater Co.	TSP	Same as above
0700006.	J02	FMC Plant Sweetwater Co.	TSP, Windspeed, Wind Direction	Within 10-20 mi. of mining complex at Rock Springs
0700007	F01	Q Private residents Sweetwater Co. near Eden	TSP	Within about 30 mi. of mining complex at Rock Springs
0700007	F02	Texas Gulf Sulfur Sweetwater Co.	TSP	Near Rock Springs mining complex
0700008	J02	Texas Gulf Sulfur Sweetwater Co.	TSP	Same as above
0700009	J09	Texas Gulf Sulfur Sweetwater Co.	TSP	Same as above
0700010	J02	Texas Gulf Sulfur Sweetwater Co.	TSP	Same as above
0700011	J02	Allied Chemical Company Green River Sweetwater Co.	TSP	These two sites may related more to mining than anything else.

(continued)

Table 12. (Continued)

Site Number	Location	Pollutants Monitored	Estimated Proximity to Mining Areas
Wyoming (continued)			
0700012 J02	Allied Chemical Company Sweetwater Co.	TSP	Near Allied Chemical mining complex
0700013 J02	Green River Sweetwater Co.	TSP	Same as above
0700014 J02	Green River Sweetwater Co.	TSP	Same as above
0700015 J02	Green River Sweetwater Co.	TSP	Same as above

TABLE 13. MEASURES FOR EVALUATING HEALTH STATUS, ENVIRONMENTAL QUALITY, AND COMMUNITY HEALTH AND ENVIRONMENTAL SERVICES

Attribute To Be Evaluated	Factors That Should Be Considered	Data Required
I. Health Status of the Population	Causes of Mortality	Crude mortality rates Age, race, sex and cause specific mortality rates Comparative mortality rates such as standardized mortality ratios (SMR's) for various local, county, state, regional, or national jurisdictions Relative significance of leading causes of death or "proportional mortality ratios" (PMR's) for various jurisdictions
	Causes of Morbidity	Same as mortality data Annual or seasonal rates of communicable diseases
	Current Health Problems	Annual trends in occurrence of death and disease, age and cause specific Recent and current outbreaks of infectious diseases Trends in use of treatment facilities by discharge diagnosis
II. Trends in Population	Annual Rates of Population Change	Birth rates Rate of population increase (decrease) Annual estimates of population Population projections: short range—annual projections for next five years long range—projections at five year intervals
	Age Composition of the Population	Age specific estimates and projections as above
III. Health Services	Public Health Services	Recent, current, and long-range trends in occurrence of communicable diseases Rates of fetal and infant mortality Rates of childhood diseases and deaths Maternal mortality rate Rates of immunization for communicable diseases
	Personal Health Services	Rates and trends in morbidity and mortality compared with state and national standards

(continued)

TABLE 13. (Continued)

Attribute To Be Evaluated	Factors That Should Be Considered	Data Required
III. Health Services	Personal Health Services	Type number, capacity, and accessibility of facilities for health services Type, number, and location of personnel to provide health services
	Health Service Area	Delineation of primary district and regional health service area
	Delivery of Services	Health services utilization surveys, national health survey
I. Environmental Quality	Food Sanitation	Recent and current outbreaks of food-borne toxins and pathogens Results of inspections of food processing and food handling establishments
	Environmental Sanitation	Recent and current occurrence of rodent and arthropod-borne pathogens Condition of premises hygiene
	Air Quality	Air quality data
	Water Quality	Water quality data
	Noise	Noise intensity measurements
II. Community Environmental Services	Water Supply	Type(s) of source(s) and capacity Type and capacity of treatment facility Type and capacity of water storage facility Geographic extent and capacity of distribution system Proportion of dwelling units served by system Percent of system capacity used by system components
	Sewage Disposal	Type and capacity of treatment facility Geographic distribution and capacity of collecting system Type and capacity of effluent and solids disposal system Proportion of dwelling units served by system Percent of system capacity used by system components

(continued)

TABLE 13. (Continued)

Attribute To Be Evaluated	Factors That Should Be Considered	Data Required
II. Community Environmental Services	Solid Waste Disposal	Type and capacity of disposal system Type and capacity of collecting system Geographic coverage of collecting system Proportion of residences and businesses served by system Percent of system capacity used by system components

TABLE 14. TYPE OF HEALTH STATUS INFORMATION AVAILABLE[a]

State	Morbidity	Mortality	Manpower	Facilities
Colorado	Number of reportable diseases by county - 1977	Number of deaths by county by selected cause of death - 1976 & 1977 Death rates by county 1970-1976		
Central-NE HSA	School entry immunization by county - 1977 Labor force disability indicators for the state - 1970 Recordable occupational injury & illness for state - 1974 & 1975	Crude and age adjusted death rates and SMR's for selected causes by county - 1975 & 1976 aggregated. Various measures of infant mortality by county through 1976	Population to physician ratios by county -1975 Number of MD specialists by HSA - 1975 Number of RN's and LPN's by field of practice and county of employment	Various hospital utilization rates by county - 1975 Hospital financial data by county - 1976 Nursing care and intermediate care facilities utilization rates by county - 1976.
Montana (HSA)		Number of deaths from selected causes by county - 1976	Number of 4 MD specialists and population to physician ratios by county - 1976 Number of RN's by county - 1976	Number of general hospital beds by county Number of patient days by hospital - 1976

(continued)

TABLE 14. (Continued)

State	Morbidity	Mortality	Manpower	Facilities
North Dakota	Various tabulations of reportable diseases and immunizations	Number of deaths from selected causes by county - 1975 & 1976		
		Various measures of infant mortality by county - 1976 & 1976		
Western HSA		Death rates for 5 leading causes of death by county - 1976	Number of 8 health professionals by county	Various measures of utilization of hospitals, long-term care facilities, custodial care facilities by facility - 1976
Utah	Number of reportable diseases by county - 1977	Number of deaths from selected causes by county - 1975	Number of 16 health professionals by county - 1976	Various measures of hospitalization by hospital - 1976
Wyoming	Number of reportable diseases by county - 1974	Number of deaths from selected causes by county - 1971-1975 (individual years and aggregated)	Number of 14 health professionals by county, population to professional ratio for 6-1976	Several measures of utilization of hospitals and nursing care facilities by county - 1974

(a) Unless otherwise indicated, information has been obtained from State Health Departments.

To obtain this information, the appropriate staff within the State Health Departments of each of the five states were contacted, as well as some Health Systems Agency personnel. Most of these organizations provided the number of specific types of health professionals by geographic units, usually by county. The aggregation of type of health personnel varied among the agencies as did the time span for tabulations. Data on hospital facilities including number of hospital beds and percent occupancy by hospital or by county were also received from a large portion of the agencies contacted. A few agencies provided similar measures for facilities other than hospitals, such as nursing homes. No utilization measures classified according to discharge diagnosis were received.

Morbidity Data--

Preferred indicators of health status include morbidity measures such as incidence and prevalence rates of nonreportable, nonfatal diseases, as well as annual and seasonal trends in rates of communicable disease. Age- and cause-specific rates for chronic diseases of adulthood are especially desirable indicators for geographical comparisons.

This information was requested from State Health Departments and Health Systems Agencies. The only measure provided by the majority of agencies contacted was the number of reportable diseases by county. Percent of school populations immunized (by county) was provided by two agencies contacted. In addition, this effort yielded several morbidity measures which are more useful for economic than for epidemiological analyses, such as functional labor force disability rates and reportable occupational injuries and illnesses.

Mortality Data--

Mortality data which are useful indicators of the health status of a population are: age-,sex-, and cause-specific rates of mortality; comparative rates of mortality (age- and cause-specific) for comparable geographical units; and the relative significance of leading causes of death, that is, proportional mortality.

The same agencies (Health Departments, Health Systems Agencies) were asked to provide this type of information. All of the agencies contacted provided an aggregation of number of deaths by cause and by county. However, each agency aggregated the causes of death differently and used unique time spans for tabulations. Cause-specific rates had been calculated by two of the agencies and comparative cause-specific rates by one. None of the agencies could provide a simultaneous tabulation by age and cause for number of deaths by county.

The National Center for Health Statistics was also contacted to obtain mortality data. Information received from this organization consisted of the numbers of deaths for 34 selected causes by county and numbers of deaths for 69 selected causes by age, race, sex, on the state level (U.S. DHEW, 1975).

Calculation of SMR's--The intent of this data collection effort was to find an indicator of health status which could be used to compare small units within the region with one another as well as with the region as whole. The information received from State Health Departments and Health Systems Agencies was either not the type of data desired or it was not organized in a consistent fashion among all the agencies, but the National Center for Health Statistics provided a consistent data source for all counties within the region. This information was used in combination with data from the Bureau of the Census to calculate a comparative mortality rate, that is, a standardized mortality ratio (SMR) indirectly adjusted for age, race, and sex for 11 causes of death for each county.

For the purpose of this study, 11 causes of death were chosen for calculation of county standardized mortality ratios. The causes of death investigated included the following: total malignant neoplasms, malignant neoplasms of the digestive organs, malignant neoplasms of the respiratory system, malignant neoplasms of the urinary organs, major cardiovascular disease, ischemic heart disease, cerebrovascular diseases, respiratory diseases, cirrhosis of the liver, motor vehicle accidents, and suicide and homicide. These causes are listed in Table 15 along with their respective ICDA numbers. Note that within the major categories of malignant neoplasms and cardiovascular diseases, there are subdivisions. Each of these causes was chosen either because it was a major contributor to total mortality or because it may in some way be related to impacts of extensive expansion of mining. For example, malignant neoplasms of the digestive system or urinary organs may be related to water pollution from mining, motor vehicle accidents to transportation problems, and cirrhosis or suicide and homicide to socioeconomic impacts of mining expansion. There was a constraint, however, in that rare conditions could not be considered due to small populations at risk.

Since this area is not typical of the United States as a whole for the causes of death of interest, age-race-sex specific mortality rates for this five-state area, (Montana, Wyoming, Colorado, North Dakota, Utah) were used for standardization rather than using the rates of the United States as a whole. As illustrated in Table 16, the area has lower death rates for malignant neoplasms and cardiovascular disease, while death rates for suicide and homicide, and motor vehicle accidents are somewhat higher in this area than in the United States. Sixteen death rates were calculated for each of the 11 causes of death, one for each age (<25, 25-44, 45-64, >64), race (white, nonwhite) and sex group. The total number of deaths in the five-state area from a given cause in a given age-race-sex category was divided by the size of the population in the corresponding category for the five-state area to derive age-race-sex specific rates for the standard population. These rates were then used to indirectly adjust the crude, cause-specific county mortality rates, as described below.

An SMR was calculated for each of the 11 causes for each county by dividing the observed number of deaths by the expected number of deaths. The observed number of deaths was obtained by averaging the annual number of deaths for a given county and cause for the years 1974, 1975, and 1976. The

TABLE 15. CAUSES OF DEATH FOR STUDY

Descriptor	ICDA No.
Malignant Neoplasms	140-209
M.N. of Digestive Organs	150-159
M.N. of Respiratory System	160-163
M.N. of Urinary Organs	188, 189
Major Cardiovascular Disease	390-448
Ischemic Heart Disease	410-413
Cerebrovascular Disease	430-438
Influenza, Pneumonia, Bronchitis, Emphysema, and Asthma	470-474 480-486 490-493
Cirrhosis	571
Motor Vehicle Accidents	E810-E823
Suicide, Homicide	E950-E978

TABLE 16. COMPARISON OF CAUSE-SPECIFIC MORTALITY RATES (PER 100,000) IN WESTERN STATES AND UNITED STATES TOTAL

Disease Category	Age-Sex-Race Adjusted Rate for Five Western States, 1974-1976	U.S. Total Rate, 1975	Ratio of Western States to U.S. Total
Malignant Neoplasms	153.9	171.7	0.896
Cardiovascular Diseases	434.2	455.8	0.953
Ischemic Heart Disease	267.4	301.7	0.886
Cerebrovascular Disease	94.8	91.1	1.041
Respiratory Diseases	52.2	38.1	1.370
Cirrhosis	17.3	14.8	1.169
Motor Vehicle Accidents	32.5	21.5	1.512
Suicide-Homicide	25.2	22.7	1.110

expected number of deaths was derived by applying the age-race-sex specific rates for a given cause of death in the standard population (Appendix C, Table 1) to the age-race-sex population distribution of the county. County population distributions were available in the 1970 Bureau of the Census reports. The 1970 distribution proportions were applied to the 1975 county population totals in order to estimate the 1975 age-race-sex structure. This serves to make the observed and expected deaths more consistent in the years for which the numbers were calculated.

SMR's are presented in Appendix C, Table 2. The geographic distributions of these values are presented in Figures 4 through 14. From observational comparisons of these distributions to the distribution of mining activity in the area (illustrated in Figures 2 and 3), it appears that the only disease categories elevated in the areas currently impacted by mining are motor vehicle accidents, cirrhosis, and perhaps suicide-homicide. However, more rigorous analyses are required to adequately assess the effect of mining activity on county mortality.

While the SMR can be used to compare the cause-specific mortality of each county with that of the region as a whole, comparisons of the SMR's between counties are not valid due to the variability in age distributions. That the SMR for one county is greater than the SMR for a second county does not necessarily imply that the risk of death in the first county is greater than the risk of death in the second.

An alternative method for comparing mortality experiences between counties was to classify SMR's qualitatively and examine the effect of mining by log-linear analysis. For each cause of death, the significance of the departure of a county's SMR from its expected value of one (1.0) under the null hypothesis was tested by χ^2 with one degree of freedom. Here χ^2 equals the observed minus expected deaths squared divided by expected deaths. County SMR's were then classified as significantly higher, significantly lower, or not significantly different from expected at $p < 0.1$. The distribution of these quantile levels of mortality experience were compared across counties to determine the effect of mining activity on cause-specific mortality.

Two factors, the extent of current mining operations and the percent of the work force employed in mining, were used to define the mining activity of a county. Current mining production was not considered a sufficient indicator of a county population's involvement in mining since mining employees may in fact reside in counties without mining operations. A third factor, percent of the population employed in manufacturing, was included in the analyses because of its possible confounding effect. Activities and exposures associated with manufacturing may also affect mortality due to the causes examined and thus may mask or enhance differences if not taken into account.

Current mining production consisted of three levels: no current mining, one current mining operation and more than one current mine. After examining the distribution of mining and manufacturing employment, low and

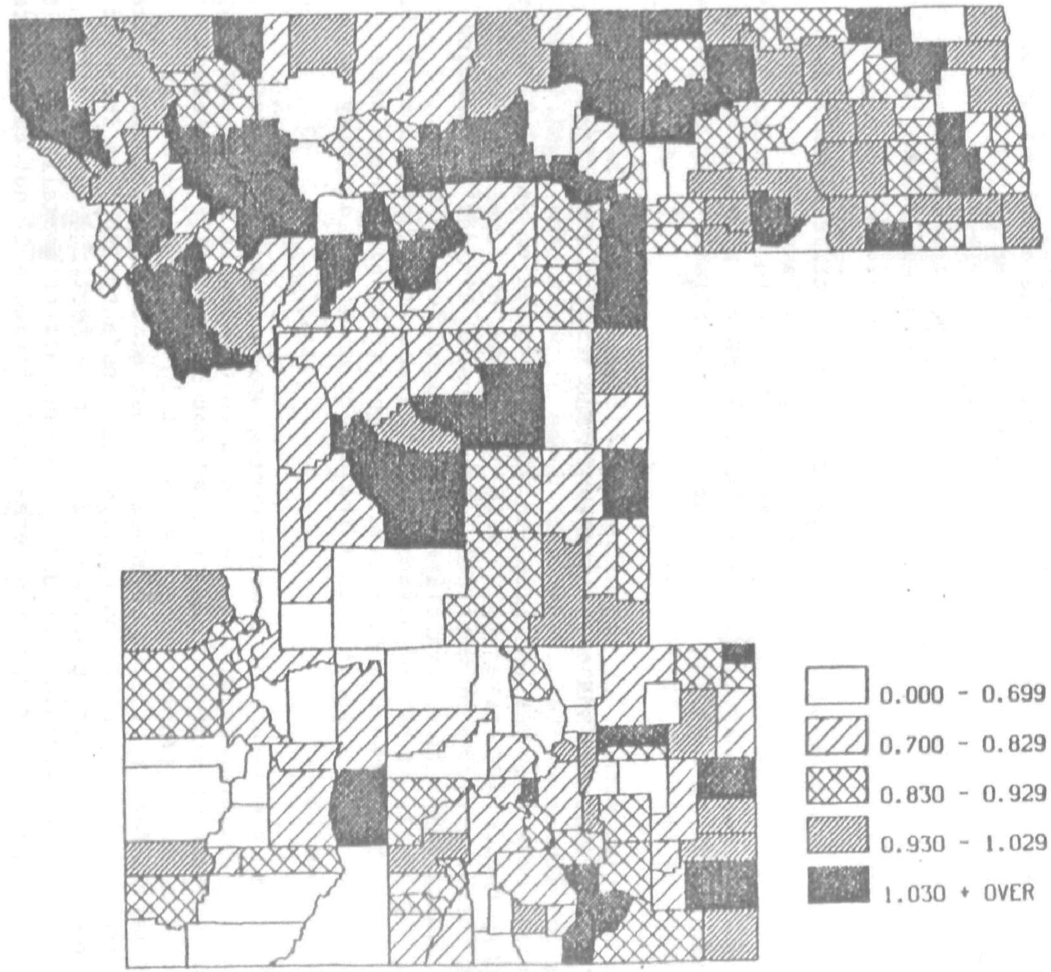

Figure 4. Geographic distribution of SMR's from deaths due to malignant neoplasms (total) in EPA Region VIII

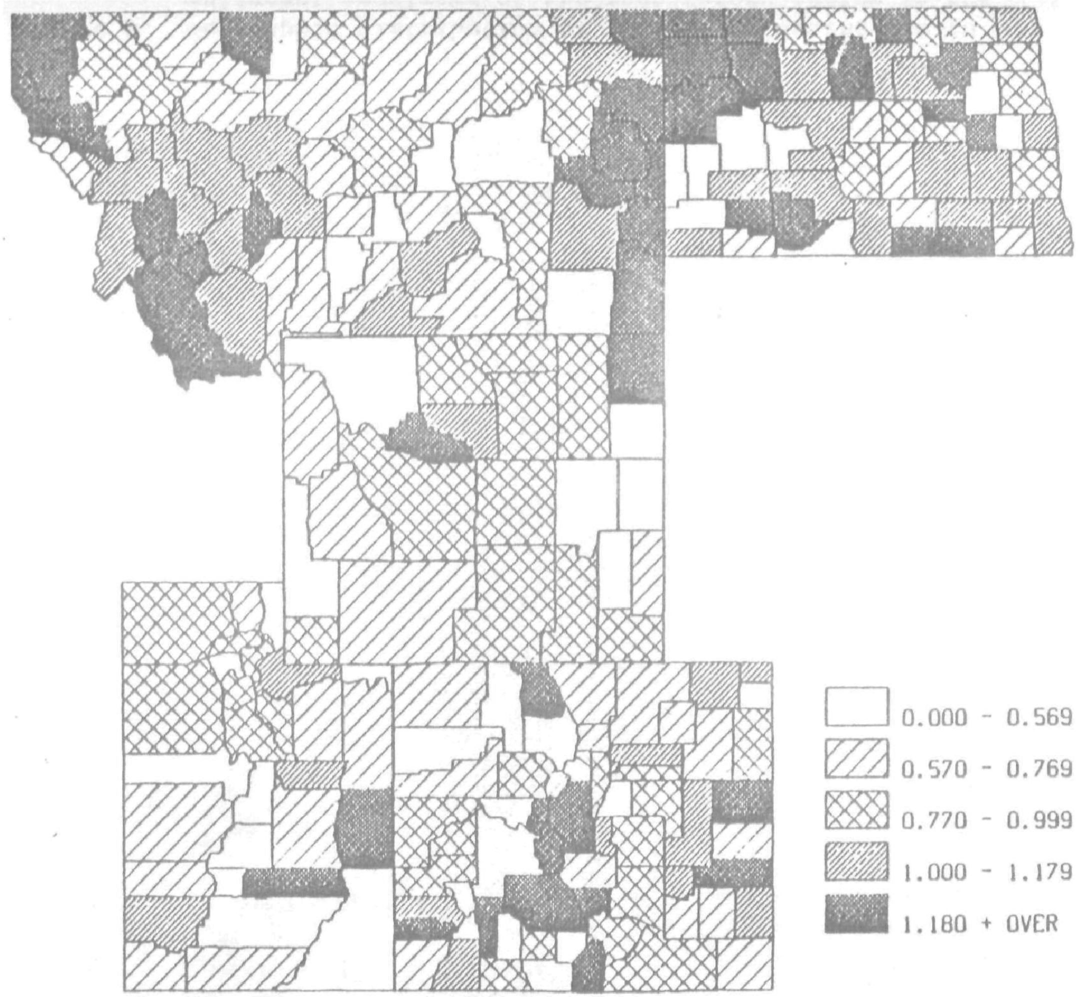

Figure 5. Geographic distribution of SMR's from deaths due to malignant neoplasms of the digestive system in EPA Region VIII

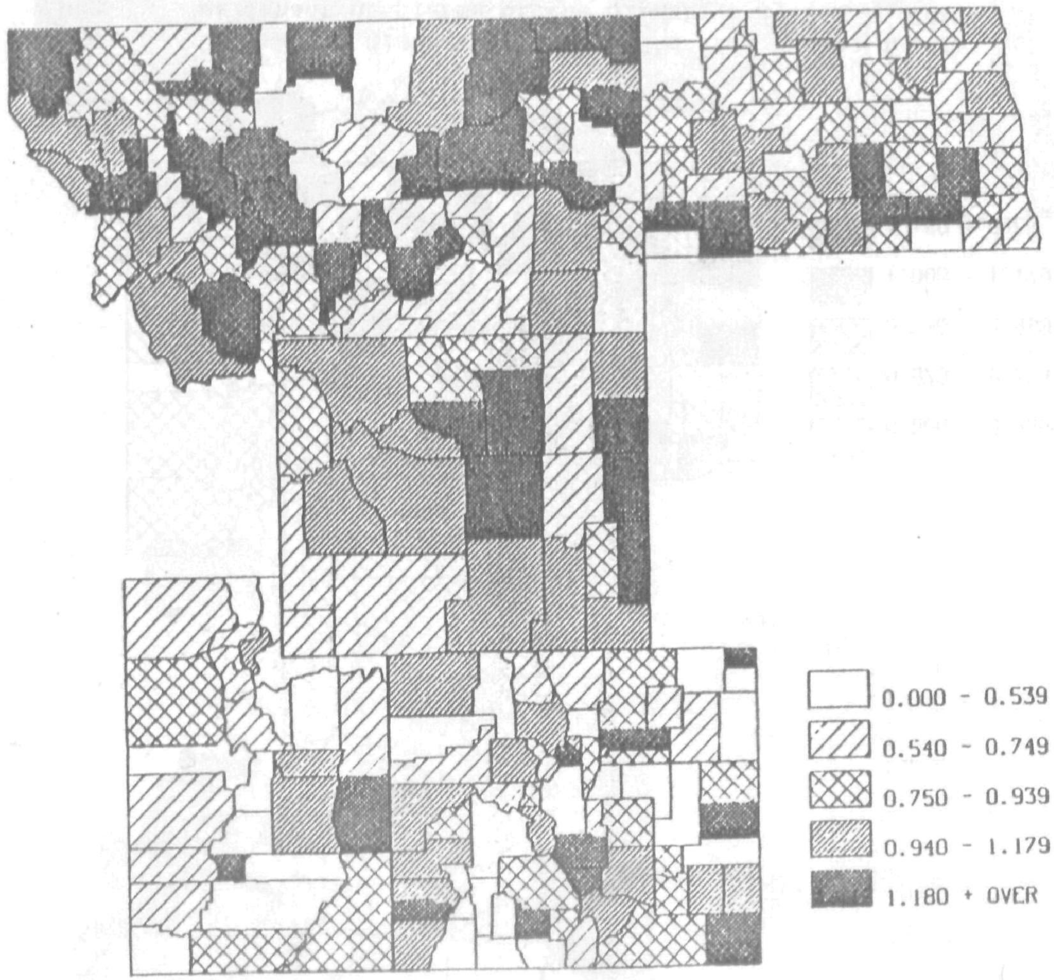

Figure 6. Geographic distribution of SMR's from deaths due to malignant neoplasms of the respiratory system in EPA Region VIII.

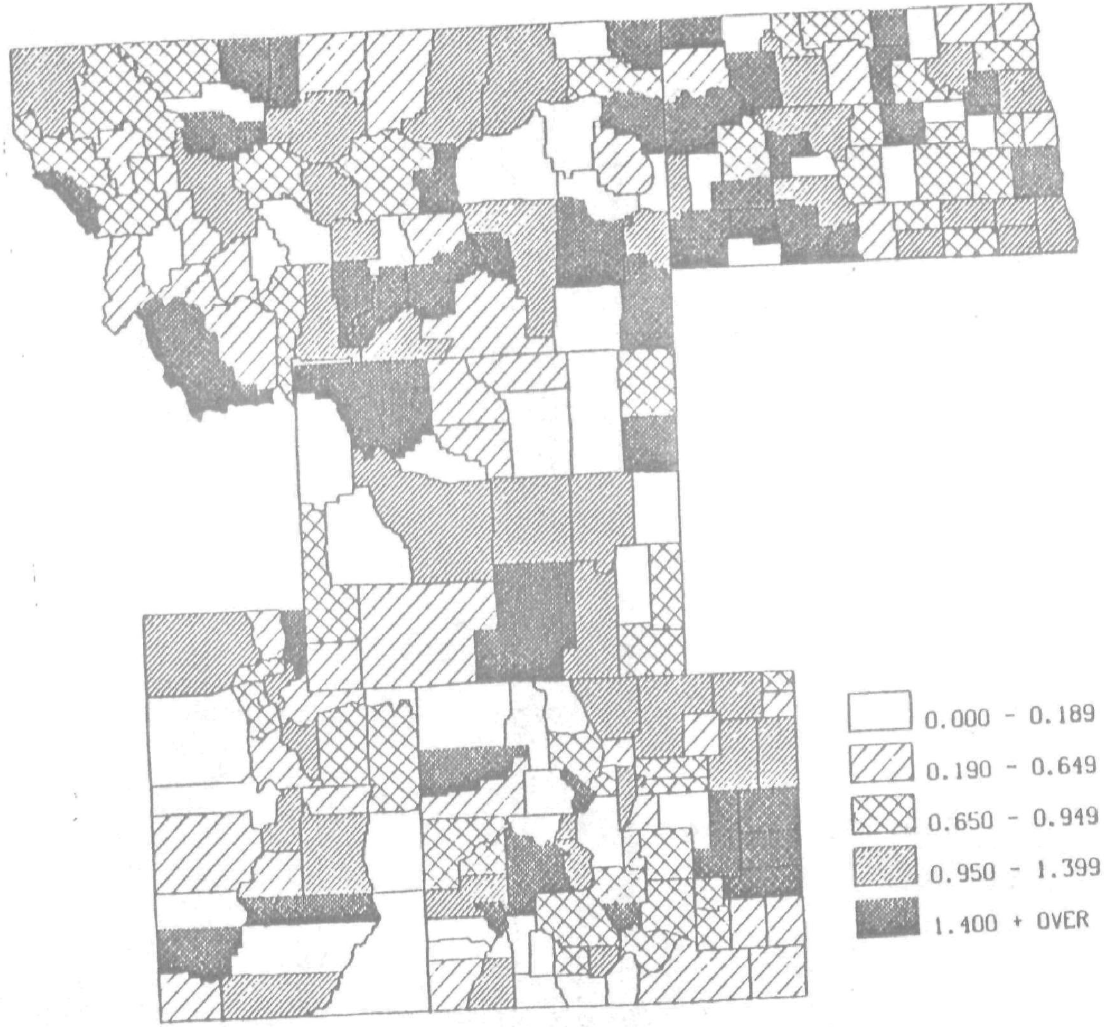

Figure 7. Geographic distribution of SMR's from deaths due to malignant neoplasms of the urinary tract in EPA Region VIII

Figure 8. Geographic distribution of SMR's from deaths due to major cardiovascular disease in EPA Region VIII

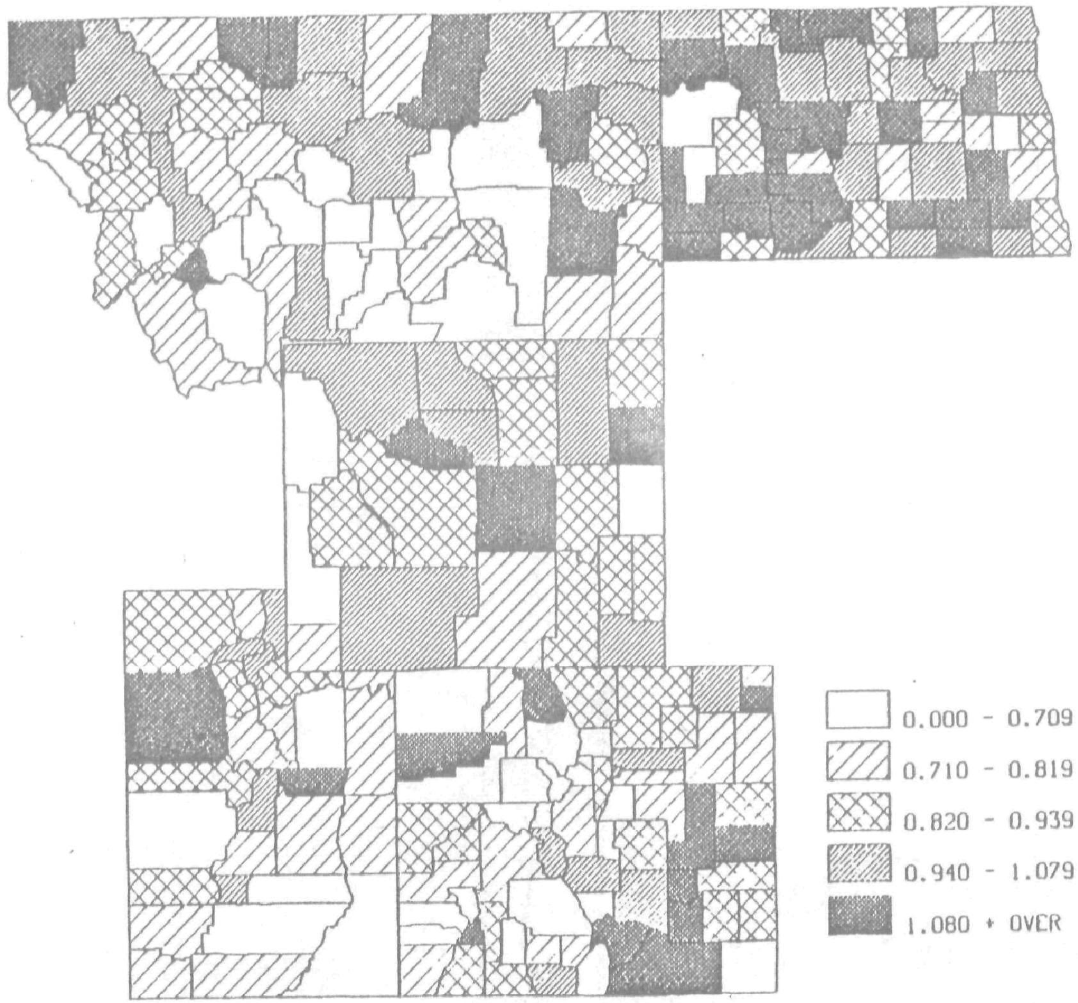

Figure 9. Geographic distribution of SMR's from deaths due to ischemic heart disease in EPA Region VIII

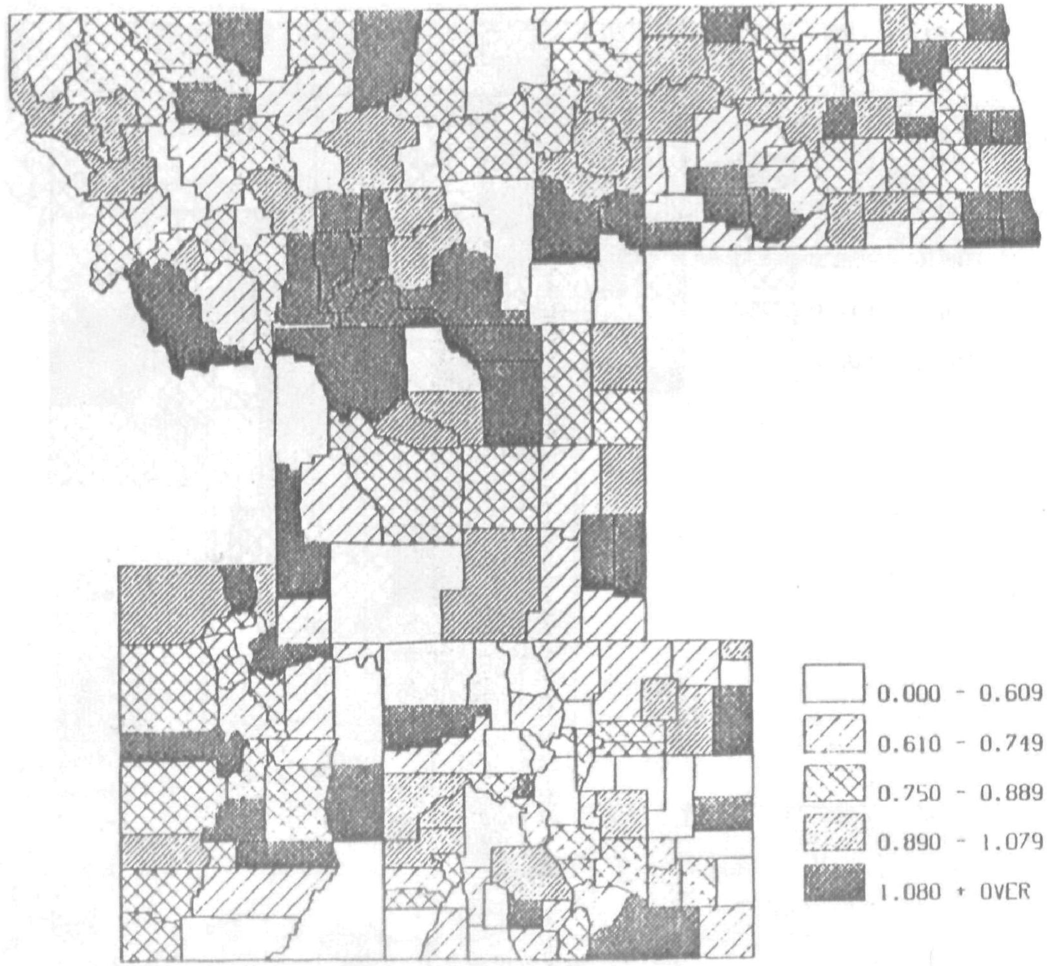

Figure 10. Geographic distribution of SMR's from deaths due to cerebrovascular disease in EPA Region VIII

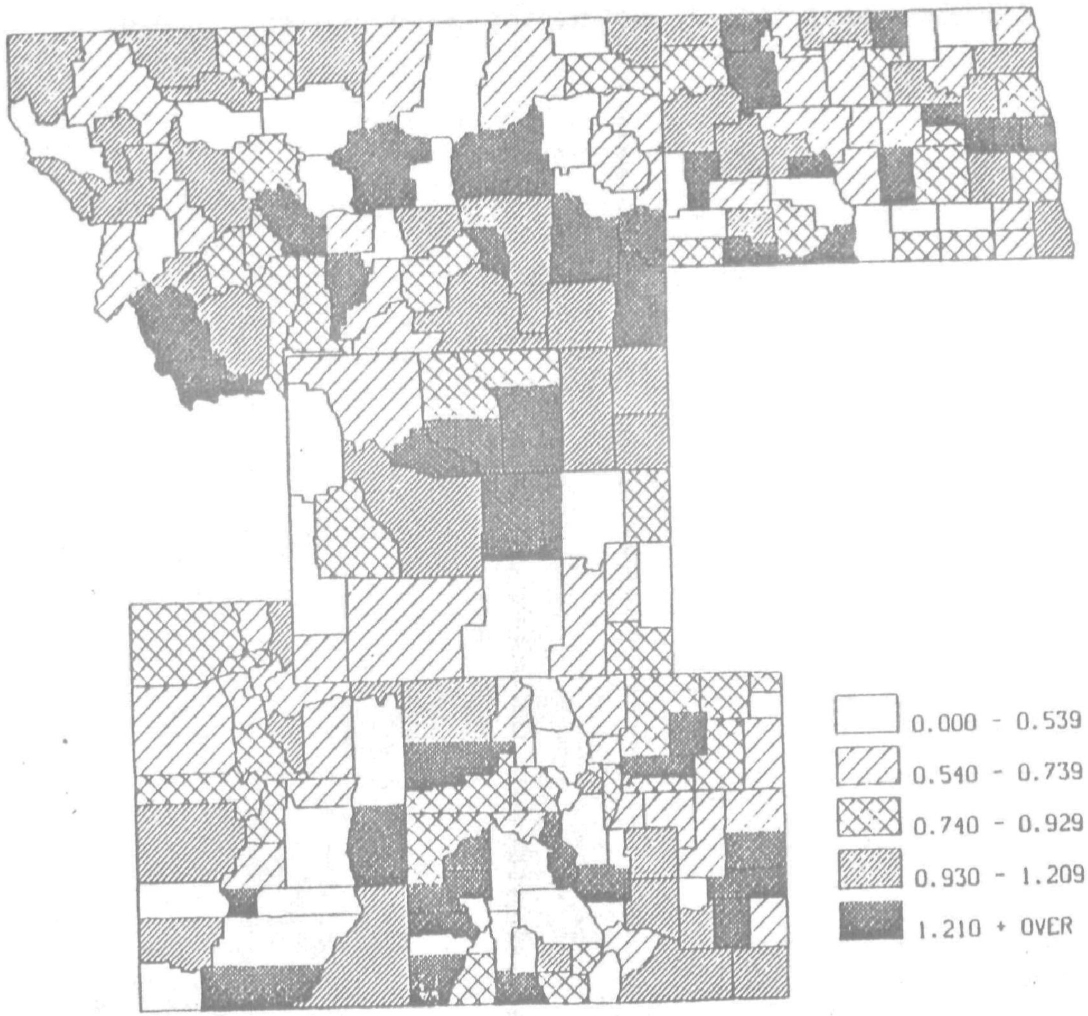

Figure 11. Geographic distribution of SMR's from deaths due to respiratory diseases in EPA Region VIII

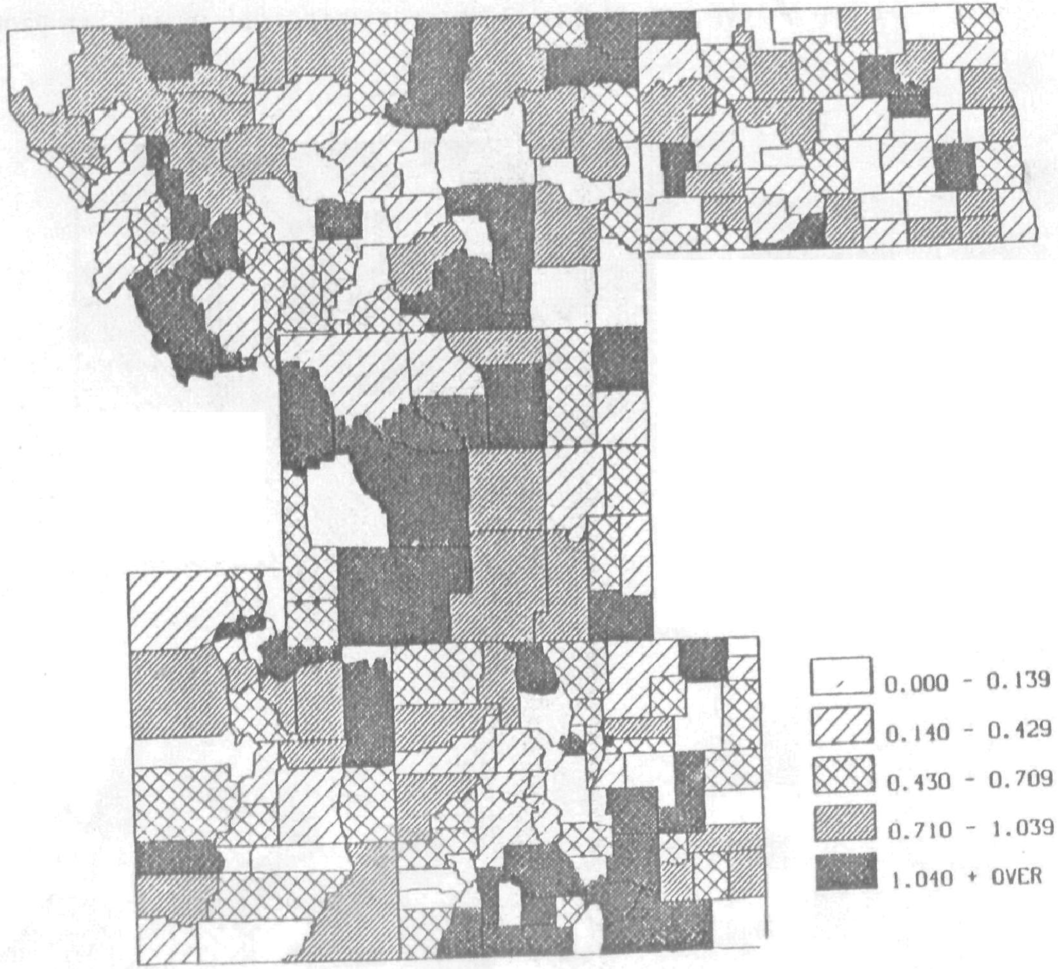

Figure 12. Geographic distribution of SMR's from deaths due to cirrhosis in EPA Region VIII

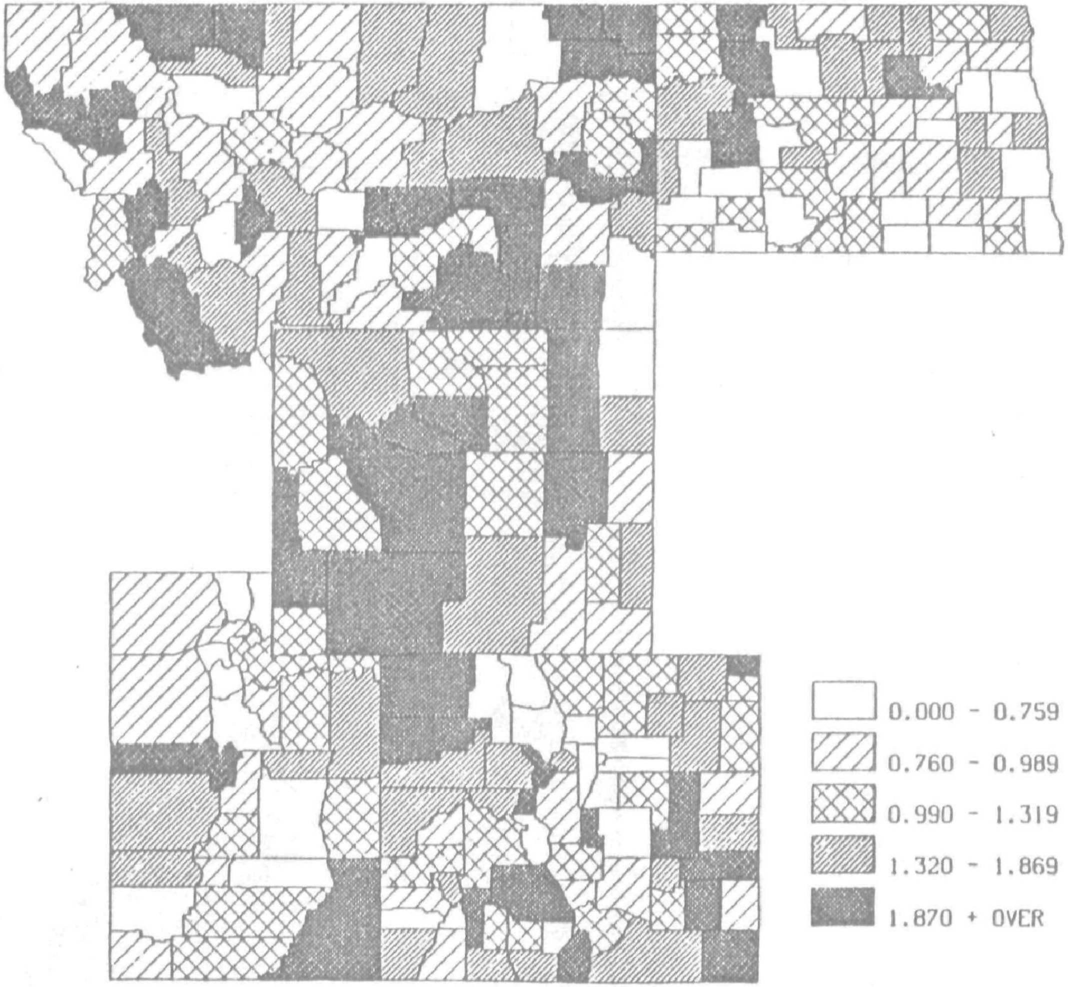

Figure 13. Geographic distribution of SMR's from deaths due to motor vehicle accidents in EPA Region VIII

Figure 14. Geographic distribution of SMR's from deaths due to suicide and homicide in EPA Region VIII

high levels were set at less than five percent and greater than or equal to five percent of the work force employed respectively.

Of the 11 causes of death examined by log-linear analysis, motor vehicle accidents was the only cause for which SMR categories appeared to depart from expected, although total logit variation did not quite reach the .05 level of significance. Examination of the summary results presented in Table 17 reveal significant differences across levels of current mining production. No effects from mining employment and no significant interaction effects were observed. Table 18 shows the distribution of SMR categories across levels of current mining. Estimates of the log-linear parameters divided by their standard errors indicate that significantly fewer high SMR's (and significantly more nonsignificant SMR's) are found in counties with no current mining operations. Frequency distributions for SMR categories by mining activity factors for each cause of death are presented in Appendix C.

TABLE 17. RESULTS OF LOG-LINEAR ANALYSIS OF SMR CATEGORIES FOR MOTOR VEHICLE ACCIDENTS

Summary of Logit Analysis

Source	df	Component X^2_{LR}	p
Due to Current Mining Activity (C)	4	13.45	.01
Due to Mining Employment (M)	2	4.39	.12
Due to Manufacturing Employment (F)	2	5.45	.07
Due to Interaction (CxM)	4	2.13	.75
Due to Interaction (CxF)	4	3.96	.43
Due to Interaction (MxF)	2	0.74	.69
Due to Interaction (CxMxF)	4	2.25	.69
Total Logit Variation	22	32.37	.07

TABLE 18. DISTRIBUTION OF SMR CATEGORIES FOR MOTOR VEHICLE ACCIDENTS ACROSS LEVELS OF CURRENT MINING OPERATIONS

		SMR		
		HIGH	NS	LOW
Current Mining Operations	None	14	151	9
	1	7	16	1
	>1	6	20	0

There are two relevant conclusions which can be drawn from these comparisons. First, there are no areas within this region with blatantly unusual patterns of mortality; the area is reasonably uniform in terms of the health status of the population, although small populations allow for some large perturbations in SMR's. Second, more detailed information on health status must be obtained in order to examine specific areas such as communities within the region.

SECTION 4

CRITIQUE OF DATA QUALITY

COAL MINING ACTIVITIES

Conclusions

In addressing the quality of the available data, current and future mining can be considered jointly. The coal mining tabulations used in this report are the most accurate comprehensive listings available, but still suffer from certain inadequacies. The major problem is the changing operational status of current mines (start-ups and shut-downs) and uncertain development of future mines. As noted earlier, marginally viable mining operations are sensitive to slight fluctuations in the cost of coal and transportation, so that a mine listed as producing currently may actually produce only sporadically. Future coal production is even more tentative. Changing environmental protection standards, water availability, and competition for resources all serve to make proposed coal mining uncertain. In addition to these problems, the characteristics of the mines are not likely to be perfectly accurate (e.g., location, chemical characteristics of the coal). Finally, production of current mines could not be quantified in many instances.

Recommendations

The solutions to all of these problems rely on obtaining information specific to each mine. The mine operators or developers could verify some of the descriptive information on the mine and at least estimate the production and the likelihood of implementing any future plans. Contact with the local authorities responsible for environmental protection, water usage, etc., would be a useful supplement to the mine owners' data. It is obviously not essential to pursue such information on every mine, but those of greatest relevance should be studied in such a manner.

IMPACTED COMMUNITIES

Conclusions

The approach taken to identify mining-impacted areas (both current and future) was intended to be an initial screening and is adequate for that purpose. The characterization of the areas in terms of demographic, social, and economic characteristics is rather crude, and definitely inadequate for any detailed analysis. There are two major problems. First, the available data is not sufficiently detailed. For example, the employees in a county engaged in manufacturing is available, but not a breakdown into such categories as metal smelting, chemical production, etc. Second, most of the information is tabulated on a county basis and not on the community level. In these large, sparsely populated counties, the county's average for a given variable may be a poor approximation for the community of interest.

Recommendations

The only approach to overcoming this data insufficiency is to obtain community-level data on a site-by-site basis. That is, for those communities of special interest, the local authorities should be contacted directly to obtain the desired demographic, social, and economic data. The goals of this study do not, however, suggest that this process be carried out for every coal-impacted community.

WATER QUALITY

Conclusions

Monitoring data are available regarding the quality of surface water, groundwater, and public water supplies in or near mining-impacted communities. Not only does the amount and quality of the data vary considerably between those three types of data, but also their relevance from a human health standpoint differs.

As indicated, comprehensive data on surface water is available only for recent years (1975 to present). Monitoring sites, in general, are well placed with respect to locations of the mines such that mining impacts on water quality, if present, should be detected. The frequency of sampling and the constituents monitored at each site are appropriate and should provide adequate quantitative data for studies of potential ecological effects of mining. Potential human health effects are linked to surface water quality only indirectly, since surface water is normally treated by various methods (filtration, sedimentation, chlorination, iron removal, pH adjustment, etc.) prior to human consumption. Due to the limited knowledge of the effects of water treatment on levels of various constituents of finished water, data on the chemical composition of raw (surface) waters provide only a rough indicator of the actual doses of these constituents present in drinking water. There is little historical data on water quality, so past exposure levels in most communities cannot even be estimated reasonably.

Present groundwater data are especially deficient in providing information on levels of specific constituents. Extensive well-sampling programs are underway but the emphasis of these programs is on the quantity of water available rather than its quality. Little can be said about human exposures from groundwater except where wells are the source of public water supplies.

The specific source(s) of drinking water can be identified for most communities by means of the Inventory of Public Water Supplies (U.S. EPA, 1978). This has been done for all potentially impacted communities as shown in Appendix D, Table 1. Municipal water treatment plants routinely analyze samples of finished water for chlorine, fluoride, and bacteria in accordance with their own quality control procedures and state health department requirements. Turbidity, pH, color, iron, hardness, and alkalinity are also monitored by most plants. The water poses a nuisance to facilities or equipment or elicits complaints from consumers unless these parameters are kept within certain limits. Substances such as heavy metals or organics, while potentially important from a human health standpoint, tend only to be spot-checked at infrequent intervals (i.e., in accordance with Safe Drinking Water Act provisions).

Recommendations

Comprehensive analyses of tap water are nonexistent for these mining communities. Clearly, sampling of treated drinking water is essential if human exposure levels are to be established. Protocols for systematic sampling of tap water need to be developed as part of any epidemiologic study of mining impacts. Particular emphasis should be placed on securing baseline exposure data for a wide range of potential pollutants, possibly by means of a pilot program. Pilot program results could suggest the most efficient and economical sampling protocol for future studies and/or document excessive exposure levels in specific communities or areas.

AIR QUALITY

Conclusions

Air quality has not traditionally been a major concern in the sparsely populated western coal mining areas, and the region's air has not been sampled intensively. Although the number of sites listed in Table 12 is fairly large, most of these monitors are distant from the mines. A single monitor located several miles away gives little indication of such critical factors as which direction the mine-related air emissions travel and where roads or railroad tracks are located relative to the air sampler. Locating the monitors in population centers is certainly a rational means of identifying human exposures, but it reveals little about the role of coal mining on air quality. Also, the recent initiation of monitoring in many of these areas limits one's ability to ascertain parallel changes in mining and air quality over time.

The second major consideration concerns the chemicals which are analyzed at the stations listed in Table 12. Almost all stations monitor TSP, which is consistent with a focus on coal mining particulate emissions. Even monitors several miles from a mine would detect dramatic increases in particulate matter. Very little else, however, is monitored. Many of the air quality changes consequent to population influx, industrial processes, and coal burning would not be detected with the current sampling network.

Several other problems are inherent in the lack of specificity of TSP. Natural sources of particulates (e.g., from dust storms) are not distinguishable from mine-related or other sources of particulates. In addition, a variety of toxic substances are associated with particulate matter, e.g., cadmium. The variability in chemical composition (and thus variability in chemical toxicity) of particulates is not reflected in aggregate measures of TSP.

Recommendations

The recommendations to be made for air quality monitoring depend on the purpose for which the data are desired. In order to fully understand the nature of air pollutants generated by coal mining and related activities, the number of monitors would have to be greatly expanded. Other sources of pollution (motor vehicles, industries) would necessitate expansion of the number of air pollutants analyzed. If the focus is protection of health rather than characterizing air quality per se, then current monitoring should continue to be close to population centers. Baseline conditions are relatively pristine in most areas, however, and it is very unlikely that any long-term excursions above standards will occur. The TSP monitoring which is done would indicate any dramatic changes in air in the population centers. Thus, until new population centers arise or other major sources of air pollution are created, the current network of stations will adequately survey human exposures in the area.

HEALTH STATUS

This section addresses the adequacy of the accessible data used to characterize the health status of the population. The goal was to acquire data which could be used to compare and contrast small geographical units within the region, covering health services information, morbidity data, and mortality data. In this section, each of these categories is addressed again, supplying conclusions from data acquired thus far, and recommending means of acquiring more desirable information. Table 19 summarizes this section.

Health Services Information

Conclusions--

The number of health professionals per county was obtained for most of the area. However, the forms of aggregation of health personnel by the agencies yielded incongruent categories. In addition, time spans utilized for tabulations varied among the agencies from which information was received. Numbers of hospital beds and occupancy rates by hospital or county were received for a large portion of the five-state area. This information can be used to describe health care systems of individual counties, and to plan health policy and funding within a county. However, since it is not consistent in terms of measurements, this information could

TABLE 19. ADEQUACY OF INFORMATION AVAILABLE ON THE STATE LEVEL FOR EVALUATING HEALTH STATUS

	Data Required	Data Obtained
Mortality	Age and cause specific rates of mortality	Numbers of deaths from selected causes
	Comparative rates of mortality	Age adjusted rates for specific causes for two HSA's out of seven such agencies contacted
		SMR's for one HSA
Morbidity	Incidence and prevalence rates of various diseases	Numbers of reportable diseases and percent of school population immunized
Use of Health Facilities	Utilization rates by discharge diagnoses	Measures of utilization such as number of patient days, percent occupancy, number of beds available

not be used for such purposes as comparison of availability or accessibility of health care in different areas.

Recommendations--

The desired measures of health services information have been discussed previously (Table 13). They are: (1) the type, number, capacity, and accessibility of health services facilities by community; (2) the type, number, and location of personnel to provide health services; and (3) trends in the use of treatment facilities by discharge diagnosis. It would not be feasible to collect this information on a systematic basis for the whole western coal region. Such an effort, however, would be reasonable if it included only those communities selected for detailed analyses. This data could be obtained via a survey of health care facilities and personnel in the community and an analysis of hospital discharge data and physician's office records. This could be accomplished simultaneously with analyses of hospital and office records for the purpose of obtaining morbidity data.

Morbidity Data

Conclusions--

The agencies contacted for morbidity data provided numbers of cases of reportable diseases by county and percent of school populations immunized. This type of information is important for some purposes (e.g., monitoring and controlling infectious diseases), but generally does not lend itself well to descriptions of the health status of small areas nor to the study of epidemiological relationships in these areas. These types of diseases and conditions are no longer major contributors to disability within the United States.

Recommendations--

Measures of morbidity which are more desirable for the purpose of this program are incidence and prevalence rates of those nonreportable, nonfatal chronic diseases of adulthood such as hypertension and chronic bronchitis (see Table 13). These types of diseases are more significant contributors to poor health in modern society than are communicable diseases, and are more likely to be affected by coal mining activities. Since it appears that such information has not been aggregated on any area-wide basis, it is suggested that data of this nature be secured for selected communities via analysis of hospital discharge data and physicians' office records. A household health survey could supply additional information of this nature.

Incidence and prevalence rates of site-specific tumors can also be useful indicators of an area's health status. Such data could be acquired for community or county units by searching computer-recorded statistics from state tumor registries or the Third National Cancer Survey conducted by the National Cancer Institute which included the entire state of Colorado (Williams et al., 1977).

Mortality Data

Conclusions--

All of the agencies from whom mortality data were requested provided an aggregation of number of deaths by cause of death and by county. However, each State Health Department or Health Systems Agency aggregated the causes into different categories and used unique time spans for its tabulations. Actual rates (as opposed to counts) were calculated by only a few of these agencies and tabulations of rates by age, cause, and county of death were calculated by none. Therefore, since this mortality data was not congruent throughout the region, it could not be employed to characterize the health status of county units in the region. The information obtained from the National Center for Health Statistics did, however, provide congruent area-wide tabulations of deaths on the county level (U.S. DHEW, 1975). This was used to calculate cause-specific standardized mortality ratios, which permit useful descriptive comparisons of the area on the county level. Excess mortality from specific causes can be detected using this information, and the relationship between these anomalies and various social or demographic characteristics (as possible explanations) can be explored.

Recommendations--

Although the calculated SMR's are useful for broad comparisons, the identification of subtler problems in specific geographical areas (communities) would require more detailed information. Examples would include site-specific cancer death rates, and more detailed divisions of cardiovascular disease deaths. Apparently, the only way to provide a more detailed data set of this nature would be to sort through death certificates manually. This would be a costly and time-consuming procedure, and, therefore, it is not recommended that such a task be undertaken for the entire region. Study of selected communities in this manner might be worthwhile. The procedures recommended previously for gathering further morbidity data, however, would provide a superior basis for characterizing and comparing the health status of specific communities.

SECTION 5

SITE SELECTION PROCESS

RATIONALE

The overall objective of this research program is the selection of one or more communities which will be impacted by increased coal mining. This is the first major step in evaluating the potential for adverse health effects as a consequence of this activity. Since there is a focus on drinking water-based impacts, the selected communities should include some which are subject to coal mining pollution in water and others which are not. This would serve to isolate the water-mediated effects of coal development on health.

Compilation of health and environmental quality data on communities with developing mines and current mines will provide a baseline for conducting prospective studies of environmental changes and health consequences of coal mining activities. Research efforts up to this time have been directed toward characterizing the entire western coal region in order to identify specific sites that are representative of the area. Effort has also been devoted to identifying communities which would be eligible as potential study sites. The characterization of the region and the initial steps taken in selecting a coal-impacted community were described in earlier sections. Site selection began with the identification of all communities within a 20-mile radius of a current or developing mine. Those communities with fewer than 1,000 residents were subsequently eliminated because it was felt that they were too small to be suitable for retrospective epidemiological studies. A larger study population is needed to derive reliable estimates of morbidity and mortality rates and provide information on some of the more uncommon conditions that may occur very infrequently in small populations. The remainder of this section describes additional steps that were taken in order to choose sites that are adequate for the purposes of this study. Each criterion for elimination of candidates is explained and the new list yielded from that elimination step is included.

CRITERIA FOR SITE SELECTION

Population Size

Only communities with more than 1,000 residents were included in the list of eligible study sites as it appears in Tables 6 and 7. Communities were excluded if they had a population greater than 30,000 are were a suburb of a city of greater than 30,000. It was believed that larger communities would have many confounding factors affecting the health of the population. For example, a large amount of traffic contributes considerably to air pollution and may conceal any such contribution from mining activity. A large community is more likely to have varied bases for its economy. There may be several primary industries, any or all of which may have a significant impact on the health of the population. It would be extremely difficult to associate community health problems directly with mining in such an area. In addition to the multiple types of industrial activity, urbanization itself has an impact on health status. Most importantly, urban communities are rather unrepresentative of this generally rural area.

The list of communities with populations greater than 1,000 and less than 30,000 (and not a suburb of a community of greater than 30,000) is shown in Table 20. These communities were subsequently evaluated on the nature of their public water supply and the spatial relationship between mining activity and the drinking water source.

Community Water Supply

The second criterion in screening study site candidates was the nature of the public water supply system. Acceptability was defined as a single-source surface water supply. This was based on several considerations.

Groundwater sources were eliminated since there is much less pollutant mobility in groundwater than in surface water. With less movement, the impacts of the mining effluents in water systems would not be transmitted to as large an area, and might not be transmitted at all, depending on the location of the water table and geological formations in the area in relation to the location of the coal deposits. In addition, there was virtually no information on baseline chemical conditions for groundwater. The single-source requirement is based on a need to categorize communities clearly into exposed/unexposed relative to mining, rather than allowing for communities with partially impacted water systems. In addition, interpretation of chemical analyses of water quality would be complicated if the water input were derived from several sources.

This requirement of a single source surface water supply resulted in a substantial decrease in study site candidates (Table 19). Acceptable communities number 15 in Colorado, and 4 in Wyoming.

Location of Mining Activity Relative to Drinking Water Source

The final major criterion is not actually a basis for eliminating candidate communities, but rather a basis for dichotomizing the 19 communities listed in Table 21. In order to be considered a study community (one which would be expected to demonstrate water-mediated health effects from mining), coal mining must exist within 20 miles upstream from the community water intake, and drinking water supplies must be drawn from the impacted river or stream downstream from the mine. Communities with downstream

TABLE 20. COMMUNITIES WITHIN 20 MILES OF MINING WITH MORE THAN 1,000 AND FEWER THAN 30,000 RESIDENTS[(a)]

Colorado

Berthoud
Brighton
Canon City
Carbondale
Craig
Durango
Eaton
Elizabeth
Erie
Evans
Florence
Glenwood Springs
Hayden
Lafayette
Louisville
Lyons
Meeker
Paonia
Rangely
Rifle
Steamboat Springs
Trinidad
Walsenburg

Montana

Circle
Roundup

North Dakota

Beulah
Bowman
Crosby
Garrison
Hazen
Hebron
Hettinger
Minot
New Town
Parshall
Stanley
Velva
Williston

Utah

Cedar City
Ephraim
Helper
Huntington
Mount Pleasant
Price
Wellington

Wyoming

Gillette
Glenrock
Green River
Kemmerer
Rawlins
Rock Springs
Sheridan

(a) Those communities which are suburbs of cities with more than 30,000 residents have also been eliminated.

TABLE 21. COMMUNITIES WITHIN 20 MILES OF MINING WITH MORE THAN 1,000 AND FEWER THAN 30,000 RESIDENTS WHICH ARE SERVED BY A SINGLE-SOURCE SURFACE WATER SUPPLY SYSTEM

COLORADO	
Berthoud	Lafayette
Canon City	Louisville
Craig	Lyons
Delta	Meeker
Durango	Rangely
Erie	Steamboat Springs
Evans	Walsenburg
Hayden	
WYOMING	
Green River	
Kemmerer	
Rock Springs	
Sheridan	

or "off-stream" mining, and those whose water was not obtained from the impacted source, are considered control sites (those which would not be expected to demonstrate water-mediated health effects). Table 22 shows that there are far more in the group of potential control sites (15) than in the group of potential study sites (four).

FINAL SITE SELECTION

Based on the preceding steps, the candidates in Table 23 were derived. Since the ultimate study sites will be selected from this list, an effort was made to characterize these communities in some detail. In fact, all the pertinent information which could easily be obtained from published data sources was utilized in compiling Table 23.

There are two purposes to compiling this array of information: (1) desirable and undesirable features of the communities for study purposes can be easily identified, and (2) matching of sets of the communities can be carried out using the characteristics in the table as criteria. For the latter purpose, the items were categorized (Table 24). This facilitates comparisons among the communities by making identification of approximate equivalence a simple task of matching the numbers. With this layout of the information, the similarities and differences between any pair of communities are easily identified. Finally, the geographic location of these communities is depicted in Figure 15.

In order to confirm the accuracy of the list, the 19 study site candidates were re-examined in detail on two criteria. First, the nature of the drinking water source and its location relative to the mining activity were clarified by contacting the municipal water suppliers. Coal mine locations were verified using the U.S. Bureau of Mines, 1978 information. Second, the degree of urbanization in areas surrounding study site candidates was subjectively evaluated for its representativeness of western mining areas. Factors given consideration in this evaluation were county population density and proximity to a large city.

The clarification of the nature of the drinking water source and its location in relation to the mining activity produced several changes in the list of study site candidates. It was discovered that Kemmerer, Wyoming could not be considered a study site as originally believed. Careful examination of the local geography indicated that the mining activity was downstream from the community's water intake. Consequently, Kemmerer was changed to the category "control community." Meeker, Colorado, in Rio Blanco County and Durango, Colorado, in LaPlata County were eliminated from the list when it was discovered that their drinking water source was groundwater. Walsenburg, Colorado, (Huerfano County) and Delta, Colorado, (Delta County) were eliminated because they had multiple-source drinking water supplies.

TABLE 22. RELATIONSHIP BETWEEN COAL MINING AND DRINKING WATER IN COMMUNITIES WITHIN 20 MILES OF COAL MINING WITH MORE THAN 1,000 AND FEWER THAN 30,000 RESIDENTS AND WITH A SINGLE-SOURCE SURFACE WATER SUPPLY

Study Communities	Control Communities
Colorado	Colorado
Craig	Berthoud
Hayden	Canon City
Rangely	Delta
	Durango
Wyoming	Erie
	Evans
Kemmerer	Lafayette
	Louisville
	Lyons
	Meeker
	Steamboat Springs
	Walsenburg
	Wyoming
	Green River
	Rock Springs
	Sheridan

TABLE 23. STUDY SITE CANDIDATES[a]: ESTIMATED MINING, DEMOGRAPHIC, AND OTHER CHARACTERISTICS

Site	Area Coal Mining[b] Type[c]	Current Tonnage[d]	Projected Tonnage[e]	1975 Population	Percent Annual Change in Population, 1970-1975	Per Capita Income, 1974 (dollars)	Coal-Based Electricity Production (mWe) Current	Future[f]	Population Density in County (persons/sq mi)	Latitude (nearest degree)
					STUDY COMMUNITIES					
COLORADO										
Craig	Mixed	2.7	5.8	5,426	5.5	4,833	180	1,956	1	41
Hayden	Surface	10.1	15.2	1,338	14.4	5,492	180	1,956	1	41
Rangely	Mixed	0	3.7	1,792	2.4	4,526	0	550	1	40
WYOMING										
Kemmerer	Surface	4.1	9.5	2,658	3.0	4,578	710	1,540	2	42
					CONTROL COMMUNITIES					
COLORADO										
Berthoud	Underground	0.3	0.3	2,653	15.9	4,310	0	0	34	40
Canon City	Mixed	0.1	0.1	12,791	3.1	3,658	43	43	14	38
Delta	Mixed	0.3	0.3	3,632	-0.3	3,519	0	0	13	39
Durango	Underground	0.1	0.2	11,771	2.6	4,149	6	0	11	37
Erie	Mixed	0.3	0.3	1,662	10.0	3,651	267	246	22	40
Evans	Underground	0	0	3,455	6.6	4,147	0	0	22	40
Lafayette	Mixed	0.3	0.3	4,686	6.5	4,430	267	246	176	40
Louisville	Mixed	0.3	0.3	3,143	5.7	4,487	267	246	176	40
Lyons	Mixed	0.3	0.3	1,193	4.7	3,483	267	246	176	40
Meeker	Underground	0	0.1	1,986	4.6	4,206	0	0	1	40
Steamboat Springs	Surface	7.5	12.4	3,013	5.5	6,219	180	436	1	41
Walsenburg	Surface	0.3	0.3	4,018	-1.4	4,432	11	11	4	37
WYOMING										
Green River	Underground	0	1.6	7,423	14.6	4,937	16	15	2	42
Rock Springs	Mixed	3.4	13.3	17,773	10.0	5,358	516	2,015	2	42
Sheridan	Surface	11.5	47.0	11,617	1.3	4,551	8	508	7	45

(a) Criteria for inclusion in this category are: (1) coal mining within 20 miles, (2) population greater than 1,000 and less than 30,000, and (3) a single-source surface water supply.

(b) Includes all mining within 20 miles and all mines in a cluster that is within 20 miles at its closest point; current production was assumed to continue unless otherwise noted; unavailable data were assumed to indicate no production.

(c) The predominant type of mining in the area is listed; "mixed" is given when neither type clearly predominates.

(d) Highest in years 1975-1979 (millions of tons per year).

(e) Highest in 1980 or later (millions of tons per year).

(f) Future value is the estimated production after existing expansion plans have been implemented.

TABLE 24. CODED PRESENTATION OF STUDY SITE CHARACTERISTICS FROM TABLE 21[a]

Site	Type[b]	Current Output[c]	Projected Output[d]	1975 Population[e]	Rate of Change in Population, 1970-1975[f]	Per Capita Income, 1974[g]	Coal-Based Electricity Production: Current[h]	Coal-Based Electricity Production: Future[i]	Population Density[j]	Latitude[k]
STUDY COMMUNITIES										
COLORADO										
Craig	M	2	3	3	2	2	2	4	1	3
Hayden	S	3	3	1	3	3	2	4	1	3
Rangely	M	1	2	1	1	2	1	3	1	2
WYOMING										
Kemmerer	S	2	3	2	2	2	3	4	2	3
CONTROL COMMUNITIES										
COLORADO										
Berthoud	U	1	1	2	3	2	1	1	3	2
Canon City	M	1	1	4	2	1	1	1	3	1
Delta	M	1	1	2	1	1	1	1	3	2
Durango	U	1	1	4	1	2	1	1	3	1
Erie	M	1	1	1	3	1	2	2	3	2
Evans	U	1	1	2	3	2	1	1	3	2
Lafayette	M	1	1	3	3	2	2	2	4	2
Louisville	M	1	1	2	2	2	2	2	4	2
Lyons	M	1	1	1	2	1	2	2	4	2
Meeker	U	1	1	1	2	2	1	1	1	2
Steamboat Springs	S	3	3	2	2	3	2	2	1	3
Walsenburg	S	1	1	3	1	2	1	1	2	1
WYOMING										
Green River	U	1	2	4	3	2	1	1	2	3
Rock Springs	M	2	3	4	3	3	3	4	2	3
Sheridan	S	3	3	4	1	2	1	3	2	4

(a) All of Table 21's footnotes are applicable; units in footnotes c-k correspond to those in Table 23.

(b) U = Underground; S = surface; M = mixed surface and underground.

(c) 1 = 0-0.5; 2 = 0.6-5.0; 3 = 5.1+.

(d) 1 = 0-0.5; 2 = 0.6-5.0; 3 = 5.1+.

(e) 1 = 1,000-1,999; 2 = 2,000-3,999; 3 = 4,000-5,999; 4 = 6,000+.

(f) 1 = <3; 2 = 3-6; 3 = >6.

(g) 1 = 0-3,999; 2 = 4,000-4,999; 3 = 5,000+.

(h) 1 = 0-50; 2 = 51-500; 3 = 500+.

(i) 1 = 0-50; 2 = 51-500; 3 = 500-1,000; 4 = 1,000+.

(j) 1 = ≤1; 2 = 2-7; 3 = 8-35; 4 = (176).

(k) 1 = 37-38; 2 = 39-40; 3 = 41-42; 4 = 43+.

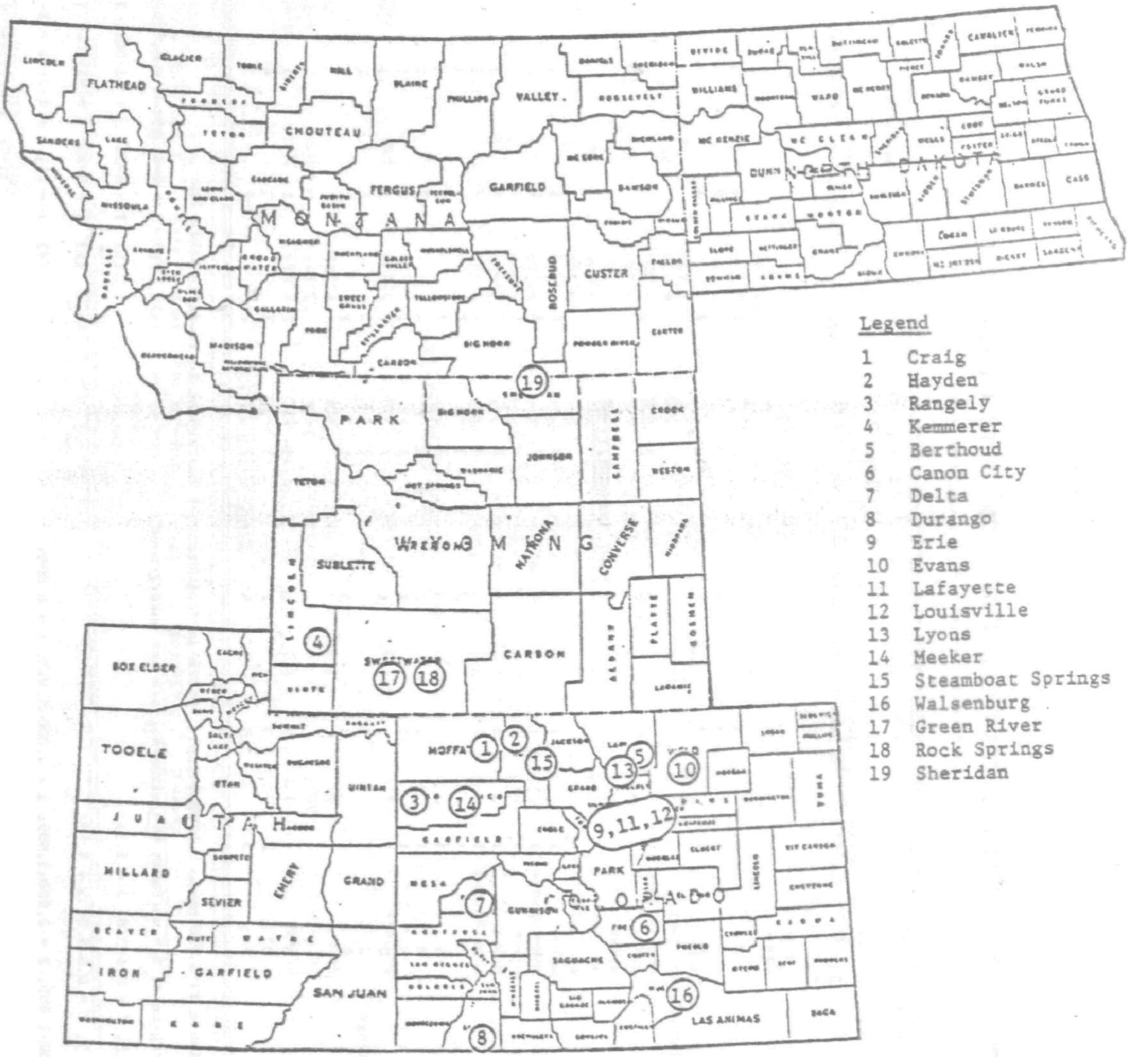

Figure 15. Locations of 19 study site candidates

Evaluation of the degree of urbanization lead to the elimination of the following Colorado communities: Berthoud in Larimer County; Erie, Lafayette, Louisville, and Lyons in Boulder County; and Evans in Weld County. All of these areas are unrepresentative of western mining areas due to their proximity to the Boulder metropolitan area.

The revised list of study site candidates is presented in Table 25, along with pertinent information about each community. There are two purposes to compiling this array of information: desirable and undesirable features of the communities for study purposes can be easily identified, and matching of sets of the communities can be carried out using the characteristics in the table as criteria. For the latter purpose, the items were made categorical (Table 26). This facilitates comparisons among the communities by making identification of approximate equivalence a simple task of matching the numbers. With this layout of the information, the similarities and differences between any pair of communities are easily identified.

DETAILED CHARACTERIZATION OF STUDY SITE CANDIDATES

The nine remaining study sites have been examined in much greater detail. The location and status of mining were verified, and data on drinking and surface water quality parameters were tabulated.

The location and status of mining were verified by re-examining original information sources. These sources included MILS (U.S. Bureau of Mines, 1978), U.S. Bureau of Mines Information Circulars 8719 (Corsentino, 1976) and 8772 (Rich, 1978), and the Keystone Coal Industry Manual (Nielson, 1977). All available mining information was compiled in Table 25. In this table, all of the mines near each of the communities are listed along with data on that mine. The column titled "Dot No." in Table 27 refers to mapping that was done on large detailed county maps (these maps are discussed further below).

As discussed in Section 3, Research Methodology, surface water quality data were acquired from the U.S. Geological Survey for many water monitoring sites considered to be mining impacted or near communities considered to be mining impacted. A list of the monitoring sites relevant to the nine remaining communities was tabulated (Table 28) and the chemical analyses were summarized (Tables 29-35). This included all monitors in the same county as the community of interest and on the same stream from which the community derives its public water supply. Water quality parameters included were those which were believed to be potentially related to mining or health and/or recorded for drinking water. The site number refers to the location of that monitor on the detailed maps mentioned previously. The distance, in miles, of the monitor from the community drinking water intake is also provided.

The drinking water quality data is given in Tables 36 through 43 for each community, and Table 44 summarizes this information. Analyses of

TABLE 25. STUDY SITE CANDIDATES[a]: ESTIMATED MINING, DEMOGRAPHIC, AND OTHER CHARACTERISTICS

Site	Area Coal Mining[b]			1975 Population	Percent Annual Change in Population, 1970-1975	Per Capita Income, 1974 (dollars)	Coal-Based Electricity Production (mWe)		Population Density in County (persons/sq mi)	Latitude (nearest degree)
	Type[c]	Current Tonnage[d]	Projected Tonnage[e]				Current	Future[f]		
STUDY COMMUNITIES:										
Colorado										
Craig	Mixed	2.7	5.8	5,426	5.5	4,833	180	1956	1	41
Hayden	Surface	10.1	15.2	1,338	14.4	5,492	180	1956	1	41
Rangely	Mixed	0	3.7	1,792	2.4	4,526	0	550	1	40
CONTROL COMMUNITIES										
Colorado										
Canon City	Mixed	0.1	0.1	12,791	3.1	3,658	43	43	14	38
Steamboat Springs	Surface	7.5	12.4	3,013	5.5	6,219	180	436	1	41
Wyoming										
Green River	Underground	0	1.6	7,423	14.6	4,937	16	15	2	42
Kemmerer	Surface	4.1	9.5	2,658	3.0	4,578	710	1540	2	42
Rock Springs	Mixed	3.4	13.3	17,773	10.0	5,358	516	2015	2	42
Sheridan	Surface	11.5	47.0	11,617	1.3	4,551	8	508	7	45

(a) Criteria for inclusion in this category are (1) coal mining within 20 miles, (2) population greater than 1,000 and less than 30,000, and (3) a single-source surface water supply.

(b) Includes all mining within 20 miles and all mines in a cluster that is within 20 miles at its closest point; current production was assumed to continue unless otherwise noted, and unavailable data were assumed to indicate no production.

(c) The predominant type of mining in the area is listed, and "mixed" is given when neither type clearly predominates.

(d) Highest in years 1975-1979, in millions of tons per year.

(e) Highest in 1980 or later, in millions of tons per year.

(f) Future value is the estimated production after existing expansion plans have been implemented.

TABLE 26. CODED PRESENTATION OF STUDY SITE CHARACTERISTICS FROM TABLE 23[a]

Site	Type[b]	Current Output[c]	Projected Output[d]	1975 Population[e]	Rate of Change in Population, 1970-1975[f]	Per Capita Income, 1974[g]	Coal-Based Electricity Production: Current[h]	Coal-Based Electricity Production: Future[i]	Population Density[j]	Latitude[k]
STUDY COMMUNITIES										
Colorado										
Craig	M	2	3	3	2	2	2	4	1	3
Hayden	S	3	3	1	3	3	2	4	1	3
Rangely	M	1	2	1	1	2	1	3	1	2
CONTROL COMMUNITIES										
Colorado										
Canon City	M	1	1	4	2	1	1	1	3	1
Steamboat Springs	S	3	3	2	2	3	2	2	1	3
Wyoming										
Green River	U	1	2	4	3	2	1	1	2	3
Kemmerer	S	2	3	2	2	2	3	4	2	3
Rock Springs	M	2	3	4	3	3	3	4	2	3
Sheridan	S	3	3	3	1	2	1	3	2	4

(a) All of Table 25's footnotes are applicable; units in footnotes c-k correspond to those in Table 24.

(b) U = Underground; S = Surface; M = Mixed surface and underground.

(c) 1 = 0-0.5; 2 = 0.6-5.0; 3 = 5.1+.

(d) 1 = 0-0.5; 2 = 0.6-5.0; 3 = 5.1+.

(e) 1 = 1,000-1,999; 2 = 2,000-3,999; 3 = 4,000-5,999; 4 = 6,000+.

(f) 1 = <3; 2 = 3-6; 3 = >6.

(g) 1 = 0-3,999; 2 = 4,000-4,999; 3 = 5,000+.

(h) 1 = 0-50; 2 = 51-500; 3 = 500+.

(i) 1 = 0-50; 2 = 51-500; 3 = 500-1,000; 4 = 1,000+.

(j) 1 = ≤1; 2 = 2-7; 3 = 8-35; 4 = (176).

(k) 1 = 37-38; 2 = 39-40; 3 = 41-42; 4 = 43+.

TABLE 27. MINING PLOTTED ON DETAILED COUNTY MAPS

State & County	Dot No.	Mine Name	Location (description/ coordinates)	Type	Production in Millions of Tons Per Year	Owner	
						Company	Location
COLORADO							
Fremont	1	Black Diamond	N 38° 17'53" W 105° 09'53"	Surface and Underground	0.04 (1976); 0.06 (1977)	G.E.C. Minerals	Florence, CO
	2	Caldirola No. 1	N 38° 20'45" W 105° 10'27"	Underground			
	3	Canon Monarch	N 38° 16'06" W 105° 09'02"	Underground			
	4	Cedar Canon Strip	N 38° 20'50" W 105° 11'05"	Surface	0.002 (1976); 0.003 (1977)	Cedar Canon Coal Co.	Florence, CO
	5	Cedar Canon Underground	N 38° 20'55" W 105° 11'30"	Underground			
	6	G.E.C. S&A	N 38° 17'20" W 105° 10'15"	Surface	0.04 (1977)	G.E.C. Minerals	Florence, CO
	7	Golden Quality No. 5	N 38° 20'05" W 105° 11'35"	Underground		Golden Quality Coal Co.	Canon City, CO
	8	Hastings	6 mi. SW of Florence	Surface		Robert M. Hastings	Beulah, CO
	9	Newlin Creek	T 20 S, R 69 W	Underground		Newlin Creek Coal Corp.	Canon City, CO
	10	Twin Pines	N 38° 20'25" W 105° 10'43"	Underground	0.05 (1977); 0.05 (1980)	Twin Pines Coal Co.	Canon City, CO
Moffat	1	Colowyo Mine	T 3 N, R 93 W 28 mi. SW of Craig	Surface	0.25 (1977); 3.0 (1980)	Colowyo Coal Co.	Craig, CO
	2	Trapper	T 5-6 N, R 91 W 6 mi. SW of Craig	Surface	0.4 (1977); 2.2 (1979)	Utah International Inc.	Craig, CO
	3	Williams Fork No. 1	N 40° 25'10" W 107° 38'45"	Surface			
	4	Wise Hall No. 5	N 40° 25'55" W 107° 39'00"	Underground	0.4 (1977); 0.6 (1980)	Empire Energy Corp.	Des Plains, IL
Rio Blanco	1	Gordon	T 2 N, R 101 W; T 3 N, R 101 W; 6 mi. NE of Rangely	2 Underground 1 Surface	1.5 (1980); 2.3 (1985); 3.7 (1990)	Moon Lake Electric Co.	Roosevelt, UT
	2	Rienau No. 2	N 40° 06'50" W 107° 50'30"	Underground	0.04 (1978)	Sewanee Mining Co., Inc.	Meeker, CO
	3	Unnamed	T 2 N, R 93 W			Northern Natural	Billings, MT

(continued)

TABLE 27. (Continued)

State & County	Dot No.	Mine Name	Location (description/ coordinates)	Type	Production in Millions of Tons Per Year	Owner	
						Company	Location
COLORADO Routt	1	Apex	N 40° 18'02" W 107° 02'04"	Underground			
	2	Apex No. 2	N 40° 17'35" W 107° 01'50"	Underground	0.10 (1977); 0.25 (1980)	Sunland Mining Corp.	Oak Creek, CO
	3	Blazer	T 7 N, R 87 W; 5 mi. NW of Milner	Underground	0.25 (1977)	Blazer Fuels Co.	Louisville, CO
	4	Dawson Unit	T 6 N, R 88 W; 2 mi. E of Hayden	Underground	0.1 (1977); 2.0-4.0 (Maximum)	Coals Fuels Corp.	Rollinsville, CO
	5	Denton Strip	N 40° 18'45" W 107° 20'00"	Surface		Milner Coal Co.	Milner, CO
	6	Edna	N 40° 19'55" W 107° 00'40"	Surface	1.1 (1976); 1.0 (1979); 0.85 (1980)	Pittsburg & Midway Coal Mining Co.	Oak Creek, CO
	7	Eilt's Property	T 6 N, R 87 W; 2 mi. S of Bear River	Surface	0.15 (1977); 0.25 (1978)	Sun Coal Co.	Milner, CO
	8	Energy Strip No. 1	N 40° 20'50" W 107° 03'45"	Surface	1.5 (1976); 1.7 (1978)	Energy Fuels, Inc.	Steamboat Springs, CO
	9	Energy Strip No. 2	N 40° 21'35" W 107° 11'30"	Surface	1.0 (1976); 1.1 (1978)	Energy Fuels, Inc.	Steamboat Springs, CO
	10	Energy Strip No. 3	T 5 N, R 86 W; 5 mi. SE of Milner	Surface	0.5 (1978); 0.1 (1978)	Energy Fuels, Inc.	Steamboat Springs, CO
	11	Hayden Gulch	10 mi. S of Hayden	Surface	1.0 (1978)	W.R. Grace & Co.	Denver, CO
	12	Johnnie's Coal Mine	N 40° 16'41" W 107° 02'14"	Underground			
	13	Meadows No. 1	T 6 N, R 87 W	Surface		Sun Coal Co.	Milner, CO
	14	Peabody Pit	N 40° 26'55" W 107° 07'42"	Surface			
	15	Seneca	N 40° 26'00" W 107° 06'35"	Surface	1.5 (1976)	Peabody Coal	St. Louis, MO
	16	Seneca Strip No. 2	T 5-6 N, R 87 W; 7 mi. SE of Hayden	Surface	0.7 (1975)	Seneca Coals, Ltd.	Hayden, CO
	17	Sun	N 40° 19'58" W 107° 20'12"	Underground	0.3 (Planned)	Ruby Construction Co.	Louisville, KY
	18	Unnamed	10 mi. W of Steamboat Springs			Shell Oil Co.	Houston, TX

(continued)

TABLE 27. (Continued)

State & County	Dot No.	Mine Name	Location (description/coordinates)	Type	Production in Millions of Tons Per Year	Owner Company	Owner Location
WYOMING							
Lincoln	1	Elkol	N 41° 48'20" W 110° 37'30"	Surface	1.8 (1976)3; 1.1 (1980)	Kemmerer Coal Co.	Frontier, WY
	2	Skull Point	T 20 N, R 117 W	Surface	1.0-2.0 (1980)	FMC Corp.	Kemmerer, WY
	3	Sorensen	N 41° 48'20" W 110° 37'30"	Surface	2.3 (1976) 3.0-4.7 (1980)	Kemmerer Coal Co.	Frontier, WY
	4	Twin Creek Project	T 21 N, R 116 W; Adjacent to Elkol/Sorensen	Surface	3.0 (1980)	Rocky Mountain Energy Co.	Denver CO
Sheridan	1	Big Horn No. 1	N 44° 53'55" W 106° 58'35"	Surface	0.75 (1976); 1.5 (1980)	Big Horn Coal Co.	Sheridan, WY
	2	East and West Decker Mines	N 45° 03'00" W 106° 51'00"	Surface	10.2 (1976); 20.0 (1981)	Decker Coal Co.	Decker, MT
	3	PSO Mine No. 1	N 44° 32'55" W 106° 57'50"	Surface	0.5 (1978)	Ash Creek Mining Co.	Lakewood, CO
	4	Spring Creek Mine	N of Decker (MT)	Surface	10.0 (1980)	Pacific Power & Light Co.	Portland, OR
	5	Youngs, Tanner, & Squirrel Creeks, Unnamed	Near Decker (MT)	Surface	6.0 (1980); 15.0 (1985)	Shell Oil Co.	Denver, CO
Sweetwater	1	Black Butte	N 41° 35'40" W 108° 40'15"	Surface	4.2 (1980)	Black Butte Coal Co. (RMEC)	Sheridan, WY
	2	Cherokee	T 20 N, R 92 W	Surface	6.0 (1984)	Rocky Mountain Energy Co.	Denver, CO
	3	Jim Bridger Mine	N 41° 46'35" W 108° 45'20"	Surface	3.4 (1976); 7.5 (1980)	Bridger Coal Co. (PPLC)	Rock Springs, WY
	4	Long Canyon	T 21 N, R 104 W; NW of Superior	Underground		Rocky Mountain Energy Co.	Denver, CO
	5	Rainbow No. 8	N 41° 31'20" W 109° 13'40"	Underground	0.1 (1976)	Columbine Mining Co.	Rock Springs, WY
	6	Stansbury No. 1	N 41° 41'55" W 109° 11'15"	Underground		Stansburg Coal Co.	Denver, CO

TABLE 28. WATER MONITORING SITES PLOTTED ON DETAILED MAPS

State	County	Map No.	Site Number
Colorado	Fremont	1	07094500
		2	07096000
			000007
		3	000129
		4	07097000
	Moffat	1	09246550
		2	09247500
		3	09247500
		4	402627107390700
		5	402456107413500
		6	402650107541900
		7	09251000
		8	000039
		9	4032121080519
		10	402709108263000
		11	000040
		12	09260050
		13	402811108384500
		14	403009108464200
		15	402910108515300
		16	403144108584900
		17	403146108584900
	Rio Blanco	1	67-001
		2	67-006
		3	09304200
		4	09304500
		5	000043
		6	09304800
		7	000117
		8	401221082412000
		9	09306300
	Routt	1	401048106544800
		2	401418106562200
		3	09237500
		4	402230106493000
		5	000088
		6	402356106500000
		7	402544106493600
		8	402737106493700
		9	09239000
		10	402759106493100
		11	09239500
		12	402921106502700
		13	402934106505400
		14	402598106515200
Colorado	Routt (con't)	15	403000106515700
		16	403015106522000
		17	403017106525800
		18	403002106545500
		19	402932106564900
		20	402902106580000
		21	000038
		22	402840107004200
		23	402854107020500
		24	402902107043000
		25	09244410
		26	0924440
		27	403051107124500
		28	403006107154200
		29	4029301071742[illegible]
Wyoming	Lincoln	1	90223000
		2	09224050
	Sheridan	1	026504
		2	026501
		3	000355
		4	06305500
			000511
		5	00R278
			000278
	Sweetwater	1	09211200
			000579
		2	415553110023[illegible]
		3	41570010955[illegible]
		4	[illegible]
		5	[illegible]
		6	[illegible]
		7	09216300
		8	000530
		9	[illegible]
		10	[illegible]
		11	[illegible]
		12	[illegible]
			[illegible]
		13	WY-0000043-1
		14	09217000
			000531
		15	09217010
			000532
		16	360501
		17	360503
		18	360504
		19	360505

TABLE 29. SURFACE WATER QUALITY PARAMETERS[(a)] IN RELATION TO DRINKING WATER INTAKE OF CRAIG, MOFFAT COUNTY, COLORADO

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/ℓ)[(b)]	Hardness (mg/ℓ)	Calcium (mg/ℓ)[(b)]	Magnesium (mg/ℓ)[(b)]	Sodium (mg/ℓ)[(b)]	Sulfate (mg/ℓ)	Cadmium (µg/ℓ)[(b)]	Chromium (µg/ℓ)[(b)]	Arsenic (µg/ℓ)[(b)]	Copper (µg/ℓ)[(b)]	Lead (µg/ℓ)[(b)]
1	-7[(c)]	7.89 (40)	0.01 (1)	118.20 (40)	29.62 (40)	10.75 (40)	21.08 (40)	50.22 (40)	0.67 (12)	2.18 (11)	0.55 (11)	3.92 (12)	3.00 (12)
2	0	8.06 (8)	0.16 (5)	115.43 (7)	30.03 (7)	9.83 (7)	21.33 (3)	39.24 (10)	0.40 (5)	—	0.25 (4)	2.00 (5)	1.40 (5)
3	11	8.05 (40)	0.01 (1)	115.44 (39)	28.92 (39)	10.52 (39)	23.07 (38)	57.01 (39)	0.50 (10)	2.22 (9)	0.78 (9)	2.10 (10)	2.50 (10)
4	22	8.50 (1)	0.01 (1)	—	—	—	—	—	0.00 (1)	—	—	1.00 (1)	1.00 (1)
5	35	8.60 (1)	0.01 (1)	—	—	—	—	—	0.00 (1)	—	—	1.00 (1)	2.00 (1)
6	100	8.90 (1)	0.01 (1)	140.00 (1)	32.00 (1)	15.00 (1)	24.00 (1)	77.00 (1)	0.00 (1)	—	—	1.00 (1)	0.00 (1)
7	133	7.68 (722)	0.27 (46)	145.49 (689)	35.48 (522)	14.61 (522)	33.79 (524)	69.11 (688)	0.94 (17)	3.75 (16)	0.81 (16)	5.18 (17)	3.29 (17)
8	145	8.23 (63)	—	175.25 (57)	—	—	—	97.65 (52)	—	—	—	—	—
9	151	—	—	54.00 (1)	14.00 (1)	4.70 (1)	—	50.00 (3)	—	—	—	—	—
10	220	—	—	180.00 (1)	40.00 (1)	19.00 (1)	—	83.00 (1)	—	—	—	—	—
11	228	8.32 (56)	—	180.00 (53)	—	—	—	111.58 (52)	—	—	—	—	—
12	232	6.50 (2)	0.00 (1)	—	—	—	—	—	0.00 (1)	—	—	2.00 (1)	0.00 (1)
13	255	8.40 (1)	—	—	—	—	—	—	—	—	—	—	—
14	279	8.80 (1)	—	—	—	—	—	—	—	—	—	—	—
15	305	8.50 (1)	—	—	—	—	—	—	—	—	—	—	—
16	344	—	—	136.00 (2)	33.50 (2)	13.50 (2)	—	61.00 (2)	—	—	—	—	—
17	344	8.60 (1)	—	—	—	—	—	—	—	—	—	—	—

(a) The number provided for each parameter represents the mean value; the following number in parentheses is the number of measurements on which the mean is based.

(b) Dissolved.

(c) Negative distances are upstream, positive distances are downstream.

TABLE 30. SURFACE WATER QUALITY PARAMETERS[a] IN RELATION TO DRINKING WATER INTAKE OF HAYDEN, ROUTT COUNTY, COLORADO

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/ℓ)[b]	Hardness (mg/ℓ)	Calcium (mg/ℓ)[b]	Magnesium (mg/ℓ)[b]	Sodium (mg/ℓ)[b]	Sulfate (mg/ℓ)	Cadmium (µg/ℓ)[b]	Chromium (µg/ℓ)[b]	Arsenic (µg/ℓ)[b]	Copper (µg/ℓ)[b]	Lead (µg/ℓ)[b]
1	-57.6[c]	8.80 (1)	—	—	—	—	—	—	0.00 (1)	—	—	1.00 (1)	0.00 (1)
2	-53.7	8.14 (5)	0.07 (5)	—	—	—	—	—	0.00 (1)	—	—	2.00 (1)	0.00 (1)
3	-46.5	7.93 (3)	—	161.33 (3)	42.33 (3)	14.17 (3)	8.30 (1)	32.33 (3)	—	—	—	—	—
4	-38.3	—	—	140.00 (1)	38.00 (1)	12.00 (1)	—	33.92 (4)	—	—	—	—	—
5	-37.5	8.28 (38)	—	152.40 (35)	106.85 (34)	11.91 (34)	9.69 (35)	38.94 (35)	—	—	—	—	—
6	-35.6	7.68 (5)	0.06 (5)	150.00 (1)	36.00 (1)	15.00 (1)	7.00 (1)	30.00 (1)	0.05 (4)	—	0.67 (3)	0.50 (4)	1.25 (4)
7	-32.9	8.32 (12)	0.07 (3)	—	—	—	—	—	0.00 (1)	—	0.00 (1)	3.00 (1)	0.00 (1)
8	-30.0	7.89 (17)	—	—	—	—	—	—	—	—	—	—	—
9	(d)	6.35 (6)	0.05 (7)	—	—	—	—	1.23 (3)	—	—	—	—	—
10	-29.8	7.97 (8)	—	—	—	—	—	—	—	—	—	—	—
11	-28.4	7.90 (26)	0.08 (5)	114.50 (6)	30.27 (6)	9.92 (6)	10.03 (3)	24.07 (7)	0.04 (5)	—	0.25 (4)	2.40 (5)	0.80 (5)
12	-27.6	—	—	—	—	—	—	—	—	—	—	—	—
13	-27.5	7.37 (21)	0.08 (4)	—	—	—	—	—	—	—	—	—	—
14	-26.5	7.87 (8)	—	—	—	—	—	—	—	—	—	—	—
15	-26.4	7.65 (17)	—	—	—	—	—	—	—	—	—	—	—
16	-26.0	7.73 (9)	—	—	—	—	—	—	—	—	—	—	—
17	-25.6	7.92 (18)	—	—	—	—	—	—	—	—	—	—	—
18	-23.7	7.89 (17)	—	—	—	—	—	—	—	—	—	—	—

(continued)

TABLE 31. SURFACE WATER QUALITY PARAMETERS[a] IN RELATION TO DRINKING WATER INTAKE OF RANGELY, RIO BLANCO COUNTY, COLORADO

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/ℓ)[b]	Hardness (mg/ℓ)	Calcium (mg/ℓ)[b]	Magnesium (mg/ℓ)[b]	Sodium (mg/ℓ)[b]	Sulfate (mg/ℓ)	Cadmium (μg/ℓ)[b]	Chromium (μg/ℓ)[b]	Arsenic (μg/ℓ)[b]	Copper (μg/ℓ)[b]	Lead (μg/ℓ)[b]
1	-86.4[c]	8.63 (4)	—	141.75 (4)	—	—	—	—	—	—	—	—	—
2	-80.0	9.13 (2)	—	160.00 (2)	—	—	—	—	—	—	—	—	—
2	-80.0	8.08 (15)	0.13 (15)	179.33 (15)	54.60 (15)	9.95 (15)	3.46 (15)	88.67 (15)	—	—	1.00 (4)	—	3.00 (4)
3	-63.8	8.31 (8)	0.09 (9)	176.22 (9)	53.67 (9)	10.41 (9)	4.26 (9)	72.89 (9)	—	—	—	—	—
4	-61.6	8.15 (6)	0.09 (5)	197.00 (8)	57.12 (8)	13.08 (8)	16.33 (6)	91.19 (8)	—	—	—	—	—
5	-54.6	8.43 (62)	—	242.83 (54)	—	—	—	117.63 (49)	—	—	—	—	—
6	-47.9	8.21 (52)	—	261.22 (41)	71.12 (41)	20.07 (41)	35.92 (41)	137.40 (41)	0.67 (9)	3.11 (9)	0.92 (26)	1.70 (10)	2.50 (10)
7	-36.7	8.51 (30)	—	265.06 (33)	—	—	—	158.56 (32)	—	—	—	—	—
8	-25.7	8.40 (2)	0.09 (1)	260.00 (1)	59.00 (1)	28.00 (1)	110.00 (1)	160.00 (1)	2.00 (1)	10.00 (1)	1.00 (1)	6.00 (1)	7.00 (1)
9	- 4.0	8.28 (36)	—	278.43 (37)	70.27 (37)	24.70 (37)	62.86 (35)	166.84 (37)	1.00 (8)	5.44 (9)	1.57 (23)	2.33 (9)	4.11 (9)

(a) The number provided for each parameter represents the mean value; the following number in parentheses is the number of measurements on which the mean is based.

(b) Dissolved.

(c) Negative distances are upstream, positive distances are downstream.

TABLE 32. SURFACE WATER QUALITY PARAMETERS[a] IN RELATION TO DRINKING WATER INTAKE OF CANON CITY, FREMONT COUNTY, COLORADO

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/ℓ)[b]	Hardness (mg/ℓ)	Calcium (mg/ℓ)[b]	Magnesium (mg/ℓ)[b]	Sodium (mg/ℓ)[b]	Sulfate (mg/ℓ)	Cadmium (μg/ℓ)[b]	Chromium (μg/ℓ)[b]	Arsenic (μg/ℓ)[b]	Copper (μg/ℓ)[b]	Lead (μg/ℓ)[b]
1	-8.0[c]	—	—	—	—	—	—	—	—	—	—	—	—
2	0.8	8.33 (151)	0.16 (69)	120.37 (127)	33.13 (106)	8.45 (106)	10.78 (106)	31.17 (127)	—	—	—	—	—
2	0.8	8.21 (49)	—	138.45 (49)	—	—	—	31.89 (45)	—	—	—	—	—
3	5.8	8.60 (1)	—	74.00 (1)	—	—	—	23.00 (1)	—	—	—	—	—
4	15.8	7.98 (21)	0.30 (21)	205.82 (22)	55.05 (22)	16.45 (22)	25.64 (22)	119.41 (22)	—	—	—	—	—

(a) The number provided for each parameter represents the mean value; the following number in parentheses is the number of measurements on which the mean is based.

(b) Dissolved.

(c) Negative distances are upstream, positive distances are downstream.

TABLE 33. SURFACE WATER QUALITY PARAMETERS[a] IN RELATION TO DRINKING WATER INTAKE OF GREEN RIVER AND ROCK SPRINGS, SWEETWATER COUNTY, WYOMING

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/l)[b]	Hardness (mg/l)	Calcium (mg/l)[b]	Magnesium (mg/l)[b]	Sodium (mg/l)[b]	Sulfate (mg/l)	Cadmium (µg/l)[b]	Chromium (µg/l)[b]	Arsenic (µg/l)[b]	Copper (µg/l)[b]	Lead (µg/l)[b]
1	-48.6[c]	8.10 (171)	0.05 (2)	174.17 (166)	46.72 (166)	13.95 (166)	19.25 (166)	72.98 (166)	2.08 (12)	2.50 (12)	1.17 (12)	1.92 (12)	3.75 (12)
2	-44.8	—	0.02 (1)	170.00 (1)	44.00 (1)	14.00 (1)	25.00 (1)	81.00 (1)	—	—	—	—	—
3	-40.3	—	0.01 (1)	160.00 (1)	42.00 (1)	14.00 (1)	26.00 (1)	80.00 (1)	—	—	—	—	—
4	-32.7	—	0.02 (1)	170.00 (1)	43.00 (1)	14.00 (1)	28.00 (1)	82.00 (1)	—	—	—	—	—
5	-27.6	—	0.00 (1)	170.00 (1)	43.00 (1)	15.00 (1)	28.00 (1)	86.00 (1)	—	—	—	—	—
6	-25.7	—	0.00 (1)	260.00 (1)	60.00 (1)	26.00 (1)	77.00 (1)	220.00 (1)	—	—	—	—	—
7	-21.0	8.11 (115)	0.06 (2)	224.20 (143)	56.38 (143)	20.23 (143)	45.44 (143)	167.18 (143)	—	—	—	—	—
8	-20.0	—	—	—	—	—	—	—	—	—	—	—	—
9	-15.9	—	0.00 (1)	250.00 (1)	58.00 (1)	26.00 (1)	80.00 (1)	250.00 (1)	—	—	—	—	—
10	- 9.5	—	0.00 (1)	260.00 (1)	60.00 (1)	26.00 (1)	73.00 (1)	240.00 (1)	—	—	—	—	—

(continued)

TABLE 33. (Continued)

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/l)(b)	Hardness (mg/l)	Calcium (mg/l)(b)	Magnesium (mg/l)(b)	Sodium (mg/l)(b)	Sulfate (mg/l)	Cadmium (μg/l)(b)	Chromium (μg/l)(b)	Arsenic (μg/l)(b)	Copper (μg/l)(b)	Lead (μg/l)(b)
11	- 4.4	—	0.00 (1)	260.00 (1)	59.00 (1)	27.00 (1)	79.00 (1)	250.00 (1)	—	—	—	—	—
12	1.3	—	—	—	—	—	—	—	—	—	—	—	—
13	1.6	8.37 (3)	—	—	—	—	—	—	—	130.00 (1)	—	—	—
14	2.5	8.05 (681)	0.10 (49)	230.50 (657)	56.91 (558)	21.12 (558)	48.44 (655)	167.32 (633)	1.62 (13)	1.67 (12)	0.85 (13)	2.42 (12)	3.08 (13)
14	2.5	8.74 (5)	—	—	—	—	—	—	5.71 (7)	10.71 (7)	—	10.14 (7)	11.14 (7)
15	3.2	8.30 (48)	0.08 (18)	228.33 (60)	55.48 (60)	21.80 (60)	53.82 (60)	176.15 (60)	2.23 (13)	0.77 (13)	1.15 (13)	1.92 (13)	6.62 (13)
16	12.4	8.49 (7)	—	—	—	—	—	—	—	—	—	—	—
17	24.8	8.58 (16)	—	—	—	—	—	—	—	—	—	—	—
18	28.9	8.52 (16)	—	—	—	—	—	—	—	—	—	—	—
19	37.1	8.49 (19)	—	—	—	—	—	—	—	—	—	—	—

(a) The number provided for each parameter represents the mean value; the following number in parentheses is the number of measurements on which the mean is based.

(b) Dissolved.

(c) Negative distances are upstream, positive distances are downstream.

TABLE 34. SURFACE WATER QUALITY PARAMETERS[a] IN RELATION TO DRINKING WATER INTAKE OF KEMMERER, LINCOLN COUNTY, WYOMING

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/l)[b]	Hardness (mg/l)	Calcium (mg/l)[b]	Magnesium (mg/l)[b]	Sodium (mg/l)[b]	Sulfate (mg/l)	Cadmium (μg/l)[b]	Chromium (μg/l)[b]	Arsenic (μg/l)[b]	Copper (μg/l)[b]	Lead (μg/l)[b]
1	-20.4[c]	—	0.09 (3)	164.00 (5)	50.80 (5)	9.26 (5)	2.00 (5)	22.20 (5)	—	—	—	—	—
2	3.0	7.69 (33)	—	250.00 (33)	69.85 (33)	—	16.27 (33)	112.67 (33)	0.08 (10)	3.00 (10)	1.40 (10)	1.40 (10)	1.90 (10)

(a) The number provided for each parameter represents the mean value; the following number in parentheses is the number of measurements on which the mean is based.

(b) Dissolved.

(c) Negative distances are upstream, positive distances are downstream.

TABLE 35. SURFACE WATER QUALITY PARAMETERS[a] IN RELATION TO DRINKING WATER INTAKE OF SHERIDAN, SHERIDAN COUNTY, WYOMING

Site Number	Distance from Water Intake (miles)	pH	Nitrate (mg/ℓ)[b]	Hardness (mg/ℓ)	Calcium (mg/ℓ)[b]	Magnesium (mg/ℓ)[b]	Sodium (mg/ℓ)[b]	Sulfate (mg/ℓ)	Cadmium (μg/ℓ)[b]	Chromium (μg/ℓ)[b]	Arsenic (μg/ℓ)[b]	Copper (μg/ℓ)[b]	Lead (μg/ℓ)[b]
1	-6.7[c]	7.31 (9)	0.54 (7)	11.74 (7)	3.60 (7)	0.70 (7)	1.03 (7)	0.70 (7)	—	—	—	—	—
2	0.9	7.77 (22)	0.37 (13)	29.65 (27)	7.84 (19)	2.14 (18)	1.59 (18)	5.02 (25)	—	—	—	—	—
3	9.7	7.83 (20)	—	—	—	—	—	—	—	—	—	—	—
4	10.6	7.82 (185)	0.01 (2)	315.05 (184)	59.21 (184)	40.59 (184)	28.61 (184)	146.55 (184)	0.92 (12)	1.67 (12)	0.25 (12)	2.38 (16)	2.88 (16)
5	21.1	—	—	—	—	—	—	—	—	—	—	—	—

(a) The number provided for each parameter represents the mean value; the following number in parentheses is the number of measurements on which the mean is based.

(b) Dissolved.

(c) Negative distances are upstream, positive distances are downstream.

TABLE 36. CHEMICAL ANALYSES OF FINISHED DRINKING WATER OF CRAIG, COLORADO

Parameter (units)	Date of Sampling[a]				
	April 4, 1974	June 8, 1972	July 20, 1977	September 21, 1978	November 16, 1976
AGGREGATES					
Turbidity (TU)	10	2.9	0.32	0.15	0.2
Color (Cobalt units)	0	5			3
Total Hardness as $CaCO_3$ (mg/l)	220	59	182		155
Phenolphthalein Alkalinity (mg/l)	0	4	0		0
Total Alkalinity (mg/l)	158	76	128		115
Dissolved Solids (mg/l)	565	147	340		240
Specific Conductance (μmhos)		268	600		480
CHEMICALS[b] (mg/l)					
Ammonia as N	0.12	0			0
Arsenic	0	0	0	<0.005	0
Boron	0.07	0.04			0.04
Calcium as $CaCO_3$	206	36	109		100
Chloride	16	6	15		15
Fluoride	0.25	0.3	0.95	0.6	0.5
Magnesium	3	6	18		12
Nitrate as N	0	0	0.13		0
Phosphate as P	0	0.03	0		0
Potassium			4		
Sodium	84	40	45		35
Sulfate	255	55	130		85

(continued)

TABLE 36. (Continued)

Parameter (units)	Date of Sampling[a] April 4, 1974	June 8, 1972	July 20, 1977	September 21, 1978	November 16, 1976
TOXIC METALS (mg/l)					
Barium			0	0	0
Cadmium	0	0	0	0	0
Chromium	0	0	0	0	0
Copper	0	0	0.5		0
Iron	0.3	0.05	0.07		0.1
Lead	0	0	0	0	0
Manganese	0	0.05	0.12		0
Mercury			0	0	0
Molybdenum	0				0
Selenium	0	0		<0.005	
Silver			0	0	0
Zinc	0.1	0	0.07		0

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Nontoxic metals and nonmetals.

TABLE 37. CHEMICAL ANALYSES OF FINSIHED DRINKING WATER OF HAYDEN, COLORADO

Parameter (units)	Date of Sampling[a] January 19, 1978	April 5, 1974	June 8, 1972	September 21, 1978	October 4, 1976	October 12, 1977
AGGREGATES						
Turbidity (TU)	2.5	4.8	3.9	2.0	3.1	2.0
Color (Cobalt units)		0	30		0	
Total Hardness of $CaCO_3$ (mg/l)		188	32		120	132
Phenolphthalein Alkalinity (mg/l)		0	0		0	
Total Alkalinity (mg/l)		124	44		110	100
Dissolved Solids (mg/l)		360	99		200	165
Specific Conductance (μmhos)		566	128		320	277
CHEMICALS[b] (mg/l)						
Ammonia as N		0.04	0		0	
Arsenic		0	0	<0.005	0	0
Boron		0.05	0.06		0	
Calcium as $CaCO_3$		188	20		80	34
Chloride		11	7		10	15
Fluoride		0.65	0.7	0.3	0.4	0.20
Magnesium		0	3		9	24
Nitrate as N		0	0		0.3	0
Phosphate as P		0	0.10		0	<0.03
Potassium						2
Sodium		33	17		20	17
Sulfate		140	25		40	39

(continued)

TABLE 37. (Continued)

Parameter (units)	Date of Sampling[a]					
	January 19, 1978	April 5, 1974	June 8, 1972	September 21, 1978	October 4, 1976	October 12, 1977
TOXIC METALS (mg/l)						
Barium				0	0	0
Cadmium		0	0	0	0	0
Chromium		0	0	0	0	0
Copper		0.14	0.05		0	<0.01
Iron		0.2	0.60		0.2	0.55
Lead		0	0	0	0	0
Manganese		0	0		0	0.06
Mercury			0.0003[c]		0	
Molybdenum		0			0	
Selenium		0	0	<0.005	0	
Silver				0	0	0
Zinc		0.5	0		0	<0.05

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Nontoxic and nonmetals.

(c) The mercury sample was taken June 7, 1978.

TABLE 38. CHEMICAL ANALYSES OF FINISHED DRINKING WATER OF RANGELY, COLORADO

Parameter (units)	Date of Sampling[a]			
	May 6, 1975	June 8, 1972	July 20, 1977	November 17, 1976
<u>AGGREGATES</u>				
Turbidity (TU)	0.81	37.0	0.62	11
Color (Cobalt units)	0	20		0
Total Hardness as $CaCO_3$ (mg/l)	272	170	446	275
Phenolphthalein Alkalinity (mg/l)	4	0	0	0
Total Alkalinity (mg/l)	190	108	256	180
Dissolved Solids (mg/l)	575	304	880	610
Specific Conductance (μmhos)	840	460	1410	800
<u>CHEMICALS[b] (mg/l)</u>				
Ammonia as N	0	0		0
Arsenic	0	0	0	0
Boron	0	0.08		0
Calcium as $CaCO_3$	188	119	221	170
Chloride	42	27	84	50
Fluoride	0.2	0.3	0.3	0.2
Magnesium	20	12	55	26
Nitrate as N	0	0	1.6	0
Phosphate as P	0	0.08	0	0
Potassium			6	
Sodium	75	41	122	85
Sulfate	189	105	340	180
<u>TOXIC METALS (mg/l)</u>				
Barium			0	0
Cadmium	0	0	0	0
Chromium	0	0	0	0
Copper	0	0	0	0
Iron	0	0.25	0	0.2
Lead	0	0	0	0
Manganese	0	0	0	0
Mercury			0	0
Molybdenum				0
Selenium	0.002	0		
Silver			0	0
Zinc	0.4	0	0	0

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Non-toxic metals and non-metals.

TABLE 39. CHEMICAL ANALYSES OF FINISHED DRINKING WATER OF CANON CITY, COLORADO

Parameter (units)	Date of Sampling[a] February 21, 1973	March 17, 1972	June 28, 1977	September 23, 1971	September 27, 1978	October 1, 1974	October 19, 1976
AGGREGATES							
Turbidity (TU)	3.0	3.0	0.2	6.1	0.15	0.43	0.14
Color (Cobalt units)		0	6	0		0	1
Total Hardness as $CaCO_3$ (mg/l)	128	133	100	131		149	150
Phenolphthalein Alkalinity (mg/l)	8	0	70	24		0	0
Total Alkalinity (mg/l)	104	100	140	112		108	90
Dissolved Solids (mg/l)	199	195	250	184		203	170
Specific Conductance (µmhos)	335	290	0	282		312	230
CHEMICALS[b] (mg/l)							
Ammonia as N	0	0	0	0.12		0	0
Arsenic	0	0	0	0	<0.005	0	0
Boron	0.04	0	0	0.16		0	0
Calcium as $CaCO_3$	96	101	70	99		10	105
Chloride	13	13	11	10		51	10
Fluoride	0.5	0.5	0.3	0.3	0.3	0.4	0.3
Magnesium	8	8	9	8		34	11
Nitrate as N	0	0	0.1	0		0	0.3
Phosphate as P	0.02	0.02	0	0		0	0
Potassium			2				
Sodium	15	14	7	25		14	10
Sulfate	39	40	40	45		0	40

(continued)

TABLE 39. (Continued)

Parameter (units)	Date of Sampling[a]						
	February 21, 1973	March 17, 1972	June 28, 1977	September 23, 1971	September 27, 1978	October 1, 1974	October 19, 1976
TOXIC METALS (mg/l)							
Barium			0		0		0
Cadmium	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0
Copper	0	0	0	0		0	0
Iron	0	0	0	0.73		10	0.4
Lead	0	0	0	0	0	0	0
Manganese	0	0	0	0		0	0
Mercury			0		0		0
Molybdenum			0			0	0
Selenium	0	0		0		0	
Silver			0		0		0
Zinc	0	0.05	0	0		0	0

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Nontoxic metals and nonmetals.

TABLE 40. CHEMICAL ANALYSES OF FINISHED DRINKING WATER OF STEAMBOAT SPRINGS, COLORADO

Parameter (units)	Date of Sampling[a] February 20, 1974	June 9, 1972	July 22, 1977	September 22, 1978	October 4 1976
AGGREGATES					
Turbidity (TU)	2.5	8.5	0.29	0.35	0.3
Color (Cobalt units)	10	30			13
Total Hardness as $CaCO_3$ (mg/l)	24	20	16		16
Phenolphthalein Alkalinity (mg/l)	0	0	0		0
Total Alkalinity (mg/l)	36	16	8		24
Dissolved Solids (mg/l)	35	25	20		30
Specific Conductance (µmhos)	40	22	40		30
CHEMICALS[b] (mg/l)					
Ammonia as N	0.04	0			0
Arsenic	0	0	0	<0.005	0
Boron	0	0.05			0
Calcium as $CaCO_3$	16	8	12		10
Chloride	9	5	5		5
Fluoride	1.2	1.1	0.17	0.2	0.1
Magnesium	2	3	1		1
Nitrate as N	0.23	0	0.46		0.6
Phosphate as P	0	0.05	0		0
Potassium			2		
Sodium	3	1	2		5
Sulfate	2	5	<5		5

(continued)

TABLE 40. (Continued)

Parameter (units)	Date of Sampling[a] February 20, 1974	June 9, 1972	July 22, 1977	September 22, 1978	October 4 1976
TOXIC METALS (mg/l)					
Barium			0	0	0
Cadmium	0	0	0	0	0
Chromium	0	0	0	0	0
Copper	0.65	0	0.1		0.1
Iron	0.4	0.60	0.10	.	0.2
Lead	0	0	0	0	0
Manganese	0	0	0		0
Mercury			0	0	0
Molybdenum	0				0
Selenium	0	0		<0.005	0
Silver			0	0	0
Zinc	0.14	0.30	0.02		0

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Nontoxic metals and nonmetals.

TABLE 41. CHEMICAL ANALYSES OF FINISHED DRINKING WATER OF GREEN RIVER AND ROCK SPRINGS, WYOMING

Parameter (units)	Date of Sampling[a]	
	February 9, 1978	March 1, 1979
AGGREGATES		
Turbidity (TU)	2.30	
Color (Cobalt units)		5.0
Total Hardness as $CaCO_3$ (mg/l)	230.0	
Phenolphthalein Alkalinity (mg/l)		
Total Alkalinity (mg/l)		
Dissolved Solids (mg/l)	403.6	369.0
Specific Conductance (umhos)	621	
CHEMICALS[b] (mg/l)		
Ammonia as N		
Arsenic	<0.001	<0.001
Boron	0.06	
Calcium as $CaCO_3$	57.6	
Chloride	12.0	8.0
Fluoride	0.23	0.21
Magnesium	20.64	
Nitrate as N	0.03	0.54
Phosphate as P		
Potassium	1.948	
Sodium	53.0	
Sulfate	172.0	156.0
TOXIC METALS (mg/l)		
Barium	0.04	0.10
Cadmium	<0.001	<0.001
Chromium	<0.001	<0.001
Copper	0.006	0.008
Iron	0.119	0.052
Lead	<0.001	<0.001
Manganese	0.002	0.016
Mercury	<0.0002	<0.0002
Molybdenum		
Selenium	<0.001	<0.001
Silver	<0.001	<0.001
Zinc	0.367	0.018

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Nontoxic metals and nonmetals.

TABLE 42. CHEMICAL ANALYSES OF FINISHED DRINKING WATER OF KEMMERER, WYOMING

Parameter (units)	Date of Sampling[a] June 16, 1978	October 3, 1973
AGGREGATES		
Turbidity (TU)		
Color (Cobalt units)		
Total Hardness as $CaCO_3$ (mg/l)		143
Phenolphthalein Alkalinity (mg/l)		
Total Alkalinity (mg/l)		
Dissolved Solids (mg/l)		626
Specific Conductance (μmhos)		284
CHEMICALS[b] (mg/l)		
Ammonia as N		
Arsenic	<0.005	<0.007
Boron		0.03
Calcium as $CaCO_3$		35
Chloride		4.6
Fluoride	0.6	0.1
Magnesium		44
Nitrate as N	0	0.2
Phosphate as P		
Potassium		0.9
Sodium		5.3
Sulfate		14
TOXIC METALS (mg/l)		
Barium	<0.5	<0.5
Cadmium	<0.001	<0.001
Chromium	<0.01	<0.01
Copper		0.04
Iron		0.1
Lead	<0.01	<0.01
Manganese		<0.05
Mercury	<0.001	
Molybdenum		
Selenium	<0.005	<0.001
Silver	<0.01	<0.05
Zinc		0.04

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Nontoxic metals and nonmetals.

TABLE 43. CHEMICAL ANALYSES OF FINISHED DRINKING WATER OF SHERIDAN, WYOMING

Parameter (units)	Date of Sampling[a] January 19, 1978	February 14, 1973	June 2, 1967	December 9, 1967
AGGREGATES				
Turbidity (TU)				
Color (Cobalt units)				
Total Hardness as $CaCO_3$ (mg/l)		38		42
Phenolphthalein Alkalinity (mg/l)				
Total Alkalinity (mg/l)				
Dissolved Solids (mg/l)		150		118
Specific Conductance (μmhos)		213		
CHEMICALS[b] (mg/l)				
Ammonia as N				
Arsenic	<0.1	<0.007		0.01
Boron		0.12		
Calcium as $CaCO_3$		10	4.6	
Chloride		45	0	0
Fluoride	0.1	0.1		0.4
Magnesium		2.9	3.6	4
Nitrate as N	1.8	0.09	0.07	0
Phosphate as P				
Potassium	0.9	0.7		
Sodium		25	1.6	
Sulfate		4.1	4.8	8

(continued)

TABLE 43. (Continued)

Parameter (units)	Date of Sampling[a] January 19, 1978	February 14, 1973	June 2, 1967	December 9, 1967
TOXIC METALS (mg/l)				
Barium	<0.5	<0.5		0
Cadmium	<0.001	<0.001		0.001
Chromium	<0.01	<0.01		0.001
Copper		<0.01		0
Iron		0.1		0.5
Lead	<0.01	<0.01		0.004
Manganese		<0.05		0
Mercury	<0.001			
Molybdenum				
Selenium	<0.005	<0.001		0.01
Silver	<0.05	<0.05		0.0002
Zinc		0.05		0.1

(a) Sampling dates are in order within the calendar year to convey any seasonal trends.

(b) Nontoxic metals and non metals.

TABLE 44. AVERAGE DRINKING WATER QUALITY PARAMETERS IN STUDY SITE CANDIDATES[a]

Community	Hardness (mg/l)	Calcium (mg/l)[b]	Magnesium (mg/l)[b]	Sodium (mg/l)[b]	Sulfate (mg/l)[b]
			STUDY COMMUNITIES		
Craig	129.00(4)	112.75(4)	9.75(4)	51.00(4)	131.25(4)
Hayden	100.80(4)	68.40(4)	7.80(4)	20.80(4)	53.80(5)
Rangely	290.75(4)	174.5(4)	28.25(4)	80.75(4)	203.5(4)
			CONTROL COMMUNITIES		
Canon City	131.83(6)	80.17(6)	13.00(6)	14.17(6)	34.00(6)
Steamboat Springs	19.00(4)	11.50(4)	1.75(4)	2.75(4)	3.00(4)
Green River and Rock Springs	230.00(1)	57.60(1)	20.64(1)	53.00(1)	164.00(2)
Kemmerer	143.00(1)	35.00(1)	11.0(1)	5.30(1)	14.00(1)
Sheridan	40.00(2)	7.30(2)	3.5(3)	13.3(2)	5.63(3)

(continued)

TABLE 44. (Continued)

Community	Cadmium (μg/l)[b]	Chromium (μg/l)[b]	Arsenic (μg/l)[b]	Copper (μg/l)[b]	Lead (μg/l)[b]
		STUDY COMMUNITIES			
Craig	0(5)	0(5)	0(5)	125.0(4)	0(5)
Hayden	0(5)	0(5)	0(5)	47.5(4)	0(5)
Rangely	0(4)	0(7)	0(7)	0(6)	0(7)
		CONTROL COMMUNITIES			
Canon City	0(7)	0(5)	0(5)	212.50(4)	0(5)
Steamboat Springs	0(5)	0(4)	0(4)	0(4)	0(4)
Green River and Rock Springs	<1(2) 3)	0.33(3)	3.33(3)	0(2)	1.33(3)
Kemmerer	<1(2)	<1(2)	<1(2)	7.00(2)	<1(3)
Sheridan	0.33(3)	<10(2)	<6(2)	40.00(1)	<10(2)

(a) The number provided for each parameter represents the mean value; the following number in parentheses is the number of measurements on which the mean is based.

(b) Dissolved.

drinking water were not done at regular or frequent intervals making this information adequate only for general comparisons.

One area of concern which was investigated in only a cursory manner is the relationship between surface water quality and drinking water quality. The treatment processes utilized by public water suppliers are quite variable (see Appendix D) and the effect of these processes on specific water constituents is often uncertain. Using the surface and drinking water information for the nine study site candidates (eight water supplies), rank-order correlations were computed (Table 45). Although the data is very sparse, there is some indication that minerals are transmitted from surface waters to drinking water. Unfortunately, there are too few data to draw any inferences about trace elements.

In order to determine the relative positions of the surface water monitoring sites, the drinking water intakes, and the mines, these three items were plotted on detailed county maps. This illustrated whether the mining was upstream or downstream from the drinking water intake and the relative positions of monitoring sites and coal mining.

Criteria for Comparison of Candidates

Although the nine remaining study site candidates are homogeneous, in that they were carefully selected to meet several criteria, significant differences remain. Additional considerations were specified in order to further reduce the list of candidate communities. It should be noted that many of these considerations have elements of subjectivity, and the researchers' judgments (based on all available empirical data) were used.

Quantity of Coal Mining--

Although all nine sites are potentially impacted by coal mining, there is great variability in the annual coal tonnage produced in the areas. The communities impacted by the greater rate of coal production are obviously more desirable for study. Since mining serves as an indirect measure of a potential exposure, more intense mining would be expected to produce greater effects on the community's residents. Since the linkages from mining to water pollution and from water pollution to health are tenuous, the study sites should be selected to maximize the probability of detecting these effects.

Relative Importance of Coal Mining to the Community's Economy--

This factor is related to the size of the town, the quantity of the mining, the proximity of mining to the town, and other economic activities in the area. A given production level (tons of coal mined per year) has different implications for a town of 1,000 than for a town of 15,000. Also competing economic activities (e.g., recreation) would tend to dilute the importance of coal mining. Although epidemiologic studies require large populations to obtain reliable disease rates, in this instance a small population with few non-coal economic activities is most desirable because small communities would be more intensively impacted by coal mining

TABLE 45. RANKS AND CORRELATIONS OF SURFACE WATER AND DRINKING WATER CONSTITUENTS IN THE STUDY SITE CANDIDATES[a]

Community	Hardness[b]		Calcium[b]		Magnesium[b]		Sodium[b]		Sulfate[b]		Cadmium[c]	
	S[d]	D[e]	S	D	S	D	S	D	S	D	S	D
STUDY COMMUNITIES												
Craig, CO	115(6)	129(5)	30(7)	113(2)	9.8(5)	9.8(5)	21(3)	51(3)	39(5)	131(3)	0.4	0
Hayden, CO	140(4)	101(6)	33(5)	68(4)	13.0(3)	7.8(6)	20(4)	21(4)	68(4)	54(4)	0.4	0
Rangely, CO	278(1)	291(1)	70(1)	175(1)	24.7(1)	28.3(1)	63(1)	81(1)	167(2)	203(1)	1.0	0
CONTROL COMMUNITIES												
Canon City, CO	120(5)	132(4)	33(4)	80(3)	8.5(7)	13.0(3)	11(6)	14(5)	31(6)	34(5)	--	0
Steamboat Springs, CO	115(7)	19(8)	31(6)	12(7)	9.9(4)	1.8(8)	10(7)	3(8)	1(8)	3(8)	0.4	0
Green River/Rock Springs, WY	230(3)	230(2)	57(3)	58(5)	21.1(2)	20.6(2)	48(2)	53(2)	167(1)	164(2)	1.6	0
Kemmerer, WY	250(2)	143(3)	70(2)	35(6)	9.3(6)	11.0(4)	16(5)	5(7)	113(3)	14(6)	0.8	0
Sheridan, WY	30(8)	40(2)	8(8)	7(8)	2.1(8)	3.5(7)	2(8)	13(6)	5(7)	6(7)	0.9	0.33
	r_s[f] = .88,		r_s = .43		r_s = .45		r_s = .88		r_s = .81		____[g]	
	$p<.01$		$p<.20$		$p<.20$		$p<.01$		$p<.02$			

(continued)

TABLE 45. (Continued)

Community	Chromium[c] S	Chromium[c] D	Arsenic[c] S	Arsenic[c] D	Copper[c] S	Copper[c] D	Lead[c] S	Lead[c] D
STUDY COMMUNITIES								
Craig, CO	2.2	0	0.3(6)	0	2.0(5)	125(2)	1.4	0
Hayden, CO	20.0	0	1.0(3)	0	1.2(7)	48(3)	1.6	0
Rangely, CO	5.4	0	1.6(1)	0	2.3(4)	0(7)	4.1	0
CONTROL COMMUNITIES								
Canon City, CO	--	0	--	0	--	0(7)	--	0
Steamboat Springs, CO	--	0	0.3(6)	0	2.4(2)	213(1)	0.8	0
Green River/Rock Springs, WY	1.7	0	0.9(4)	0	2.4(1)	7(5)	3.1	0
Kemmerer, WY	3.0	0	1.4(2)	0	1.4(6)	40(4)	1.9	0
Sheridan, WY	1.7	0.33	0.3(6)	3.33	2.4(3)	0(7)	2.9	1.33
	___(g)		___(g)		r_s=-.27 p<.20		___(g)	

(a) Each value provided is the mean measurement and the number which follows in parentheses is the rank-order of that measurement.
(b) Measured in mg/l.
(c) Measured in μg/l.
(d) Surface water values taken from the monitoring site closest to the community's drinking water intake.
(e) Drinking water values.
(f) Spearman rank-order correlation coefficient.
(g) Insufficient variability among drinking water measurements to derive ranks.

activities and competing economic production would tend to dilute the effects of coal mining. The chosen sites should experience as intense and undiluted an impact of coal mining as possible.

Clarity of Water-Impacted Areas--

Although the categorization of communities as study or control sites is presented as a dichotomy, the actual status of some communities is somewhere between these extremes. To emphasize differences in community health based on mining/water impacts, the study sites should fall neatly into one category or the other, and not be ambiguous on this criterion.

Quality of Water Monitoring--

Surface water monitoring activities in the western coal mining areas under consideration are quite variable both in the number of monitoring stations and in the chemicals analyzed. Obviously, it is desirable to have monitoring stations close to the drinking water intakes and to have those stations analyzing such constituents as toxic metals in addition to usual water parameters.

Presence of Air Monitoring--

There is some variability among the nine sites in the extent of air quality sampling. It is advantageous for a community to have air quality data available, in part because air quality may be affected by surface mining. In addition, an epidemiologic survey should take air pollution exposures into account as a significant influence on health.

Proximity to Control Sites--

The spatial arrangement of the nine study site candidates indicates a cluster of communities (northwestern Colorado and southwestern Wyoming) with two distant sites (Canon City, Colorado, and Sheridan, Wyoming). Choices within the cluster are preferred since exposed and control sites (in terms of mining/water impacts) can be close to one another. This allows for matching of the two communities in terrain, climate, etc., and also would facilitate travel between them as required in an epidemiologic field study.

Availability of Other Information--

Several detailed studies of western coal areas have been completed, and communities surveyed in such research documents are preferable. The level of detail is variable, but often such topics as environmental quality, socioeconomic character of the area, and projected changes consequent to coal mining are covered. This criterion is based not on inherent characteristics of the communities, but rather on the pragmatic advantage of being able to utilize the material compiled by others.

Presence of Coal-Utilizing Facilities--

Since coal-utilizing facilities have their own potential environmental and health impacts, it is important that their presence be noted in site selection. Whether this factor increases or decreases desirability of a site is not, however, entirely clear.

Because coal burning pollutes the air and water through stack releases and leaching of bottom ash, the presence of such facilities makes isolation of mining-based pollutant effects quite difficult. However, mine-mouth electricity production is increasingly common at large western coal mines. In fact, many of the large expansions are linked to coal-burning power plant construction. Thus mining areas with coal-utilizing facilities would suffer from greater difficulty in isolating mining effects but be better representatives of the expanding western coal mining areas.

Community Profiles

The following sections provide an overview of the information readily available on the nine study site candidates. These descriptions include objective information on geographic and demographic characteristics as well as subjective evaluations of the data quality (i.e., quantity of coal mining, relative importance of coal mining, etc.). Table 46 provides a categorical representation of each of those factors for all the communities. Although such simplified schemes sacrifice some detail, it does provide a summary of community profiles. Greater detail can be found in the text which follows.

Craig, Moffat County, Colorado--

The 1975 population of Craig, Colorado, was 5,426. The annual population growth rate from 1970 to 1975, 5.5 percent, was somewhat higher than the growth rate for the entire state (2.9 percent). The per capita income in Craig is $4,833, considerably higher than the state average of $4,030. Moffat County is located in the northwest corner of Colorado, and approximately two-thirds of its inhabitants reside in Craig. The median age in the county is 31.1 years, 10.5 percent of the residents being over 65. More than 99 percent of the population is white.

Mining activity which would potentially have an impact on Craig's water is located between 25 and 50 miles upstream in Routt County (east of Craig). There are 18 mines in this area, 11 of them surface. They are all medium size mines, each providing around one million tons per year. Projections of future production are similar to levels of current production. The distance between the mining activity and Craig's water intake would greatly dilute any impacts that the mining might have on the drinking water quality. This detracts from Craig's attractiveness as a study site, since its status with respect to potential exposure would be somewhat tenuous. There are additional mines downstream from Craig, approximately eight to ten miles southwest of town in Moffat County. Two of these are surface and one is underground. An additional surface mine exists 28 miles southwest of Craig. These are currently small producers (0.25 - 0.4 million tons per year) with plans for up to three million tons by 1980.

Colorado Ute Electric Association has plans for start-up of a large (350 - 1,520 Megawatts) coal-fired electric generating facility just south of Craig. This would be a major additional source of pollution, possibly confounding and/or camouflaging impacts from mining pollution. This will make mining impacts extremely difficult to detect if the facility is at the

TABLE 46. RATING OF CANDIDATE STUDY SITES ON SELECTION CRITERIA[a]

Criteria[b]	STUDY COMMUNITIES			CONTROL COMMUNITIES	
	Craig, CO	Hayden, CO	Rangely, CO	Canon City, CO	Steamboat Springs, CO
Quantity of Coal Mining (0 = little, 1 = very much)	1	1	0	0	1
Relative Importance of Coal Mining (0 = minor importance, 1 = major importance)	1	1	0.5	0	0
Clarity of Mining/Water Impact Status (0 = uncertain, 1 = very clear)	0.5	1	0.5	1	1
Quality of Water Monitoring Data (0 = poor, 1 = excellent)	1	0.5	0.5	0	0
Quality of Air Monitoring Data (0 = none, 1 = some)	1	1	1	1	1
Proximity to Other Sites (0 = near, 1 = distant)	1	1	1	0	1
Availability of Other Information Sources (0 = not available, 1 = available)	1	1	1	0	1
Presence of Coal-Burning Power Plant (0 = present, large; 0.5 = present, small; 1 = absent)	0	0	0.5	1	1

(continued)

TABLE 46. (Continued)

Criteria(b)	CONTROL COMMUNITIES		
	Kemmerer, WY	Rock Springs, WY	Sheridan, WY
Quantity of Coal Mining (0 = little, 1 = very much)	1	1	1
Relative Importance of Coal Mining (0 = minor importance, 1 = major importance)	1	0	1
Clarity of Mining/Water Impact Status (0 = uncertain, 1 = very clear)	1	1	1
Quality of Water Monitoring Data (0 = poor, 1 = excellent)	0.5	1	0.5
Quality of Air Monitoring Data (0 = none, 1 = some)	0	1	1
Proximity to Other Sites (0 = near, 1 = distant)	1	1	0
Availability of Other Information Sources (0 = not available, 1 = available)	1	1	0.5
Presence of Coal-Burning Power Plant (0 = present, large; 0.5 = present, small; 1 = absent)	0	0.5	0.5

(a) Details of the criteria can be found in the text.

(b) All items are scaled with larger values indicative of greater desirability.

mine mouth and/or located upstream from the drinking water intake. Agriculture is the only other activity which contributes significantly to the economy.

Surface water quality monitoring is fairly thorough on the Yampa River near Craig. There are three monitors within 11 miles of town, all of which measure several mineral parameters and toxic metals. There are many additional monitors on the river further downstream. The air quality monitor in Craig measures nitrates and sulfates as well as total suspended particulates (TSP) and benzene soluble organic fraction (BSOF). Overall, the environmental quality monitoring is relatively comprehensive in Craig as compared to other communities under consideration.

Review of other data sources pertaining to this area indicates that the United States Bureau of Land Management has published an Environmental Impact Statement and Supplement concerning northwestern Colorado (U.S. Dept. of the Interior, 1976). This region includes Craig, Hayden, Steamboat Springs, and Rangely. This document would be valuable in identifying features of the community pertinent to an epidemiological study, such as current environmental quality and socioeconomic characteristics.

Craig is located in the cluster of candidate communities in northwestern Colorado and southwestern Wyoming. Therefore, it would be well matched with other communities within this cluster in terms of climate, geography, etc. Also, it would be easily accessible from any of the other communities except Sheridan, Wyoming, and Canon City, Colorado.

In summary, Craig's only major detriment is that it is not close to the mining activity that would potentially impact its drinking water supply, tending to dilute its status as a study vs. a control site. The mining in the area does constitute a significant portion of the community's economy, its major competitors being agriculture and electricity generation. The environmental monitoring activity is comparatively good. It is in a favorable location relative to other potential study sites, and the United States Bureau of Land Management's Comprehensive Environmental Impact Statement would be quite useful.

Hayden, Routt County, Colorado--

Routt County is located in northwestern Colorado. The county population is almost exclusively white (over 99 percent). The median age in the county is 28.5 years; this is fairly typical of the eight communities under consideration. Hayden, with a population of 1,338 in 1975, is located in the west-central portion of the county. It grew very rapidly between 1970 and 1975 (14.4 percent annually). The per capita income in the community, $5,492, is relatively high compared to the other mining communities and the state as a whole.

As was mentioned in the discussion of Craig, there are 18 mines in Routt County. All but three of these mines are located between 0.5 and three miles upstream from Hayden on the Yampa River drainage system. Nine of those mines on the Yampa River drainage system are surface. The other three mines, two surface and one underground, are approximately one and one-half miles south of Craig. Currently, the mines in the county produce around ten million tons per year. Production is estimated to increase to 15 million tons per year by the early 1980's.

Other industries which contribute significantly to the economy of Routt County are agriculture, coal-based electricity production, and recreation. There is a great deal of nearby mining which is directly upstream of Hayden's drinking water supply. However, these impacts might be hidden or confounded by pollution from the generating facility, if it is upstream from the community. Often these facilities are built at the mine mouth, and waste products are stored in piles that would be vulnerable to leaching toxic substances into the water. Air pollution from the generating facility would also have a potential impact on the health of the residents. In addition, the generating facility is a significant competitor for the town's labor resources.

All surface water quality parameters of interest are monitored eight miles upstream and two miles downstream from Hayden. There are a number of other monitors at various intervals upstream, but there is no regularity to the measurements taken. A monitor 0.3 miles downstream analyzes for all the toxic metals of interest. The air quality monitor in the area analyzes for only TSP and BSOF. The overall environmental surveillance seems adequate relative to other communities.

Hayden is in a location that would be easily accessible from all the other communities under consideration except Sheridan, Wyoming, and Canon City, Colorado. This would facilitate travel among study sites and matching of communities.

The Northwest Colorado Environmental Impact Statement and Supplement by the United States Bureau of Land Management (U.S. Dept. of the Interior, 1976) provides much information concerning Hayden that would be useful in planning an epidemiological study.

From these criteria it appears that Hayden would be a desirable study site. The only major potentially negative factor that must be considered is the influence of a large electric generating facility.

Rangely, Rio Blanco County, Colorado--

Rio Blanco County is located in northwestern Colorado, and Rangely is located in the northwestern part of the county. Approximately two-thirds of its 5,349 inhabitants reside in the two communities of Meeker and Rangely. The population is almost 99 percent white and somewhat younger than the population in the other communities under consideration (the median age being 26.9 years). Rangely's population of 1,792 (1975) residents increased at an annual rate of 2.4 percent between 1970 and 1975. This growth rate is slightly lower than that for the state of Colorado as a whole. Per capita income in Rangely is $4,526.

There are three identified mines in Rio Blanco County. Only one of these mines is in the vicinity of Rangely. This mine is approximately five miles upstream from Rangely, situated on a major tributary of the White River. It is expected to increase its production gradually with a goal of 3.7 million tons per year by 1990. Included in this mining complex are two underground and one surface mine. Two other mines are located in the eastern portion of the county near Meeker. Other energy-related activities near Rangely may include an oil shale mine and plant and a coal-fired electricity generating facility. Plans for both of these operations are tentative with indefinite start-up dates. At the present time, mining and agriculture are the only major economic activities in Rio Blanco County.

The only surface water monitor which would provide information useful for a study is four miles upstream from Rangely, between the community's water intake and the mine. This monitor is analyzing all pertinent parameters except nitrates. There are other monitors on the White River, but they are too far upstream from Rangely to be of use. The air quality monitor in the vicinity of Rangely is providing information on nitrates and sulfates as well as TSP and BSOF. Overall, the environmental quality information is adequate relative to other sites, although it would be useful to have surface water quality data from directly upstream of the mine.

The cluster of communities in northwestern Colorado and southwestern Wyoming includes Rangely. Therefore, Rangely would be readily accessible from any of these communities and fairly well matched with them in terms of such parameters as altitude, geography, and climate. Rangely is also included in the Environmental Impact Statement covering northwestern Colorado by the United States Bureau of Land Management (U.S. Dept. of the Interior, 1976).

In summary, Rangely's status as a study community is adequately clear, although a larger amount of mining would have a greater and thus more readily detectable impact. There is little other activity in the area to confound the study as the plans for oil shale mining and electricity production are very tentative and are not expected to be pursued in the near future. The environmental data is not as complete as would be desired. There is published information available concerning the area, and it is close to most of the other communities under consideration.

Canon City, Fremont County, Colorado--

Canon City is a community with approximately 13,000 residents located in central Colorado. Between 1970 and 1975 its population grew at an annual rate of 3.1 percent, which is very similar to the growth rate for the entire state of Colorado (2.9 percent). The per capita income was only $3,658 in 1974, lower than the state average of $4,030. Fremont County has a population which is fairly old (median age of 35.9) and almost exclusively white (98.2 percent). Approximately half the residents of Fremont County live in Canon City. Mining activities in the vicinity of Canon City are concentrated approximately ten miles to the southeast, directly south of Florence and east of the San Isabel National Forest. A total of ten mines were determined to be active in the area according to the sources described earlier. There is approximately an even mix of surface and underground mines and all are of moderate size. The largest estimated annual tonnage for any mine is 0.07 million tons, and both current and future total annual tonnages for the region are only 0.1 million tons. This makes Canon City one of the least desirable sites in terms of coal production. Furthermore, the population is large (for this part of the state) and somewhat distant from the mines. According to the criteria outlined earlier, both of these factors tend to dilute the impact of coal mining, and thus discourage selection of Canon City as a study site.

Canon City's designation as being free of coal mining impacts on drinking water is quite clear. The drinking water intake is located a short distance upstream from town on the Arkansas River, while drainage from the mined areas enters the Arkansas River more than five miles downstream from Canon City.

Water quality monitoring on the Arkansas River near Canon City is rather poor. Although there are three monitors within ten miles, and one within one mile, none analyze for toxic metals. Only the most basic mineral characteristics of the water are reported. An air quality monitor located in Canon City records TSP (total suspended particulates) and BSOF (benzene soluble organic fraction).

Relative to other study site candidates, Canon City is isolated. The nearest community on the list is over 200 miles away, which would be a major inconvenience in executing a field study of Canon City and another community.

Finally, a search for other data sources specifically relevant to the Canon City area produced virtually no information. This seems to reflect the impression that this part of the west is not a critical element in coal energy development.

Overall, the only major desirable features of Canon City as an investigation site are the clarity of its designation as a control site and presence of an air quality monitor. The undesirable features include relatively distant and small coal mines, large population, little surface water analysis, and absence of any useful site-specific studies.

Steamboat Springs, Routt County, Colorado--

Steamboat Springs is located in the east-central portion of Routt County which is in northwestern Colorado. The median income in Steamboat Springs, $6,219, is substantially higher than that in the other communities under consideration as well as the state as a whole. The population of the community grew 5.5 percent annually between 1970 and 1975. Routt County's population is almost exclusively white (over 99 percent). The age distribution in the county is similar to that for most of the other communities, the median age being 28.5 years with 9.7 percent of the population over 65.

There is extensive mining in Routt County approximately one to three miles west (downstream) of Steamboat Springs. Consequently, its status as a control community is unequivocal. The mines in the county are currently producing approximately ten million tons per year, and it is estimated that they will be producing 15 million tons per year by the early 1980's. A significant proportion of the economy in Steamboat Springs is derived from the recreation business, as the community is basically a ski resort area. The relatively transient population in resort areas makes them undesirable candidates for an epidemiologic study. Agriculture also has a significant role in the economic activities of the area.

Steamboat Springs takes its public water supply from the Fish Creek, a tributary of the Yampa River. There is a monitoring station on Fish Creek approximately two miles downstream from the community's water intake. The monitor is located just upstream from the confluence of the two streams. This monitor is measuring only three of the water quality parameters under consideration: pH, nitrates, and sulfates. There are numerous monitoring sites on the Yampa River downstream from Steamboat Springs. However, since the Fish Creek is not a major tributary of the river, information provided by Yampa River monitors would not provide information specific to this community. Air quality parameters measured in the area of Steamboat Springs are nitrates, sulfates, TSP, and BSOF.

The Northwestern Colorado Environmental Impact Statement by the United States Bureau of Land Management (U.S. Dept. of the Interior, 1976) contains information concerning the area of Steamboat Springs that would be very useful in designing and implementing an epidemiologic study. In addition, Steamboat Springs is in a favorable location relative to most of the other communities under consideration, as part of the cluster of communities in northwestern Colorado and southwestern Wyoming.

Although there are several factors concerning Steamboat Springs that make it attractive as a control site (location, amount and location of mining, availability of supplemental data), there are also conditions which are undesirable in epidemiological studies, most specifically the transient population consequent to the resort activity.

Green River, Sweetwater County, Wyoming--

Sweetwater County is in the southwestern portion of Wyoming. Its population is 97.5 percent white, and the age distribution of the population is similar to that of the other areas under consideration as study sites, the median age being 28.9 years with 9.6 percent of the population over 65. Most of the 30,000 residents of Sweetwater County live in either Green River or Rock Springs. Green River's population in 1975 was 7,423. The community grew rapidly between the years of 1970 and 1975 (almost 15 percent annually). The median income in 1974 was $4,937, which is somewhat higher than the median income for the state as a whole ($4,566).

There are three surface mines in Sweetwater County which will have an estimated production of approximately 13 million tons per year by 1984. Three underground mines in the county will not be contributing significantly to this production. The mining is located east of Green River in the central part of the county (one mine being located in the extreme eastern part of the county). The drainage from all the mining areas flows into completely different systems of streams than the one from which Green River takes its water supply. Consequently, the drinking water in this community will not be impacted by the mining. Mining is the primary economic activity in the county; manufacturing and agriculture also contribute substantially. The percent of the county population employed in mining, manufacturing, and agriculture is 19.2, 8.1, and 3.8 percent, respectively, with 38.0 percent of the total county population employed.

The water monitoring activity on the Green River (from which the community of Green River takes its public water supply) is satisfactory. The dissolved minerals of interest (calcium, magnesium, sodium, and sulfate) are measured 4.4 miles upstream and 2.5 miles downstream from the intake point. The monitor 2.5 miles downstream also provides data on the toxic metals of interest (cadmium, chromium, arsenic, copper, and lead). Information on these metals from upstream is only provided by a monitor 50 miles away. There are many other monitors both upstream and downstream which are analyzing for the minerals of interest. Total suspended particulates (TSP) is the only relevant air quality parameter which is being measured in the vicinity of Green River.

There are two sources of supplemental information on Green River: the Southwestern Wyoming Environmental Impact Statement by the United States Bureau of Land Management (U.S. Dept. of the Interior, 1978) and United States Geological Survey Hydrology and Economic Development Report (Lowham et al., 1976). This information would prove very useful in designing and implementing an epidemiologic study.

Another desirable feature of the Green River area is that it is part of the cluster of communities in southwestern Wyoming and northwestern Colorado. Therefore, it would be easily accessible from all of the other communities under consideration except Sheridan, Wyoming, and Canon City, Colorado.

A negative influence on Green River's desirability as a control site for an epidemiologic study is its size. Its population is more than twice as large as most of the other communities under consideration. This is also reflected in the percentage of the county population employed in manufacturing. The extent of the impact of community size and the manufacturing industry will depend on the type and amount of manufacturing located within the community. An industry with extensive pollution potential would be a problem in that impacts of this pollution would camouflage the presence or absence of mining impacts.

Kemmerer, Lincoln County, Wyoming--

Lincoln County is located in the southwest corner of Wyoming. Its population of approximately 10,000 residents is almost 100 percent white and somewhat younger than the population of other areas under discussion, the median age being 26.7 years. Kemmerer is located in the south-central portion of the county. The population of Kemmerer grew at a rate of 3.0 percent annually between 1970 and 1975 to reach a 1975 population of 2,658.

Its per capita income in 1974 was $4,478. Both Kemmerer's growth rate and per capita income are very close to those figures for the state as a whole (2.6 percent and $4,566, respectively).

There are four large surface mines in Lincoln County 6-12 miles southwest of Kemmerer. The drainage from the mined area enters the stream supplying Kemmerer's drinking water downstream from the intake point. Thus, Kemmerer is clearly not mining/water impacted. The current production of 4 million tons per year is expected to increase to 9 1/2 million tons per year in the near future. Agriculture is the other major economic activity in the area of Kemmerer. There is a coal-based electricity generating facility in the vicinity of Kemmerer, which is expected to double its output in the near future. This additional source of pollution would make isolation of mining impacts difficult if the facility is upstream from the intake for the community's water supply. In such a location, the facility would have a potential impact on the water supply that would be labeled "nonimpacted" for the purposes of the study.

There are two surface water quality monitors near Kemmerer; one is 20 miles upstream and one is 3 miles downstream. Neither monitor analyzes all the parameters of interest. The monitor upstream provides information on all the minerals but none on toxic metals. The other provides data on all the toxic metals and most of the minerals. There is no air quality monitoring activity in the area.

There are two useful sources of information and data specific to Kemmerer. These include the Southwestern Wyoming Evironmental Impact Statement by the U.S. Bureau of Land Management (U.S. Dept. of the Interior, 1978), U.S. Geological Survey Hydrology and Economic Development Report (Lowham et al., 1976). Information provided in these documents would be extremely useful in designing and implementing an epidemiological study.

Kemmerer is located in a position relative to the other communities that make it easily accessible from all areas except Sheridan, Wyoming and Canon City, Colorado.

Although the environmental monitoring in the area of Kemmerer is not completely satisfactory, it alone would not be a basis for exclusion. However, the question of the effect of the electricity generating facility is extremely important and needs to be examined further. Other factors such as the amount of mining and the availability of supplemental information are positive influences in Kemmerer's desirability as a study site.

Rock Springs, Sweetwater County, Wyoming--

Rock Springs is approximately in the center of Sweetwater County, which is located in southwestern Wyoming. Of the 30,144 inhabitants of Sweetwater County, 17,773 (over half) reside in Rock Springs. The population of the country is 97.5 percent white, the median age is 29.9 with 9.6 percent of the population over 65. The median income of the residents of Rock Springs is $4,358. The community grew at an annual rate of 10.0 percent between 1970 and 1975. The growth rate of Rock Springs is considerably higher than that value for the state as a whole (2.6 percent).

There are three surface mines in Sweetwater County which will have an estimated production of 13 million tons per year by 1984. The three underground mines in the county will not be contributing significantly to this production. The mining is located to the north, east, and south of Rock Springs. Since Rock Springs takes its water supply from the same source as Green River, its drinking water will not be impacted by the mining. As was mentioned in the discussion of Green River, the drainage from the mined areas flows into systems of streams that are completely separate from the stream supplying drinking water to the two communities.

The three major economic activities in the county are mining, manufacturing, and agriculture; 19.2, 8.1, and 3.8 percent of the population are employed in each of these areas, respectively. It is reasonable to assume that most of the manufacturing activity is taking place in the community of Rock Springs, since a large proportion of the county population is concentrated there. This could present a problem, depending on the nature of the manufacturing. If the manufacturing pollutes the area sufficiently to produce health impacts, it would be difficult to attribute the presence or absence of health effects directly to the mining activity. In addition, the size of Rock Springs is very atypical of the communities under consideration as study sites. The relatively larger amount of traffic and different social environment of a larger community could have a significant impact on the health of the residents.

The surface water quality monitoring pertinent to Rock Springs is the same as that for Green River, since the two communities share the same water supply. As was discussed with respect to Green River, this monitoring activity is satisfactory but not ideal. There are three air quality monitors in the area of Rock Springs. Total suspended particulates (TSP) is the only relevant air quality parameter measured by each of them.

There are two sources of supplemental information concerning the area of Rock Springs: the Southwestern Wyoming Environmental Impact Statement by the United States Bureau of Land Management (U.S. Dept. of the Interior, 1978) and the United States Geological Survey Hydrology and Economic Development Report (Lowham et al., 1976). Rock Springs is part of the cluster of communities in southwestern Wyoming and northwestern Colorado. Both of these points are positive factors concerning the choice of Rock Springs as a control site for an epidemiological study. Other assets are the amount and location of mining in the area, but the size of Rock Springs makes it rather undesirable.

Sheridan, Sheridan County, Wyoming--

Sheridan County is located in north-central Wyoming. Its population is mostly white. The residents in the county are considerably older than in most areas under consideration as study sites. The median age is 36.8, and 15.9 percent of the population is over 65. About 60 percent of the county's 19,924 inhabitants reside in the community of Sheridan. This community grew at a much slower rate than other communities under consideration as well as the state as a whole. Between 1970 and 1975 the annual growth rate was only 1.3 percent annually. The per capita income for the community of Sheridan ($4,551) is very similar to that for the state as a whole ($4,566).

The 11.5 million tons of coal mines per year in the vicinity of Sheridan are taken from five surface mines. This production is expected to increase to a total of 47 million tons of coal per year by 1985. This mining is located between approximately six and 30 miles downstream from the community of Sheridan. Since the community takes its water supply from several miles upstream, the mining will have no impact on its drinking water supply. Agriculture is the only other major economic activity in the county. There is a small amount of manufacturing in the county which is most likely located in the community of Sheridan.

A medium sized coal-fired electricity generating facility is being constructed in the area of Sheridan. As has been discussed, pollution from such a facility may camouflage or confound mining impacts.

The closest surface water quality monitoring activity to the community of Sheridan is approximately one mile downstream. At this site, and another one seven miles upstream from the community, measures of pH, nitrates, hardness, calcium, magnesium, sodium, and sulfates are taken. The nearest monitor providing data on concentrations of the toxic metals of interest is almost 11 miles downstream from the community of Sheridan. The only relevant air quality parameter being measured in this area is TSP.

With Sheridan serving as a control site, travel between study site and control site would be difficult and time consuming, as Sheridan is many miles from any of the other communities under consideration. All of the candidate communities except Sheridan, Wyoming, and Canon City, Colorado are close enough together that travel between any pair of them would be relatively easy.

There are two sources of data concerning the area of Sheridan: Effects of Coal Strip Mining on Water Quality (Dettman et al., 1976) and Land Reclamation Annual Report (Carter et al., 1978). These would be of some use in designing and implementing an epidemiologic study.

In summary, there are several factors which make Sheridan attractive as a choice of a control site in an epidemiological study. The mining in the area is extensive and will clearly have no impact on the community's water. In addition, mining is a relatively large part of the community's economy. However, there is a medium sized coal-fired electricity generating facility in the area; the surface water quality data as well as sources of additional information are of limited use; and Sheridan is not in a desirable geographic location for a study such as the one under consideration.

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TABLE A-1. CURRENT AND FUTURE COAL MINES IN COLORADO[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment[b] Current	Employment[b] Planned Future
Watkins' Lignite N 39°47' W 104°39'	Surface	12.5 in 1983	Moist - 30% Ash - 30% Sulfur - 0.3-0.4% Btu/lb - 4,000	0	660
Mel Martinez N 37°10' W 107°16'	Surface	0.25 in 1976 0.08 in 1977 0.25 in 1978	Moist - 4-5% Ash - 6-7% Sulfur - 0.4-0.5% Btu/lb - 11,600-12,090		10
Farmer's Mine N 38°55' W 107°46'	Underground	0.3 in 1980 1.0 in 1982	Moist - 6-7% Ash - 3.2-5.4% Sulfur - 0.4-0.6% Btu/lb - 11,500		345
King Mine (6 mi. E. of Paonia in Delta Co.)	Underground	0.5 in 1980	Moist - 2.9-6.1% Ash - 4.3-8.1% Sulfur - 0.4-1.2% Btu/lb - 12,900	8[c]	175

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Converse N 38°54' W 107°37'	Underground	1.5 in 1980 Potential	Sulfur - 0.4-0.6% Btu/lb - 12,000	10	85
Old Blue Ribbon N 38°57' W 107°32'	Underground	0.1 in 1976 0.01 in 1977 0.05 in 1980	Moist - 6.0-6.9% Ash - 3.2-5.4% Sulfur - 0.4-0.6% Btu/lb - 12,700-13, 100	10	10
Station Creek N 39°18' W 104°17'	Surface	1.0 in 1982	Lignite	0	66
Unnamed (1 mi. E. of Somerset in Gunnison County)	Underground	2.0 in 1980		10	600
Hawk's Nest East N 38°56' W 107°28'	Underground	0.2 in 1975 0.5 in 1978 0.75 in 1979	Ash - 6% Sulfur - 0.4% Btu/lb - 12,500	90 (105 in 1976)(c)	150

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Grizzly Creek N 40°32' W 106°21'	Surface	0.5 in 1979 2.0 in 1980	Moist - 20% Ash - 10% Sulfur - 0.6-0.7% Btu/lb - 9,000		40
Lorencito N 37°08' W 104°49'	Underground	0.5 in 1981 1.0 in 1982	Moist - 6% Ash - 9% Sulfur - 0.6% Btu/lb - 13,700	0	500
Maxwell N 37°10' W 104°52'	Underground	0.10 in 1978 0.25 in 1979 0.60 in 1980	Coking Coal		100
McGinley N 39°16' W 108°32'	Underground	0.25 in 1976 0.025-0.1 in 1978 0.25 maximum	Moist - 8-9% Ash - 8-9.8% Sulfur - 0.6% Btu/lb - 12,500		85
McKinley #1 (near Fruita, Mesa County)	Underground	0.1 in 1977			35

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
CMC N 39°08' W 108°20'	Underground	0.07 in 1975 0.15 in 1978 0.5 in 1979	Moist - 5-6% Ash - 7-11% Sulfur - 0.4-0.6% Btu/lb - 11,990-13,010	38[c]	175
CMC #1 Mesa County	Underground	1.4 in 1977 Start-up, 1976			480
Wise Hill #5 N 40°26' W 107°39'	Underground & Surface	0.5 in 1975 0.4 in 1977 0.6 in 1980	Moist - 16.0% Ash - 5.8% Sulfur - 0.5% Btu/lb - 10,600	72 (90 in 1976)[c]	150
Colowyo N 40°13' W 107°50'	Surface	0.25 in 1977 3.0 in 1980	Moist - 8.5-23.3% Ash - 2.7-9.4% Sulfur - 0.2-1.0% Btu/lb - 10,500		244

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Unnamed (2 mines 20 mi. S. of Craig, Moffat Co.; 14 mi. E. of Steamboat Springs, Routt County)	Surface	1.0 in 1980			75
Thompson Creek #'s 1 & 3 N 39°19' W 107°19'	Underground	#1 0.035 in 1977 0.25 in 1978 0.5 in 1979 #3 0.035 in 1977 0.25 in 1978 0.5 in 1979	Moist - 2.3-3.6% Ash - 7.6-14.1% Sulfur - 0.6-1.2% Btu/lb - 12,800-13,900	12	320
Gordon N 40°11' W 108°43'	2 Underground 1 Surface	1.5 in 1980 2.3 in 1985 3.7 in 1990	Moist - 13% Ash - 9% Sulfur - 0.4% Btu/lb - 11,100	0	700
Peanut N 38°56' W 107°00'	Underground		Anthracite		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Peacock N 37°17' W 108°03'	Underground	0.06 in 1978	Moist - 3.5-10.7% Ash - 3.4-11.3% Sulfur - 0.6-4.0% Btu/lb - 11,400-14,000		
Lincoln N 40°02' W 104°57'	Underground	0.2 in 1976 0.15 in 1977	Moist - 23.5-25.0% Ash - 6.5-8.5% Sulfur - 0.3-0.4% Btu/lb - 9,100 - 9,500		70
Mt. Gunnison N 38°52' W 107°26'	Underground	0.5 in 1981 2.5 in 1985	Moist - 10.4% Ash - 4.5% Sulfur - 0.47 Btu/lb - 11,846		
Bear N 38°55' W 107°27'	Underground	0.13 in 1975 0.2 in 1977	Moist - 4.5-7% Ash - 2.8-8.9% Sulfur - 0.4-1.0% Btu/lb - 12,170-13,690	51[c]	

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Allen N 37°09' W 104°59'	Underground	0.6 in 1975		440[c]	
Orchard Valley N 38°52' W 107°39'	Underground	0.5 in 1976 0.5-0.7 in 1978 1.0 in 1980	Moist - 10-11% Ash - 3-4% Sulfur - 0.4-0.44% Btu/lb - 12,000	140[c]	
Eagle N 40°03' W 104°59'	Underground	0.2 in 1975		59[c]	
Marr Strip #1 N 40°44' W 106°09'	Surface	0.2 in 1975 0.3 in 1980	Moist - 11.0-14.4% Ash - 2.1-10.8% Sulfur - 0.2-0.7% Btu/lb - 10,040-13,290	36[c]	
Bear Creek N 39°10' W 107°20'	Underground	0.1 in 1976 0.13 in 1979	Moist - 6% Ash - 6.5-7% Sulfur - 0.6% Btu/lb - 13,980-15,200	89[c]	

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Coal Basin N 39°13' W 107°21'	Underground	0.1 in 1976 0.13 in 1979	Moist - 4.2% Ash - 9.7% Sulfur - 0.7% Btu/lb - 13,600-15,150	65[(c)]	
Rienau #2 N 40°07' W 107°51'	Underground & Surface	1976 prep 0.04 in 1978	Moist - 10-11% Ash - 2.0-4.0% Sulfur - 0.4% Btu/lb - 13,200-13,400	12	25
Edna N 40°20' W 107°01'	Surface	0.8 in 1975 1.1 in 1976 1.0 in 1979 0.85 in 1980	Moist - 7.7-12.5% Ash - 3.3-13.2% Sulfur - 0.6-1.2% Btu/lb - 10,400-12,000	75 (77 in 1976)[(c)]	75
Energy #2 N 40°23' W 107°09'	Surface	1.0 in 1976 1.1 in 1978	Moist - 10% Ash - 4.1-9% Sulfur - 0.5% Btu/lb - 11,300-11,590	175 (151 in 1976)[(c)]	593

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Energy #3 N 40°23' W 107°02'	Surface	0.5 in 1975 0.5 in 1976 0.5 in 1978	Moist - 11% Ash - 7.2-9% Sulfur - 0.5% Btu/lb - 10,820-11,300	37[c]	
Energy #1 N 40°21' W 107°03'	Surface	1.7 in 1978	Moist - 5.7-10.4% Ash - 8-17.8% Sulfur - 0.5-0.6% Btu/lb - 10,400-11,380		
Sun N 40°20' W 107°20'	Underground	Planned 0.3	Moist - 11% Ash - 4.2-9.5% Sulfur - 0.4-0.5% Btu/lb - 10,900-11,600		65
Coal Basin	Prep. plant	>0.5 in 1976	Moist - 6% Ash - 7% Sulfur - 0.6% Btu/lb - 15,000		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Dutch Creek #1 N 39°11' W 107°20'	Underground	0.1 in 1976 0.16 in 1979	Moist - 4.0% Ash - 8.3% Sulfur - 0.7% Btu/lb - 14,000-15,280	77[c]	
Dutch Creek #2 N 39°11' W 107°20'	Underground	0.2 in 1975 0.3 in 1976 0.32 in 1979	Moist - 4.0% Ash - 8.3% Sulfur - 0.7% Btu/lb - 14,000-15,280	93[c]	
L.S. Wood N 39°12' W 107°21'	Underground	0.4 in 1975 0.3 in 1976 0.31 in 1979	Approximately the same as Dutch Creek #1	98[c]	
Nucla Strip N 38°17' W 108°35'	Surface	0.1 in 1976 0.11 in 1979	Moist - 6-8% Ash - 9.4% Sulfur - 0.8% Btu/lb - 11,550	18[c]	
Seneca Strip #2 N 40°26' W 107°02'	Surface	0.7 in 1975 1.5 in 1978	Moist - 8-10% Ash - 9.5% Sulfur - 0.5% Btu/lb - 10,500-11,130	29[c]	

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Somerset N 38°55' W 107°28'	Underground	1.0 in 1976 1.0 in 1978	Moist - 3.8-8.2% Ash - 6.7-12.0% Sulfur - 0.4-0.6% Btu/lb - 12,070-12,970	280[c]	
Unnamed N 37°39' W 104°52'	Surface	0.05-0.10 in 1979	Bituminous		
Ramey N 37°18' W 104°35'	Underground				
Unknown N 37°22' W 104°57'	Underground				
King N 37°15' W 108°05'	Underground	0.02 in 1978	Moist - 2.4-4.6% Ash - 2-7.3% Sulfur - 0.15-1.2% Btu/lb - 12,700-14,000		
Pricco N 37°11' W 104°43'	Underground				

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Highland N 37°08' W 104°27'	Underground				
Nu Gap #3 N 39°35' W 107°39'	Underground	0.001 in 1978	Moist - 3-4% Ash - 6% Sulfur - 0.4-0.5% Btu/lb - 13,000		
Unnamed 12 mi. W. of Steamboat Springs Routt County					
L.S. Wood #3 N 39°11' W 107°20'	Surface & Underground				
Unknown N 37°14' W 104°41'	Underground				
Eureka N 37°12' W 104°41'	Underground				

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment: Current	Employment: Planned Future
Four Mile N 39°24' W 107°18'	Underground				
Williamsfork #1 N 40°25' W 107°38'	Surface				
Unknown N 37°14' W 104°30'	Underground				
Jewell N 37°24' W 104°40'	Surface	0.05 in 1977	Moist - 13.85% Ash - 8.15% Sulfur - 0.44% Btu/lb - 9,207		
Cedar Canon N 38°20' W 105°11'	Surface	0.002 in 1976 0.003 in 1977	Moist - 9-10% Ash - 9.9% Sulfur - 0.6% Btu/lb - 12,290		
Canon Monarch N 38°16' W 105°09'	Underground				

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Twin Pines N 38°20' W 105°10'	Underground	0.045 in 1977 0.045 in 1978	Moist - 8.9-11% Ash - 0.6% Sulfur - 7.3-12.8% Btu/lb - 10,560-12,080		
Casselman N 40°17' W 104°36'	Underground				
Blackbird N 39°02' W 108°18'	Surface				
Farmer Mutual N 39°13' W 108°30'	Underground				
Caldirola #1 N 38°20' W 105°10'	Underground				
Bowie N 38°55' W 107°33'	Underground		Moist - 6.5% Ash - 4.7% Sulfur - 0.5% Btu/lb - 13,600		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Christenson N 40°18' W 104°36'	Underground				
Bookcliff N 39°11' W 108°28'	Underground				
George Cocharan N 39°14' W 108°31'	Underground				
Black Diamond N 38°17' W 105°09'	Surface	0.044 in 1976 0.06 in 1977	Moist - 8.9-13% Ash - 7.9-17.1% Sulfur - 0.3-0.6% Btu/lb - 10,000-11,290		
Peabody Pit N 40°26' W 107°07'	Surface				
Quatro N 37°02' W 105°02'	Underground				
Morley N 37°02' W 104°30'	Underground				

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment: Current	Employment: Planned Future
Canadian Strip N 40°41' W 106°06'	Surface				
Wilson Creek 25 mi. So. of Craig Moffat Co.	Surface				
Johnnie's N 40°16' W 107°02'	Underground				
Prosperity N 40°15' W 104°40'	Underground				
McLaughlin N 37°08' W 104°30'	Underground				
Sunlight N 39°24' W 107°19'	Underground	0.012 in 1978	Moist - 4-5.4% Ash - 4-8.5% Sulfur - 0.5-1.3% Btu/lb - 13,500		
Apex #2 N 40°18' W 107°02'	Underground	0.10 in 1977 0.25 in 1980	Moist - 6-9.2% Ash - 3-12.1% Sulfur - 0.5-0.7% Btu/lb - 12,400		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Gunbarrel N 40°01' W 105°16'	Surface				
Sunset N 40°18' W 104°36'	Underground				
Boyer Peacock N 39°12' W 108°29'	Underground				
Grasso N 39°13' W 108°30'	Underground				
Scranton N 39°47' W 104°40'	Underground				
White Ash N 40°17' W 104°36'	Underground				
Coal Gulch N 39°21' W 108°42'	Underground	0.025 in 1978	Bituminous-coking type		
Hunter Gulch N 39°18' W 108°34'	Underground				

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Bohlender N 40°16' W 104°36'	Underground				
Marr Prep P N 40°43' W 106°16'	Proc. Plant				
Corcoran N 39°14' W 108°31'	Underground				
Jarvis N 39°13' W 108°30'	Underground				
Corley S & A N 38°17' W 105°10'	Surface				
Buddy N 40°17' W 104°36'	Underground				
Anchor #1 N 39°19' W 108°39'	Underground				

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Golden Quality N 38°20' W 105°11'	Underground	Idle in 1976	Moist - 9.9-10.7% Ash - 7.4-10.4% Sulfur - 0.4-0.5% Btu/lb - 10,920 11,400		
Farmer N 39°20' W 108°41'	Underground				
Kannah Creek N 39°00' W 108°15'	Underground				
Kelehen N 39°20' W 108°42'	Surface				
Lane N 39°21' W 108°42'	Surface				
Thomas N 39°13' W 108°30'	Underground				
Unnamed N 39°01 W 108°31'	Surface				

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment: Current	Employment: Planned Future
Tomahawk N 38°55' W 102°00'	Surface	0.08 in 1977 0.25 in 1978	Moist - 8-14% Ash - 9.3% Sulfur - 0.9% Btu/lb - 11,600-12,090		
Limon N 39°21' W 103°52'	Surface	0.3 in 1977 0.8 in 1978	Moist - 33% Ash - 11-17% Sulfur - 0.17-0.43% Btu/lb - 7,000		
G.E.C. S & A N 38°18' W 105°10'	Surface	Joint output with Black Diamond to total no more than 0.1	Moist - 7.5-8.2% Ash - 9.5-11.2% Sulfur - 0.8-1.3% Btu/lb - 11,160-13,680		
Hastings 6 mi. SW of Florence Fremont County	Surface		Bituminous		
Canadian Strip N 40°44' W 106°18'	Surface	0.12 in 1977	Moist - 12.8-16.1% Ash - 3.2-19.2% Sulfur - 0.6-1.4% Btu/lb - 10,500-11,160		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Hay Gulch N 37°17' W 108°03'	Surface	0.025 in 1978 0.05 in 1980	Moist - 5-6% Ash - 7-10% Sulfur - 0.6-1.6% Btu/lb - 11,800-14,000		
Del Agua Strip N 37°21' W 104°39'	Surface	Small			
Healey Strip 1.5 mi NW Aguilar Las Animas Co.	Surface	0.15 in 1978	Moist - 2-3% Ash - 8-9% Sulfur - 0.6-0.7% Btu/lb - 12,256		
Trapper (Craig) N 40°27' W 107°34'	Surface	0.4 in 1977 2.2 in 1979	Moist - 16% Ash - 5.7% Sulfur - 0.3-0.5% Btu/lb - 9,500-11,500		
Williams Fork Strip #2 N 40°28' W 107°34'	Surface	Idle			
Denton Strip N 40°18' W 107°20'	Surface		Bituminous		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Eilt's Property N 40°28' W 107°09'	Surface then Underground	0.15 in 1977 0.25 in 1978	Moist - 8% Ash - 10% Sulfur - 0.6% Btu/lb - 10,500-12,000		
Hayden Gulch 10 mi. S of Hayden Routt County	Surface	1.0 in 1978			
Meadows #1 N 40°28' W 107°09'	Surface				
Red Cannon #1 N 38°56' W 107°58'	Underground	0.005 in 1977	Moist - 14.5% Ash - 6.7% Sulfur - 0.7% Btu/lb - 12,000		
Newlin Creek N 38°18' W 105°10'	Underground		Moist - 9.5% Ash - 9.1% Sulfur - 1.6% Btu/lb - 11,000-12,500		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Eastside N 39°36' W 108°17'	Underground	0.001 in 1977 0.008 in 1979	Moist - 3-4% Ash - 6-7% Sulfur - 0.6-0.8% Btu/lb - 12,700-13,200		
McClane (test site) N 39°26' W 108°47'	Underground				
Hawk's Nest West #3 N 38°56' W 107°28'	Underground	0.5 in 1978 0.75 in 1979	Moist - 4.4-7.1% Ash - 3.2-9.1% Sulfur - 0.3-0.5% Btu/lb - 12,400-13,400		
O.C. #2 N 38°55' W 107°28'	Underground	0.004 in 1978	Moist - 9.5-10.1% Ash - 4.3-6.0% Sulfur - 0.3-0.6% Btu/lb - 11,500-12,500		
Blue Flame N 37°17' W 108°03'	Underground	Very small	Moist - 3.8% Ash - 3-5.9% Sulfur - 0.7% Btu/lb - 13,000-14,000		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Anchor-Tresner Unit N 39°19' W 108°39'	Underground	0.125 in 1977 0.3 in 1978	Moist - 8% (washed) Ash - 8% Sulfur - 0.6-1.0% Btu/lb - 12,000		
Cameo N 39°21' W 108°05'	Underground	1977 prep 0.5 in 1979 0.9 in 1980+	Moist - 6-8% Ash - 7-11% Sulfur - 0.4-0.6% Btu/lb - 12,500		
Unnamed N 40°34' W 107°07'					
Blazer N 40°34' W 107°07'	Underground	0.25 in 1977	Moist - 8-9% Ash - 9-10% Sulfur - 0.5-0.6% Btu/lb - 10,500-12,000		
Dawson Unit N 40°29' W 107°14'	Underground	0.1 in 1977 or 1978 2.0-4.0 max	Moist - 7% Ash - 8% Sulfur - 0.5% Btu/lb - 11,500		

(continued)

TABLE A-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Elder N 38°09' W 108°17'	Underground	0.001 in 1977 0.01 in 1978	Moist - 3% Ash - 7-8% Sulfur - 0.7% Btu/lb - 13,806-14,400		

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); Mineral Industry Location System (USBM, 1978).

(b) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(c) From Keystone Coal Industry Manual (Nielson, 1977).

TABLE A-2. CURRENT AND FUTURE COAL MINES IN MONTANA[a]

Name and Location of Mine	Type of Mines	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment[b] Current	Employment[b] Planned Future
East Decker N 45°05' W 106°53'	Surface	10.2 in 1976(?) 20.0 in 1981	Moist - 24.1% Ash - 4.3% Sulfur - 0.6% Btu/lb - 9,700	128[c]	435
Rosebud N 45°50' W 106°35'	Surface	9.2 in 1976 19.1 in 1980	Moist - 24.6% Ash - 8.9% Sulfur - 0.7% Btu/lb - 8,703	275[c]	1260
Sarpy Creek N 45°49' W 107°04'	Surface	6.5 in 1980 15.0 in 1982	Moist - 23% Ash - 11% Sulfur - 0.7% Btu/lb - 8,500		990
Circle West N 47°23' W 105°34'	Surface	5.0 in 1983	Moist -34.9% Ash - 6.9% Sulfur - 0.5% Btu/lb - 6,930	0	200
Young's Creek, Tanner Creek, Squirrel Creek Unnamed N 45°03' W 107°00'	Surface	6.0 in 1980 16.0 in 1985	Moist -24% Ash - 3.5% Sulfur - 0.25% Btu/lb - 9,400		435

(continued)

TABLE A-2. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Spring Creek N 45°08' W 106°53'	Surface	10.0 in 1980			
East Sarpy Creek N 45°55' W 107°00'	Surface	Preliminary planning stages			
McCartney Blaine Co.	Surface	Preliminary planning stages			
Nance Tongue River Rosebud Co.	Surface	Preliminary planning stages	Moist - 25.1% Ash - 3.6% Sulfur - 0.35% Btu/lb - 9,373		
Absaloka Big Horn Co.	Surface	4.0 in 1975 4.1 in 1976	Moist - 23% Ash - 10% Sulfur - 0.7% Btu/lb - 8,450	120(c)	
Big Sky N 45°49' W 106°37'	Surface	2.1 in 1975 2.4 in 1976	Moist - 26.3% Ash - 10.4% Sulfur - 0.75% Btu/lb - 8,450	25(c)	
Savage Richland Co.	Surface	0.3 in 1975 0.3 in 1976	Moist - 27% Ash - 7-7.5% Sulfur - 0.5% Btu/lb - 6,500	19(c)	

(continued)

TABLE A-2. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Storm King N 46°15' W 108°26'	Underground				
Martin's Peat, Inc. N 47°50' W 113°47'	Surface				
PM Surface N 45°49' W 108°18'	Surface				
Unnamed N 45°34' W 106°11'	Surface				
Unnamed N 46°16' W 108°27'	Surface				

(continued)

TABLE A-2. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Unnamed N 46°16' W 108°20'	Surface				

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); Mineral Industry Location System (USBM, 1978).

(b) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(c) From Keystone Coal Industry Manual (Nielson, 1977).

TABLE A-3. CURRENT AND FUTURE COAL MINES IN NORTH DAKOTA[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment[b]	
				Current	Planned Future
Husky N 47°56' W 101°01'	Surface	0.14 in 1975 0.13 in 1976	Moist - 35% Ash - 7% Sulfur - 1.2% Btu/lb - 6,500	8[c]	
Coteau N 47°26' W 101°49'	Surface	7.0-7.5 in 1981 14.0-15.0 in 1985	Moist - 36% Ash - 7.4%	12	360
Falkirk N 46°49' W 100°47'	Surface	Under construction 5.0-6.0 in 1981	Moist - 39.5% Ash - 6.8% Sulfur - 0.6% Btu/lb - 6,415	21	300
Gascoyne N 46°08' W 103°04'	Surface	1.9 in 1975 2.5 in 1976	Moist - 43% Ash - 5-8.5% Sulfur - 0.75% Btu/lb - 5,900 - 6,250	73 (65 in 1976)[c]	73
Beulah N 47°16' W 101°46'	Surface	1.3 in 1976 2.2 in 1981 4.4 in 1985	Moist - 34-37% Ash - 5-8% Sulfur - 0.5-0.7% Btu/lb - 6,700 - 6,900	110 (58 in 1976)[c]	280

(continued)

TABLE A-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Glen Harold (TT) N 47°16' W 101°19'	Surface	3.8 in 1976 1.9 in 1975	Moist - 37-42% Ash - 4.0-6.5% Sulfur - 0.3-1.0% Btu/lb - 6,000-7,000	147 (151 in 1976)(c)	147
Center N 47°05' W 101°16'	Surface	1.5 in 1975 1.7 in 1976 4.4 in 1978	Moist - 39% Ash - 6.2% Sulfur - 0.6% Btu/lb - 6,650	38 (53 in 1976)(c)	80
Dunn Center N 47°23' W 102°53'	Surface	13.0-14.0 in 1982	Moist - 34.0% Ash - 8.0% Sulfur - 0.8% Btu/lb - 6,800	0	300
Noonan N 48°52' W 102°53'	Surface	0.4 in 1975 0.4 in 1976		23(c)	
Velva N 48°01' W 101°01'	Surface	0.3 in 1975 0.3 in 1976		28(c)	
Indian Head N 47°14' W 101°00'	Surface	0.8 in 1975 1.1 in 1976	Moist - 34.5% Ash - 8% Sulfur - 0.55% Btu/lb - 7,100	54(c)	

(continued)

TABLE A-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Unnamed (Heart Butte area) N 46°42' W 101°55'	Surface				
Unnamed (south of Beach) N 46°52' W 103°58'	Surface				
Arrowhead N 46°21' W 102°59'	Mineral location				
Bains Sub-Bitumino N 45°59' W 102°18'	Underground				
Chamberlain N 46°00' W 102°30'	Underground				
Knife River N 46°04' W 103°02'	Surface				
Larson B-N N 48°52' W 102°52'	Surface				

(continued)

TABLE A-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Consolidated Coal N 47°15' W 101°59'	Surface				
North (KRCC) N 47°17' W 101°42'	Surface				
Smith-Ullman-Olson N 46°01' W 102°30'	Mineral location				
Larson N 48°53' W 102°54'	Surface				
Dakota Collieries N 47°15' W 101°52'	Surface-underground				
Dakota Lanonite N 46°08' W 103°35'	Surface				
Ganther N 46°09' W 101°53'	Surface				

(continued)

TABLE A-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Dakota Star N 47°22' W 101°38'	Surface	4.0 after 1985	Moist - 37% Ash - 6-7% Sulfur - 0.7% Btu/lb - 6,800-6,900		
Carbon Coal N 46°50' W 101°34'	Surface				
Knife River N 46°08' W 103°02'	Surface				
Nygard N 47°56' W 103°09'	Surface				
Grishkousky N 47°08' W 101°47'	Surface				
Flemmer N 46°53' W 101°18'	Surface				
Roy Kern N 46°09' W 103°15'	Surface				

(continued)

TABLE A-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Custer (Truax - TR) N 47°37' W 101°17'	Surface				
Glen Harold (CCC) N 47°18' W 101°16'	Surface				
Hanging Cross N 46°45' W 101°42'	Surface				
Knifer River N 47°14' W 101°47'	Surface				
Landaker N 48°03' W 102°15'	Surface				
Art Kobs N 47°11' W 101°18'	Mineral location				
McKinley, Nelson N 48°06' W 103°32'	Underground				

(continued)

TABLE A-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment: Current	Employment: Planned Future
Freyer N 47°10' W 101°35'	Surface				
North & South BE N 47°12' W 101°43'	Mineral location				
Center Strip N 46°59' W 101°33'	Surface				
Sampson Mine N 47°14' W 102°42'	Surface				
Nokota Co. #1 South of Max McLean County	Surface	6.6 after 1982			
Renners Cove Renners Cove Mercer Co.	Surface	3.0 after 1980	Moist - 37% Ash - 7% Sulfur - 0.7% Btu/lb - 6,700-6,800		

(continued)

TABLE A-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Washburn Washburn McLean Co.	Surface	5.0 after 1985	Moist - 38% Ash - 4.4% Sulfur - 0.5% Btu/lb - 7,100		
Underwood N 47°27' W 101°07'	Surface	1.5 after 1985			
Garrison N 47°38' W 101°26'	Surface	3.30 in 1984			

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); Mineral Industry Location System (USBM, 1978).

(b) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(c) From Keystone Coal Industry Manual (Nielson, 1977).

TABLE A-4. CURRENT AND FUTURE MINES IN SOUTH DAKOTA[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Lignite Pit N 45°37' W 103°16'	Surface				
Lignite Pit N 45°49' W 103°15'	Surface				
Lignite Pit N 45°30' W 103°10'	Surface				
Lignite N 45°35' W 102°48'	Underground				
Phillips N 45°26' W 102°49'	Underground				
Lignite Pit N 45°52' W 103°25'	Surface				
Lignite Pit N 45°54' W 103°16'	Surface				

(continued)

TABLE A-4. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Lignite Pit N 45°28' W 103°09'	Surface				
Lignite N 45°35' W 102°48'	Surface				
Seidell N 45°35' W 102°21'	Surface				
Lignite Pit N 45°52' W 103°25'	Surface				
Lignite Pit N 45°54' W 103°17'	Surface				
Cooke N 45°33' W 102°08'	Surface				
Lignite N 45°40' W 102°27'	Surface & Underground				
Lignite Pit N 45°50' W 103° 15'	Surface				

(continued)

TABLE A-4. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Lignite Pit N 45°29' W 103°09'	Surface				
Cornella N 45°45' W 102°40'	Surface & Underground				
Lignite N 102°39' W 45°49'	Surface & Underground				
Lignite Pit N 45°51' W 103°16'	Surface				
Lignite Pit N 45°35' W 103°07'	Surface				
Jones N 45°34' W 102°51'	Underground				
Lignite Pit N 45°41' W 102°45'	Surface				

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); Mineral Industry Location System (USMB, 1978).

TABLE A-5. CURRENT AND FUTURE MINES IN UTAH[a]

Name and Location of Mine	Type of Mines	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment[b] Current	Employment[b] Planned Future
Soldier Canyon N 39°41' W 110°37'	Underground	0.5 in 1976 1.0 in 1978	Moist - 4.5% Ash - 8.4% Sulfur - 0.5% Btu/lb - 12,500	160	345
Braztah #3,4,5,6 N 39°43' W 111°55'	Underground	#3 & 5 - 0.3 in 1975 #3 & 5 - 0.9 in 1976 6.5 in 1980 (all)	Moist - 5.7% Ash - 9.7% Sulfur - 0.5% Btu/lb - 12,300		2,250
Deer Creek N 39°22' W 111°06'	Underground	1.0 in 1976 2.2 in 1978	Moist - 3.5% Ash - 5.6% Sulfur - 0.6% Btu/lb - 13,300		860
Wilberg N 39°19' W 111°08'	Underground	0.2 in 1976 2.2 in 1980	Moist - 5.4% Ash - 9.2% Sulfur - 0.6% Btu/lb - 12,500		760
Straight Canyon (Near Castle Dale, Emery Co.)	Underground	2.5 in 1980			860
Ferron Canyon (Near Ferron, Emery Co.)	Underground	1.0 in 1980			345

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Emery (near Emery, Emery Co.)	Underground	0.04 in 1975 0.08 in 1976 1.4 in 1980		82[c]	483
Emery Strip (near Emery, Emery Co.)	Surface	0.5 eventually			33
John Henry N 37°10' W 111°32'	Underground	0.4 eventually (Delayed)	Moist - 5-8% Ash - 4-8% Sulfur - 0.43-0.8% Btu/lb - 11,700-12,500		183
Unnamed (near Alton, Kane Co.)	Surface	11.5 in 1982	Sulfur - 1.1% Btu/lb - 10,200		760
Escalante (Near Escalante, Garfield Co.)	Underground	6.0 in 1985 Dependent on water avail.			2,070
Unnamed (Carbon Co.)	Underground	0.5 in 1980 Planning stages			170
Unnamed Factory Butte (Wayne Co.)	Surface	1.0 in 1980 Start-up 1976			345

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mines	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Unnamed (Sevier Co.)	Underground	1.0 in 1980 Planning stages			345
Intermountain Power Project (Wayne Co.)	Underground	10.0 in 1985			340
Utah #2 N 39°43' W 111°10'	Underground	0.2 in 1975 0.3 in 1976 0.7 in 1978			240
Belina #1 (Near Clear Creek, Carbon Co.)	Underground	1.3 in 1978			415
Belina # 2 (Near Clear Creek, Carbon Co.)	Underground	0.8 in 1979			275
O'Connor #1 (Near Clear Creek, Carbon Co.)	Underground	0.2 in 1980			70
Unnamed (Near Sunnyside, Carbon Co.)	Underground	Unknown	Sulfur - 0.5% Btu/lb - 12,000		790

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mines	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Star Point #3 (Near Wattis Carbon Co.)	Underground	1.0 in 1981			345
Southern Utah Fuels #1 N 38°55' W 111°25'	Underground	1.0 in 1977 1.5 in 1978	Moist - 9% Ash - 9% Sulfur - 0.6% Btu/lb - 11,200	185 (c)	520
Gordon Creek #3 (Near Helper, Carbon Co.)	Underground	0.2 in 1977	Moist - 6.3% Ash - 6.2% Sulfur - 0.5% Btu/lb - 12,500		70
Swisher #5 (Near Huntington, Emery Co.)	Underground	0.2 in 1979	Moist - 6.5% Ash - 4.9% Sulfur - 0.6% Btu/lb - 12,700		70
Huntington Canyon #4 (Emery Co.)	Underground	0.2 eventually	Moist - 4.8% Ash - 5.3% Sulfur - 0.6% Btu/lb - 13,200	10 (c)	70
Thompson (Thompson, Grand Co.)	Underground	0.6 in 1979			70

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Rilda Canyon (Huntington, Emery Co.)	Underground	0.2 eventually			70
Beehive N 39°19' W 111°05'	Underground	0.56 in 1975 0.68 in 1976		70 (c)	
Deseret N 39°19' W 111°05'	Underground	0.5 in 1976		65 (c)	
Sunnyside #1 N 39°33' W 110°22'	Underground	0.82 in 1975 0.65 in 1976		280 (c)	
Sunnyside #2 N 39°33' W 110°22'	Underground	Temporarily Inactive			
Sunnyside #3 N 39°33' W 110°22'	Underground	0.2 in 1975 0.1 in 1976		55 (c)	
Central Prep Plant (Sunnyside, Carbon Co.)	Prep Plant	0.06 in 1975 0.81 in 1976	Moist - 5% Ash - 6% Sulfur - 0.9% Btu/lb - 13,500	20 (c)	

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mines	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Starpoint # 1 & 2 N 39°31' W 111°01'	Surface & Underground	0.45 in 1975 0.55 in 1976	Moist - 9% Ash - 8.50% Sulfur - 0.65% Btu/lb - 11,500	165 (c)	
Gordon Creek #2 & 3 N 39°41' W 111°04'	Underground	0.4 in 1976	Moist - 9% Ash - 10% Sulfur - 0.5% Btu/lb - 11,500	78(c)	
Gordon Creek #6	Underground	Under Development		3 (c)	
Huntington Canyon N 39°22' W 111°07'	Underground	Opened March, 1977		10(c)	
King N 39°30' W 111°04'	Surface & Underground	0.5 in 1975 0.6 in 1976			
Wellington (Carbon Co.)	Prep Plant	0.7 in 1975		44	
Geneva (East Carbon, Emery Co.)	Underground	0.67 in 1975 0.60 in 1976	Moist - 7% Ash - 12% Sulfur - 0.86% Btu/lb - 13,500	286	

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Leamaster N 39°25' W 111°08'	Underground				
Shakespeare N 37°39' W 111°58'	Underground				
Western Mines - Gene N 39°27' W 110°20'	Underground				
Emery Pit N 38°51' W 110°15'	Surface				
Co-Op N 39°24' W 111°07'	Underground				
Trail Mountain N 39°18' W 111°11'	Underground				
Gordon Creek N 39°41' W 111°04'	Surface				

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Sun Valley N 38°46' W 111°15'	Surface				
Carbon Fuel #3 N 39°43' W 110°53'	Underground				
Larson-Rigby N 39°34' W 111°12'	Underground				
Thompson N 37°34' W 113°03'	Underground				
King #5 N 39°31' W 111°05'	Underground				
Black Ace Thompson, Grand Co.	Underground				
Ivie Creek Emery Emery Co.	Underground				

(continued)

TABLE A-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Colombine #1 Scofield, Carbon Co.	Underground				
Black Hawk Coalville, Summit Co.	Underground				
Knight Salina, Sevier Co.	Underground	0.5 in 1978			
Unnamed, South of Hiawatha, Emery Co.	Underground	1.6 in 1981			
MacKinnon #2-3, West of Hiawatha, Carbon & Emery Cos.	Underground				

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); Mineral Industry Location System (USBM, 1978).

(b) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(c) From Keystone Coal Industry Manual (Nielson, 1977).

TABLE A-6. CURRENT AND FUTURE COAL MINES IN WYOMING[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment[b] Current	Employment[b] Planned Future
Stansbury #1 N 41° 41' W 109°11'	Underground	Opening planned for 1976 1.4 in 1980	Moist - 17.5% Ash - 4.7% Sulfur - 1.1% Btu/lb - 10,500	30	275
Rainbow #8 N 41°31' W 109°13'	Underground	0.1 in 1976 0.2 in 1980	Moist - 11.4% Ash - 4.2% Sulfur - 0.9% Btu/lb - 11,700	70 (83 in 1976)[c]	70
Jim Bridger N 41°46' W 108°45'	Surface	3.4 in 1976 7.5 in 1980	Moist - 20.5% Ash - 9.7% Sulfur - 0.5% Btu/lb - 9,300	120 (165 in 1976)(c)	200
Big Horn #1 N 44°53' W 106°58'	Surface	0.8 in 1976 1.5 in 1980	Moist - 24.5% Ash - 5.8% Sulfur - 0.7% Btu/lb - 9,300	69	69
Elkol N 41°42' W 110°34'	Surface	1.0 in 1975 1.8 in 1976 1.1 in 1980	Moist - 20.4% Ash - 3.0% Sulfur - 0.7% Btu/lb - 10,200	35 (150 in 1976)[c]	80

(continued)

TABLE A-6. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment Current	Employment Planned Future
Grass Creek N 43°55' W 108°41'	Surface	0.7 in 1980	Moist - 12.1% Ash - 9.0% Sulfur - 0.4% Btu/lb - 10,800		100
Dave Johnston N 43°02' W 105°50'	Surface	2.7 in 1976	Moist - 26.3% Ash - 12.0% Sulfur - 0.5% Btu/lb - 7,500	131[c]	
Vanguard #2 & 3 N 41°53' W 106°39'	Underground	1.0 in 1975 1.1 in 1976 #2 (1.0-2.0 in 1980) #3 (0.5 in 1978)	Moist - 13.0% Ash - 11.5% Sulfur - 0.4% Btu/lb - 9,800	120 (150 in 1976)[c]	120
Medicine Bow N 41°55' W 106°46'	Surface	2.8 in 1976 3.6 in 1980	Moist - 12.0% Ash - 7.5% Sulfur - 0.5% Btu/lb - 10,200	135 (125 in 1976)[c]	135
Rosebud N 41°54' W 106°30'	Surface	1.8 in 1975 2.2 in 1976	Moist - 14.2% Ash - 8.2% Sulfur - 1.0% Btu/lb - 10,300	115[c]	
Seminoe #2 N 41°54' W 106°30'	Surface	2.9 in 1975 2.7 in 1976		121[c]	

(continued)

TABLE A-6. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
Seminoe #1 N 41°53' W 106°48'	Surface	2.4 in 1975 2.6 in 1976		166(c)	
Wyodak N 44°17' W 105°21'	Surface	0.8 in 1975 2.2 in 1980	Moist - 29.2% Ash - 9.6% Sulfur - 0.8% Btu/lb - 8,200	28	190
Bell Ayr South N 44°05' W 105°22'	Surface	3.3 in 1975 7.3 in 1976 10-15 in 1980	Moist - 26.2% Ash - 5.3% Sulfur - 0.6% Btu/lb - 8,800	250	350
Sorenson N 41°42' W 110°34'	Surface	1.7 in 1975 2.3 in 1976 3.0-4.7 in 1980	Moist - 20.9% Ash - 4.8% Sulfur - 0.6% Btu/lb - 9,500	300	350
Rawhide N 44°29' W 105°25'	Surface	8.5 in 1980	Moist - 31.0% Ash - 6.0% Sulfur - 0.4% Btu/lb - 8,100	48(c)	560
Rochelle N 43°36' W 105°14'	Surface	5.0-11.0 in 1985	Moist - 28.0% Ash - 5.6% Sulfur - 0.3% Btu/lb - 8,400		225

(continued)

TABLE A-6. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
FMC Mine, Skull Point N 41°42' W 110°38'	Surface	1.0-2.0 in 1980	Moist - 20.9% Ash - 4.8% Sulfur - 0.6% Btu/lb - 9,500	60	100
Eagle Butte N 44°26' W 105°25'	Surface	30.0 in 1980	Moist - 29.2% Ash - 9.6% Sulfur - 0.8% Btu/lb - 8,200	0	350
Cordero N 44°03' W 105°21'	Surface	Under construction 12.0 in 1986			400
Jacobs Ranch N 43°42' W 105°41'	Surface	Under construction 14.0 in 1983	Moist - 29.0% Ash - 5.8% Sulfur - 0.5% Btu/lb - 8,500	62[c]	300
East Gillette N 44°19' W 105°28'	Surface	Planned open 1977 5.0-11.0 in 1980	Moist - 31.5% Ash - 5.7% Sulfur - 0.46% Btu/lb - 8,000		300
Black Butte N 41°36' W 108°41'	Surface	4.2 in 1980 Planned open 1977	Moist - 17.7% Ash - 8.5% Sulfur - 0.4% Btu/lb - 9,700	35	200

(continued)

TABLE A-6. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment: Current	Employment: Planned Future
Thunderbird Campbell Co.	Surface	3.0 in 1980 Tentative	Moist - 27.7% Ash - 13.4% Sulfur - 0.6% Btu/lb - 7,600		225
PSO Mine N 45°00' W 107°00'	Surface	Start in 1976 0.5 in 1978			50
Buckskin Mine Campbell Co.	Surface	4.0 in 1980 Very tentative	Btu/lb - 8,200		250
Carbon County Coal N 41°53' W 106°27'	Underground	0.8 in 1976 2.5 in 1980	Moist - 11.5% Ash - 6.6% Sulfur - 0.9% Btu/lb - 10,800	90	
Twin Creek N 41°47' W 110°34'	Surface	Planning stages 3.0 in 1980			200
Caballo N 44°08' W 105°18'	Surface	Planning stages 12.0 in 1980			150
Red Rim N 41°42' W 107°31'	Surface	2.5 in 1980			

(continued)

TABLE A-6. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment[(b)] Current	Employment[(b)] Planned Future
China Butte N 41°31' W 107°38'	Surface	1.0-3.0 in 1980 4.0 in 1982			
Coal Creek Campbell County	Surface	Under development			
Rimrock #1, 2 & 5 N 41°53' W 106°38'	Surface				
Long Canyon N 41°47' W 109°10'	Underground				
Black Thunder N 43°40' W 105°15'	Surface	7.0-10.0 in 1980 20.0 in 1982	Moist - 28.1% Ash - 4.8% Sulfur - 0.3% Btu/lb - 8,600	61[(c)]	250
South Haystack N 41°23' W 110°34'	Surface	2.5-3.0 in 1978	Moisture - 20.0% Ash - 5.43% Sulfur - 0.33% Btu/lb - 9,660		
Atlantic Rim N 41°31' W 107°27'	Surface	2.0 in 1983	Moisture - 13.7% Ash - 5.69% Sulfur - 0.89% Btu/lb - 10,698		

(continued)

TABLE A-6. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment[b] Planned Future
Cherokee N 41°42' W 107°45'	Surface	6.0 in 1984	Moisture - 21.92% Ash - 14.56% Sulfur - 1.75% Btu/lb - 8,000	
Pronghorn N 44°03' W 105°21'	Surface	5.0 in 1981	Moisture - 26.96% Ash - 5.3% Sulfur - 0.42% Btu/lb - 8,590	
Cravat N 43°00' W 110°40'	Surface	Unknown		
Stevens North N 43°08' W 105°45'	Surface	5.0 in 1985		

(continued)

TABLE A-6. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr)	Coal Analysis	Employment	
				Current	Planned Future
North Gillette N 44°26' W 105°26'	Surface				

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); Mineral Industry Location System (USBM, 1978).

(b) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(c) From Keystone Coal Industry Manual (Nielson, 1977).

APPENDIX B

DEVELOPING OR EXPANDING MINES

TABLE B-1. COAL MINES UNDER DEVELOPMENT OR EXPANSION IN COLORADO[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Watkins' Lignite N 39°47' W 104°39' Adams County	Surface	12.5 in 1983 Red	Moist - 30% Ash - 30% Sulfur - 0.3-0.4% Btu/lb - 4,000	0	660
Converse N 38°54' W 107°37' Delta County	Underground	1.5 in 1980 Potential Blue	Sulfur - 0.4-0.6% Btu/lb - 12,000	10	85
Farmer's Mine N 38°55' W 107°46' Delta County	Underground	0.3 in 1980 1.0 in 1982 Blue	Moist - 6-7% Ash - 3.2-5.4% Sulfur - 0.4-0.6% Btu/lb - 11,500		345
King Mine (6 mi. E. of Paonia) Delta County	Underground	0.5 in 1980 Blue	Moist - 2.9-6.1% Ash - 4.3-8.1% Sulfur - 0.4-1.2% Btu/lb - 12,900	8[d]	175
Old Blue Ribbon N 38°57' W 107°32' Delta County	Underground	0.1 in 1976 0.01 in 1977 0.05 in 1980 Blue	Moist - 6.0-6.9% Ash - 3.2-5.4% Sulfur - 0.4-0.6% Btu/lb - 12,700-13,100	10	10
Orchard Valley N 38°52' W 107°39' Delta County	Underground	0.5 in 1976 0.5-0.7 in 1978 1.0 in 1980 Blue	Moist - 10-11% Ash - 3-4% Sulfur - 0.4-0.44% Btu/lb - 12,000	140[d]	
Station Creek N 39°18' W 104°17' Elbert County	Surface	1.0 in 1982 Blue	Lignite	0	66

(continued)

TABLE B-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Mt. Gunnison N 38°52' W 107°26' Gunnison County	Underground	0.5 in 1981 2.5 in 1985 Green	Moist - 10.4% Ash - 4.5% Sulfur - 0.47% Btu/lb - 11,846		
Unnamed (1 mi. E. of Somerset) Gunnison County	Underground	2.0 in 1980 Green		10	600
Grizzly Creek N 40°32' W 106°21' Jackson County	Surface	0.5 in 1979 2.0 in 1980 Green	Moist - 20% Ash - 10% Sulfur - 0.6-0.7% Btu/lb - 9,000		40
Marr Strip #1 N 40°44' W 106°09' Jackson County	Surface	0.2 in 1975 0.3 in 1980 Blue	Moist - 11.0-14.4% Ash - 2.1-10.8% Sulfur - 0.2-0.7% Btu/lb - 10,040-13,290	36[d]	
Hay Gulch N 37°17' W 108°03' La Plata County	Surface	0.025 in 1978 0.05 in 1980 Blue	Moist - 5-6% Ash - 7-10% Sulfur - 0.6-1.6% Btu/lb - 11,800-14,000		
Lorencito N 37°08' W 104°49' Las Animas County	Underground	0.5 in 1981 1.0 in 1982 Blue	Moist - 6% Ash - 9% Sulfur - 0.6% Btu/lb - 13,700	0	500
Maxwell N 37°10' W 104°52' Las Animas County	Underground	0.10 in 1978 0.25 in 1979 0.60 in 1980 Blue	Coking Coal		100

(continued)

TABLE B-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Cameo N 39°21' W 108°05' Mesa County	Underground	1977 prep. 0.5 in 1979 0.9 in 1980+ Blue	Moist - 6-8% Ash - 7-11% Sulfur - 0.4-0.6% Btu/lb - 12,500		
Colowyo N 40°13' W 107°50' Moffat County	Surface	0.25 in 1977 3.0 in 1980 Green	Moist - 8.5-23.3% Ash - 2.7-9.4% Sulfur - 0.2-1.0% Btu/lb - 10,500		244
Unnamed (20 mi. S. of Craig) Moffat County	Surface	1.0 in 1980 (Total with Unnamed, Moffat County) Blue			75
Wise Hill #5 N 40°26' W 107°39' Moffat County	Underground & Surface	0.5 in 1975 0.4 in 1977 0.6 in 1980 Blue	Moist - 16.0% Ash - 5.8% Sulfur - 0.5% Btu/lb - 10,600	72 (90 in 1976)[d]	150
Gordon N 40°11' W 108°43' Rio Blanco County	2 Underground 1 Surface	1.5 in 1980 2.3 in 1985 3.7 in 1990 Green	Moist - 13% Ash - 9% Sulfur - 0.4% Btu/lb - 11,100	0	700
Apex #2 N 40°18' W 107°02' Routt County	Underground	0.10 in 1977 0.25 in 1980 Blue	Moist - 6-9.2% Ash - 3-12.1% Sulfur - 0.5-0.7% Btu/lb - 12,400		
Dawson Unit N 40°29' W 107°14' Routt County	Underground	0.1 in 1977 or 1978 2.0-4.0 maximum Green	Moist - 7% Ash - 8% Sulfur - 0.5% Btu/lb - 11,500		

(continued)

TABLE B-1. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr);Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Edna N 40°20' W 107°01' Routt County	Surface	0.8 in 1975 1.1 in 1976 1.0 in 1979 0.85 in 1980	Moist - 7.7-12.5% Ash - 3.3-13.2% Sulfur - 0.6-1.2% Btu/lb - 10,400-12,000	75 (77 in 1976)[d]	75
Unnamed (14 mi. E. of Steamboat Springs) Routt County	Surface	1.0 in 1980 (Total with Unnamed, Moffat County) Blue			75

[a]Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); and Mineral Industry Location Systems (USBM, 1978).

[b]In order to be indicated on the map, a mine had to: (1) have development planned for 1980 or later and (2) be located with latitude-longitude or by some other detailed description. The total increase in tonnage was calculated as the maximum projected value minus the current value with blue = 0-1.00, green = 2.0-5.99, and red = 6.0 or greater (These were converted to symbols in this report, Figure 3).

[c]Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

[d]From Keystone Coal Industry Manual (Nielson, 1977).

TABLE B-2. COAL MINES UNDER DEVELOPMENT OR EXPANSION IN MONTANA[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
East Decker N 45°05' W 106°53' Big Horn County	Surface	10.2 in 1976(?) 20.0 in 1981 Red	Moist - 24.1% Ash - 4.3% Sulfur - 0.6% Btu/lb - 9,700	128[d]	435
Sarpy Creek N 45°49' W 107°04' Big Horn County	Surface	6.5 in 1980 15.0 in 1982 Red	Moist - 23% Ash - 11% Sulfur - 0.7% Btu/lb - 8,500		990
Spring Creek N 45°08' W 106°53' Big Horn County	Surface	10.0 in 1980 Red			
Young's Creek, Tanner Creek, Squirrel Creek Unnamed N 45°03' W 107°00' Big Horn County	Surface	6.0 in 1980 16.0 in 1985 Red	Moist - 24% Ash - 3.5% Sulfur - 0.25% Btu/lb - 9,400		435
Circle West N 47°23' W 105°34' McCone County	Surface	5.0 in 1983 Green	Moist - 34.9% Ash - 6.9% Sulfur - 0.5% Btu/lb - 6,930	0	200

(continued)

TABLE B-2. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Rosebud N 45°50' W 106°35' Rosebud County	Surface	9.2 in 1976 19.1 in 1980 Red	Moist - 24.6% Ash - 8.9% Sulfur - 0.7% Btu/lb - 8,703	275[d]	1,260

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); and Mineral Industry Location Systems (USBM, 1978).

(b) In order to be indicated on the map, a mine had to: (1) have development planned for 1980 or later and (2) be located with latitude-longitude or by some other detailed description. The total increase in tonnage was calculated as the maximum projected value minus the current value with blue = 0-1.00, green = 2.0-5.99, and red = 6.0 or greater (These were converted to symbols in this report, Figure 3).

(c) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(d) From Keystone Coal Industry Manual (Nielson, 1977).

TABLE B-3. COAL MINES UNDER DEVELOPMENT OR EXPANSION IN NORTH DAKOTA[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Falkirk N 46°49' W 100°47' Burleigh County	Surface	Under construction 5.0-6.0 in 1981 Green	Moist - 39.5% Ash - 6.8% Sulfur - 0.6% Btu/lb - 6,415	21	300
Dunn Center N 47°23' W 102°53' Dunn County	Surface	13.0-14.0 in 1982 Red	Moist - 34.0% Ash - 8.0% Sulfur - 0.8% Btu/lb - 6,800	0	300
Garrison N 47°38' W 101°26' McLean County	Surface	3.30 in 1984 Green			
Nokota Co. #1 (South of Max) McLean County	Surface	6.6 after 1982 Red			
Underwood N 47°27' W 101°07' McLean County	Surface	1.5 after 1985 Blue			
Washburn Washburn McLean County	Surface	5.0 after 1985 Green	Moist - 38% Ash - 4.4% Sulfur - 0.5% Btu/lb - 7,100		
Beulah N 47°16' W 101°46' Mercer County	Surface	1.3 in 1976 2.2 in 1981 4.4 in 1985 Green	Moist - 34-37% Ash - 5-8% Sulfur - 0.5-0.7% Btu/lb - 6,700-6,900	110 (58 in 1976)[d]	280

(continued)

TABLE B-3. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[(b)]	Coal Analysis	Employment[(c)] Current	Employment[(c)] Planned Future
Coteau N 47°26' W 101°49' Mercer County	Surface	7.0-7.5 in 1981 14.0-15.0 in 1985 Red	Moist - 36% Ash - 7.4%	12	360
Dakota Star N 47°22' W 101°38' Mercer County	Surface	4.0 after 1985 Green	Moist - 37% Ash - 6-7% Sulfur - 0.7% Btu/lb - 6,800-6,900		
Renners Cove Renners Cove Mercer County	Surface	3.0 after 1980 Green	Moist - 37% Ash - 7% Sulfur - 0.7% Btu/lb - 6,700-6,800		

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); and Mineral Industry Location Systems (USBM, 1978).

(b) In order to be indicated on the map, a mine had to: (1) have development planned for 1980 or later and (2) be located with latitude-longitude or by some other detailed description. The total increase in tonnage was calculated as the maximum projected value minus the current value with blue = 0-1.00, green = 2.0-5.99, and red = 6.0 or greater (These were converted to symbols in this report, Figure 3).

(c) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(d) From Keystone Coal Industry Manual (Nielson, 1977).

TABLE B-4. COAL MINES UNDER DEVELOPMENT OR EXPANSION IN UTAH[(a)]

Name and Location of Mine	Type of Mines	Current and Planned Future Production (million tons/yr); Map Color Indicator[(b)]	Coal Analysis	Employment[(c)] Current	Employment[(c)] Planned Future
Braztah, #3, 4, 5 and 6 N 39°43' W 110°55' Carbon County	Underground	#3 & 5 - 0.3 in 1975 #3 & 5 - 0.9 in 1976 6.5 in 1980 (all) Green	Moist - 5.7% Ash - 9.7% Sulfur - 0.5% Btu/lb - 12,300		2,250
O'Connor #1 (Near Clear Creek) Carbon County	Underground	0.2 in 1980 Blue			
Unnamed Carbon County	Underground	0.5 in 1980 Planning stages (None)			170
Star Point #3 (Near Wattis) Carbon County	Underground	1.0 in 1981 Blue			345
Emery (near Emery) Emery County	Underground	0.04 in 1975 0.08 in 1976 1.4 in 1980 Blue		82[(d)]	483
Ferron Canyon (Near Ferron) Emery County	Underground	1.0 in 1980 Blue			345
Straight Canyon (Near Castle Dale) Emery County	Underground	2.5 in 1980 Green			860
Unnamed, South of Hiawatha Emery County	Underground	1.6 in 1981 Blue			
Wilberg N 39°19' W 111°08' Emery County	Underground	0.2 in 1976 2.2 in 1980 Green	Moist - 5.4% Ash - 9.2% Sulfur - 0.6% Btu/lb - 12,500		760

(continued)

TABLE B-4. (Continued)

Name and Location of Mine	Type of Mines	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c]	
				Current	Planned Future
Escalante (Near Escalante) Garfield County	Underground	6.0 in 1985 Dependent on water available Red			2,070
Unnamed (Near Alton) Kane County	Surface	11.5 in 1982 Red	Sulfur - 1.1% Btu/lb - 10,200		760
Unnamed Sevier County	Underground	1.0 in 1980 Planning stages (None)			345
Intermountain Power Project Wayne County	Underground	10.0 in 1985 (None)			340
Unnamed (Factory Butte) Wayne County	Surface	1.0 in 1980 Start-up 1976 (None)			345

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977); and Mineral Industry Location Systems (USBM, 1978).

(b) In order to be indicated on the map, a mine had to: (1) have development planned for 1980 or later and (2) be located with latitude-longitude or by some other detailed description. The total increase in tonnage was calculated as the maximum projected value minus the current value with blue = 0-1.00, green = 2.0-5.99, and red = 6.0 or greater (These were converted to symbols in this report, Figure 3).

(c) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(d) From Keystone Coal Industry Manual (Nielson, 1977).

TABLE B-5. COAL MINES UNDER DEVELOPMENT OR EXPANSION IN WYOMING[a]

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c]	
				Current	Planned Future
Red Rim N 41°42' W 105°31' Albany County	Surface	2.5 in 1980 Green			
Bell Ayr South N 44°05' W 105°22' Campbell County	Surface	3.3 in 1975 7.3 in 1976 10-15 in 1980 Green	Moist - 26.2% Ash - 5.3% Sulfur - 0.6% Btu/lb - 8,800	250	350
Black Thunder N 43°40' W 105°15' Campbell County	Surface	7.0-10.0 in 1980 20.0 in 1982 Red	Moist - 28.1% Ash - 4.8% Sulfur - 0.3% Btu/lb - 8,600	61[d]	250
Buckskin Mine Campbell County	Surface	4.0 in 1980 Very tentative (None)	Btu/lb - 8,200		250
Caballo N 44°08' W 105°18' Campbell County	Surface	Planning stages 12.0 in 1980 Red			150
Cordero N 44°03' W 105°21' Campbell County	Surface	Under construction 12.0 in 1986 Red			400
Eagle Butte N 44°26' W 105°25' Campbell County	Surface	30.0 in 1980 Red	Moist - 29.2% Ash - 9.6% Sulfur - 0.8% Btu/lb - 8,200	0	350

(continued)

TABLE B-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
East Gillette N 44°19' W 105°28' Campbell County	Surface	Planned open 1977 5.0-11.0 in 1980 Red	Moist - 31.5% Ash - 5.7% Sulfur - 0.46% Btu/lb - 8,000		300
Jacobs Ranch N 43°42' W 105°41' Campbell County	Surface	Under construction 14.0 in 1983 Red	Most - 29.0% Ash - 5.8% Sulfur - 0.5% Btu/lb - 8,500	62[d]	300
Pronghorn N 44°03' W 105°21' Campbell County	Surface	5.0 in 1981 Green	Moist - 26.9% Ash - 5.3% Sulfur - 0.42% Btu/lb - 8,590		
Rawhide N 44°29' W 105°25' Campbell County	Surface	8.5 in 1980 Red	Moist - 31.0% Ash - 6.0% Sulfur - 0.4% Btu/lb - 8,100	48[d]	560
Rochelle N 43°36' W 105°14' Campbell County	Surface	5.0-11.0 in 1985 Red	Moist - 28.0% Ash - 5.6% Sulfur - 0.3% Btu/lb - 8,400		225
Thunderbird Campbell County	Surface	3.0 in 1980 Tentative (None)	Moist - 27.7% Ash - 13.4% Sulfur - 0.6% Btu/lb - 7,600		225

(continued)

TABLE B-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Wyodak N 44°17' W 105°21' Campbell County	Surface	0.8 in 1975 2.2 in 1980 Blue	Moist - 29.2% Ash - 9.6% Sulfur - 0.8% Btu/lb - 8,200	28	190
Atlantic Rim N 41°31' W 107°27' Carbon County	Surface	2.0 in 1983 Green	Moist - 13.7% Ash - 5.69% Sulfur - 0.89% Btu/lb - 10,698		
Carbon County Coal N 41°53' W 106°27' Carbon County	Underground	0.8 in 1976 2.5 in 1980 Blue	Moist - 11.5% Ash - 6.6% Sulfur - 0.9% Btu/lb - 10,800	90	
China Butte N 41°31' W 107°38' Carbon County	Surface	1.0-3.0 in 1980 4.0 in 1982 Green			
Medicine Bow N 41°55' W 106°46' Carbon County	Surface	2.8 in 1976 3.6 in 1980 Blue	Moist - 12.0% Ash - 7.5% Sulfur - 0.5% Btu/lb - 10,200	135	135 (125 in 1976)[d]
Vanguard #2 & 3 N 41°53' W 106°39' Carbon County	Underground	1.0 in 1975 1.1 in 1976 #2 (1.0-2.0 in 1980) #3 (0.5 in 1978) Blue	Moist - 13.0% Ash - 11.5% Sulfur - 0.4% Btu/lb - 9,800	120	120 (150 in 1976)[d]
Stevens North N 43°08' W 105°45' Converse County	Surface	5.0 in 1985 Green			
Grass Creek N 43°55' W 108°41' Hot Springs County	Surface	0.7 in 1980 Blue	Moist - 12.1% Ash - 9.0% Sulfur - 0.4% Btu/lb - 10,800		100

(continued)

TABLE B-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Elkol N 41°42' W 110°34' Lincoln County	Surface	1.0 in 1975 1.8 in 1976 1.1 in 1980 Blue	Moist - 20.4% Ash - 3.0% Sulfur - 0.7% Btu/lb - 10,200	35 (150 in 1976)[d]	80
FMC Mine, Skull Point N 41°42' W 110°38' Lincoln County	Surface	1.0-2.0 in 1980 Blue	Moist - 20.9% Ash - 4.8% Sulfur - 0.6% Btu/lb - 9,500	60	100
Sorenson N 41°42' W 110°34' Lincoln County	Surface	1.7 in 1975 2.3 in 1976 3.0-4.7 in 1980 Blue	Moist - 20.9% Ash - 4.8% Sulfur - 0.6% Btu/lb - 9,500	300	350
Twin Creek N 41°47' W 110°34' Lincoln County	Surface	Planning stages 3.0 in 1980 Green			200
Big Horn #1 N 44°53' W 106°58' Sheridan County	Surface	0.8 in 1976 1.5 in 1980 Blue	Moist - 24.5% Ash - 5.8% Sulfur - 0.7% Btu/lb - 9,300	69	69
Black Butte N 41°36' W 108°41' Sweetwater County	Surface	4.2 in 1980 Planned open 1977 Green	Moist - 17.7% Ash - 8.5% Sulfur - 0.4% Btu/lb - 9,700	35	200
Cherokee N 41°42' W 107°45' Sweetwater County	Surface	6.0 in 1984 Red	Moist - 21.92% Ash - 14.56% Sulfur - 1.75% Btu/lb - 8,000		

(continued)

TABLE B-5. (Continued)

Name and Location of Mine	Type of Mine	Current and Planned Future Production (million tons/yr); Map Color Indicator[b]	Coal Analysis	Employment[c] Current	Employment[c] Planned Future
Jim Bridger N 41°46' W 108°45' Sweetwater County	Surface	3.4 in 1976 7.5 in 1980 Green	Moist - 20.5% Ash - 9.7% Sulfur - 0.5% Btu/lb - 9,300	120 (165 in 1976)[d]	200
Rainbow #8 N 41°31' W 109°13' Sweetwater County	Underground	0.1 in 1976 0.2 in 1980 Blue	Moist - 11.4% Ash - 4.2% Sulfur - 0.9% Btu/lb - 11,700	70 (83 in 1976)[d]	70
Stansbury #1 N 41°41' W 109°11' Sweetwater County	Underground	Opening planned for 1978 1.4 in 1980 Blue	Moist - 17.5% Ash - 4.7% Sulfur - 1.1% Btu/lb - 10,500	30	275

(a) Based on Bureau of Mines Information Circular 8772 (Rich, 1978); Bureau of Mines Information Circular 8719 (Corsentino, 1976); Keystone Coal Industry Manual (Nielson, 1977), and Mineral Industry Location System (USBM, 1978).

(b) In order to be indicated on the map, a mine had to: (1) have development planned for 1980 or later and (2) be located with latitude-longitude or by some other detailed description. The total increase in tonnage was calculated as the maximum projected value minus the current value with blue = 0-1.99, green = 2.0-5.99, and red = 6.0 or greater (these were converted to symbols in this report, Figure 3).

(c) Unless otherwise noted, employment figures are from Bureau of Mines Information Circular 8772 (Rich, 1978).

(d) From Keystone Coal Industry Manual (Nielson, 1977).

APPENDIX C

ANALYSIS OF MORTALITY RATES

SEX-AGE DISEASE CATEGORY	WHITE MALE				WHITE FEMALE				NON-WHITE MALE				NON-WHITE FEMALE			
	≤ 24	25-44	45-64	≥ 65	≤ 24	25-44	45-64	≥ 65	≤ 24	25-44	45-64	≥ 65	≤ 24	25-44	45-64	≥ 65
TOT MN[(a)]	6.9	27.4	264.2	1208.9	5.1	31.4	232.5	745.6	4.2	32.6	279.2	1131.8	3.9	35.7	314.2	671.6
GI-MN [(b)]	0.1	4.3	63.4	347.5	0.1	4.4	45.4	254.2	.0	9.3	89.2	273.9	1.4	4.5	90.5	277.8
RT-MN [(c)]	0.3	4.4	96.0	296.5	0.1	1.8	31.0	60.4	.0	4.7	104.4	346.6	.0	3.1	33.5	59.1
UT-MN [(d)]	0.1	1.0	13.5	82.8	0.1	0.4	6.5	32.7	.0	1.4	20.5	104.2	.0	.0	9.1	37.2
CARDIO[(e)]	4.1	42.4	559.6	4098.8	3.3	17.6	204.7	3163.1	4.9	91.7	716.3	2867.2	5.9	34.4	280.7	2887.8
ISCHEM[(f)]	0.3	27.3	429.0	2674.4	0.1	4.6	122.5	1786.1	.0	38.6	472.8	1720.8	.0	10.3	135.5	1524.8
CEREBR[(g)]	1.0	5.5	52.1	810.8	1.1	6.3	47.2	861.8	2.3	20.0	118.6	564.7	0.6	12.0	105.9	678.2
RESPIR[(h)]	3.7	3.9	54.5	548.6	3.1	4.0	25.5	314.8	10.8	18.6	77.6	557.4	12.3	12.0	48.0	212.2
CIRRHS[(i)]	0.1	3.4	51.5	58.0	0.2	5.2	26.1	22.4	0.5	79.1	151.7	89.7	1.4	72.7	96.9	28.4
MV ACC[(j)]	41.8	50.7	33.2	53.1	15.3	14.0	13.3	21.3	73.5	125.7	74.0	72.7	26.8	53.6	20.8	21.9
SU-HOM[(k)]	14.5	46.7	47.0	51.5	4.9	15.8	17.7	14.4	45.2	156.9	89.2	89.7	16.2	43.3	20.8	15.3

(a) Total malignant neoplasms.
(b) Malignant neoplasms of the gastrointestinal system.
(c) Malignant neoplasms of the respiratory tract.
(d) Malignant neoplasms of the urinary tract.
(e) Major cardiovascular disease.
(f) Ischemic heart disease.
(g) Cerebrovascular disease.
(h) Respiratory disease.
(i) Cirrhosis of the liver.
(j) Motor vehicle accidents.
(k) Suicides and homicides.

TABLE C-2. STANDARDIZED MORTALITY RATIOS (BY COUNTY)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RT-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-COLORADO-											
ADAMS	1.070	1.067	1.264	0.883	1.018	1.030	0.867	1.359	0.888	0.744	1.148
ALAMOSA	0.814	0.546	0.887	1.282	0.741	0.752	0.665	0.805	0.506	0.754	0.533
ARAPAHOE	0.904	0.781	0.927	0.874	0.791	0.766	0.758	0.818	0.642	0.524	0.802
ARCHULETA	0.521	0.845	0.330	.000	0.930	0.914	0.394	1.364	1.625	1.830	.000
BACA	0.952	0.641	1.212	0.516	0.699	0.672	0.695	1.086	.000	2.330	0.749
BENT	1.039	0.601	1.042	0.410	0.803	0.883	0.851	1.788	0.584	1.980	0.798
BOULDER	0.551	0.604	0.474	0.467	0.601	0.625	0.509	0.569	0.468	0.757	0.758
CHAFFEE	0.922	1.243	0.989	1.322	0.918	0.954	0.694	1.221	0.421	0.555	1.615
CHEYENNE	0.971	0.622	1.190	1.423	1.021	1.121	1.208	1.213	.000	1.499	0.585
CLEAR CREEK	1.015	0.331	2.331	0.757	0.534	0.508	0.585	1.139	1.362	1.410	0.806
CONEJOS	0.563	0.294	0.531	.000	0.849	0.943	0.680	0.916	1.250	1.649	0.599
COSTILLA	1.081	1.302	0.634	.000	0.711	0.554	0.846	0.504	.000	3.236	1.493
CROWLEY	0.737	1.051	0.863	0.737	1.051	1.333	0.710	0.249	0.505	1.748	0.308
CUSTER	1.477	1.329	1.270	2.115	0.713	0.457	0.762	.000	.000	0.894	2.498
DELTA	0.808	0.946	0.908	0.741	0.817	0.840	0.913	1.217	0.513	0.908	0.792
DENVER	1.064	1.072	1.058	1.147	0.932	0.955	0.759	1.002	1.294	0.602	1.516
DOLORES	0.891	1.429	1.321	.000	0.836	0.443	0.864	.000	.000	.000	0.707
DOUGLAS	0.414	0.507	0.248	0.306	0.480	0.500	0.441	0.664	0.354	0.711	0.585
EAGLE	0.776	0.981	1.041	.000	0.488	0.405	0.488	0.813	0.263	1.423	1.249
ELBERT	0.528	0.899	0.467	.000	0.599	0.718	0.187	0.600	.000	1.249	0.561

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RT-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-COLORADO-											
EL PASO	0.912	0.906	0.902	0.842	0.890	0.899	0.926	1.204	1.070	0.637	1.041
FREMONT	0.915	0.680	1.286	0.054	1.017	1.061	0.832	1.364	0.493	1.017	1.727
GARFIELD	0.655	0.743	0.603	0.190	0.672	0.604	0.611	0.913	0.376	1.335	1.573
GILPIN	0.387	.000	1.039	.000	0.665	0.622	0.845	0.890	.000	0.541	2.961
GRAND	0.583	.000	0.956	0.716	0.554	0.589	0.728	0.262	.000	0.546	0.919
GUNNISON	0.758	0.328	0.421	2.519	0.761	0.744	0.609	0.378	0.354	1.208	.000
HINSDALE	0.386	1.412	.000	.000	0.904	0.918	0.667	.000	4.240	2.001	.000
HUERFANO	1.067	0.997	1.110	0.865	1.030	1.244	0.718	0.591	1.997	1.037	1.328
JACKSON	0.895	1.708	0.639	.000	1.020	1.336	0.587	.000	2.997	0.557	1.715
JEFFERSON	0.946	0.852	0.919	0.956	0.838	0.866	0.788	0.922	0.688	0.610	1.004
KIOWA	1.018	1.204	0.378	3.482	0.879	0.939	0.537	1.261	0.871	2.728	0.614
KIT CARSON	1.249	1.421	0.846	1.868	0.795	0.920	0.440	0.648	0.600	0.877	0.403
LAKE	1.181	1.197	0.933	1.001	0.754	0.406	1.080	1.596	0.349	1.877	1.134
LA PLATA	0.827	1.020	0.526	1.277	0.830	0.862	0.636	0.760	1.674	0.848	1.204
LARIMER	0.678	0.675	0.569	1.089	0.831	0.866	0.734	0.658	0.618	0.998	0.763
LAS ANIMAS	0.895	0.855	0.842	0.551	1.075	1.119	1.080	1.018	1.601	1.415	1.031
LINCOLN	0.821	1.069	0.500	1.925	1.049	1.412	0.419	0.560	2.730	2.852	1.132
LOGAN	0.900	1.135	0.449	1.887	1.006	1.072	0.696	0.830	1.246	1.521	0.891
MESA	0.863	0.871	1.123	0.948	0.873	0.840	0.975	0.832	0.743	1.603	1.226
MINERAL	0.313	.000	.000	.000	0.515	0.442	.000	.000	.000	1.273	1.745

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RT-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CERBRA[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-COLORADO-											
MOFFAT	0.625	0.634	1.024	.000	0.684	0.588	0.528	0.954	0.587	2.163	1.448
MONTEZUMA	0.744	0.623	0.987	0.637	0.815	0.816	0.591	1.313	0.566	1.485	1.475
MONTROSE	0.953	0.926	1.071	1.390	0.894	0.756	1.051	1.407	0.667	1.017	0.853
MORGAN	0.675	0.617	0.738	0.372	0.924	0.922	0.962	1.320	0.642	1.359	1.049
OTERO	0.728	0.570	0.925	0.759	1.029	1.166	0.903	1.156	0.833	1.248	1.821
OURAY	0.854	0.346	.000	4.462	0.663	0.531	0.871	0.284	.000	1.325	1.697
PARK	0.719	1.309	0.508	.000	0.594	0.787	0.350	.000	.000	0.893	0.778
PHILLIPS	0.923	0.456	0.517	0.569	1.218	1.396	0.437	0.354	0.400	1.025	0.299
PITKIN	0.753	0.435	0.744	.000	0.541	0.459	0.796	0.553	0.340	1.511	0.666
PROWERS	1.074	1.165	1.155	0.608	1.060	0.922	0.593	0.716	0.906	0.982	0.778
PUEBLO	0.895	0.847	1.118	0.889	0.996	1.077	0.786	1.112	1.491	0.779	1.318
RIO BLANCO	0.771	.000	0.203	1.928	1.208	1.169	1.618	1.238	0.986	1.870	.000
RIO GRANDE	0.975	0.790	1.362	0.740	1.015	0.807	1.420	0.937	1.458	1.139	1.382
ROUTT	0.435	0.239	0.324	.000	0.696	0.758	0.508	0.634	0.939	0.686	0.321
SAGUACHE	0.704	1.257	0.769	0.887	0.687	0.638	1.026	0.432	1.220	1.089	1.913
SAN JUAN	0.305	.000	.000	.000	0.897	1.424	.000	.008	.000	.000	1.635
SAN MIGUEL	0.728	1.159	1.080	.000	0.592	0.586	0.689	1.569	.000	0.980	2.386
SEDGWICK	1.097	1.174	1.229	0.832	0.852	0.719	1.042	0.819	.000	1.999	1.252
SUMMIT	0.633	0.606	0.707	1.408	0.160	0.147	0.146	.000	.000	3.103	0.845
TELLER	0.961	1.055	0.718	0.640	0.384	0.317	0.648	0.221	.000	1.969	1.777

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RE-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-COLORADO-											
WASHINGTON	0.996	0.752	0.586	1.217	0.888	0.797	1.000	0.772	.000	1.388	0.231
WELD	0.751	0.749	0.847	1.094	0.810	0.808	0.703	0.853	0.374	0.992	0.681
YUMA	0.788	0.949	0.264	0.977	1.038	0.752	1.217	0.703	0.458	1.264	0.483
-MONTANA-											
BEAVERHEAD	1.204	1.354	1.179	1.422	1.062	0.762	1.038	2.134	1.438	2.458	1.096
BIG HORN	0.819	0.756	0.739	0.448	0.969	0.638	1.239	1.038	1.595	2.128	0.671
BLAINE	0.769	0.707	0.411	0.472	1.227	0.812	1.302	0.638	0.504	1.327	0.856
BROADWATER	1.415	1.799	1.787	.000	0.834	0.697	0.593	0.807	0.646	2.376	1.537
CARBON	0.862	1.128	0.725	1.010	0.876	0.587	1.128	0.546	0.676	0.865	0.695
CARTER	1.067	1.632	0.398	1.538	0.837	0.761	0.545	1.298	.000	0.535	0.679
CASCADE	1.050	1.125	1.302	0.943	0.945	0.741	0.886	0.822	0.942	1.046	1.045
CHOUTEAU	0.628	0.646	0.433	1.205	1.058	0.996	0.627	0.439	0.289	0.807	.000
CUSTER	0.927	1.076	0.946	1.661	1.156	1.112	1.269	1.532	0.894	0.796	0.957
DANIELS	0.910	1.106	1.317	.000	0.876	0.799	0.716	0.130	0.569	2.504	1.392
DAWSON	0.778	1.381	0.339	0.402	0.980	0.915	0.986	0.738	0.959	1.048	0.575
DEER LODGE	0.975	1.244	1.105	0.487	0.981	0.931	0.881	1.011	0.885	0.883	0.842
FALLON	1.267	1.479	0.878	1.940	0.884	0.720	1.164	1.395	0.572	1.452	0.818
FERGUS	0.986	0.816	0.729	0.736	1.013	1.016	0.934	1.594	0.145	0.858	0.581
FLATHEAD	0.990	0.984	0.895	0.906	0.950	0.960	0.887	0.689	0.748	0.934	0.889

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RT-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-MONTANA-											
GALLATIN	0.809	0.649	0.770	0.730	0.845	0.760	0.885	0.873	0.471	0.869	0.698
GARFIELD	1.313	0.396	1.190	.000	0.811	0.610	0.400	2.406	.000	1.322	.000
GLACIER	0.987	0.652	0.647	0.879	0.910	0.769	0.791	0.953	2.381	2.427	0.609
GOLDEN VALLEY	1.327	0.525	1.733	.000	0.859	0.596	1.271	0.413	.000	4.712	1.365
GRANITE	1.333	1.683	0.945	.000	0.827	0.669	0.683	0.416	0.645	2.486	0.464
HILL	0.997	0.861	1.601	0.575	1.005	1.035	0.755	1.174	1.036	0.873	0.713
JEFFERSON	0.841	1.125	0.857	0.605	0.660	0.615	0.801	0.903	1.099	0.635	0.469
JUDITH BASIN	0.419	0.660	.000	1.032	0.703	0.591	0.384	0.155	.000	0.878	0.475
LAKE	0.807	0.614	1.022	0.570	0.955	0.916	0.951	1.172	0.303	2.194	0.935
LEWIS + CLARK	1.056	1.008	1.422	1.063	0.904	0.800	0.739	0.991	1.020	0.981	1.372
LIBERTY	0.777	0.323	.000	7.633	1.308	1.557	0.508	0.894	0.888	1.358	.000
LINCOLN	1.165	1.333	1.747	1.133	1.139	1.182	0.747	0.938	.000	0.816	1.037
MC CONE	0.458	0.842	0.778	.000	1.209	1.112	0.769	0.472	0.761	0.863	1.158
MADISON	1.003	1.168	1.350	0.472	0.619	0.518	0.832	1.155	0.295	1.707	1.657
MEAGHER	1.426	1.131	1.882	.000	0.975	0.616	0.933	1.600	.000	1.863	0.539
MINERAL	0.948	0.761	0.960	2.791	0.598	0.553	0.256	1.045	0.627	0.877	1.296
MISSOULA	0.971	1.090	1.194	0.746	0.934	0.920	0.993	0.976	0.350	0.928	0.952
MUSSELSHELL	0.899	0.737	0.678	0.594	0.832	0.729	0.947	1.074	0.393	2.666	0.305
PARK	0.754	0.603	0.794	1.284	1.076	0.985	1.128	0.853	0.403	1.615	0.820

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN(a)	GI-MN(b)	RT-MN(c)	UT-MN(d)	CARDIO(e)	ISCHEM(f)	CEREBR(g)	RESPIR(h)	CIRRHS(i)	MV ACC(j)	SU-HOM(k)
-MONTANA-											
PETROLEUM	2.340	.000	4.649	6.375	0.601	0.436	0.609	.000	.000	1.515	.000
PHILLIPS	0.801	0.691	0.954	1.270	1.151	1.253	0.857	0.455	1.102	1.371	0.543
PONDERA	0.900	0.664	1.671	.000	0.803	0.820	0.750	0.979	0.903	1.852	1.903
POWDER RIVER	0.800	.000	1.145	.000	0.670	0.805	0.391	0.974	.000	2.411	2.561
POWELL	0.821	1.115	0.690	0.491	1.016	0.972	0.452	0.730	1.442	1.592	1.265
PRAIRIE	1.280	1.852	1.626	.000	1.115	1.074	0.952	0.520	.000	2.361	.000
RAVALLI	0.912	1.093	0.915	0.356	0.863	0.885	0.773	0.732	0.234	1.141	1.010
RICHLAND	1.256	1.199	1.564	2.463	1.116	1.046	1.036	0.675	0.704	1.142	0.789
ROOSEVELT	1.045	1.153	0.951	0.851	1.073	1.050	0.850	0.840	2.668	2.499	0.873
ROSEBUD	0.805	0.813	0.579	1.305	0.606	0.680	0.557	1.200	1.536	2.177	0.453
SANDERS	1.000	1.201	1.154	0.834	0.857	0.758	1.062	0.529	0.923	2.900	2.173
SHERIDAN	1.407	1.216	1.644	2.566	0.843	0.960	0.612	1.094	1.139	2.309	1.368
SILVER BOW	1.053	1.215	1.022	0.605	1.120	1.114	1.012	1.080	1.509	1.493	0.981
STILLWATER	0.730	0.639	0.758	1.703	0.857	0.702	1.247	0.578	.000	0.641	1.053
SWEET GRASS	1.149	0.513	1.633	1.087	0.807	0.582	1.034	1.590	0.553	0.782	0.972
TETON	0.807	0.585	0.919	2.039	0.992	0.841	1.264	0.460	0.933	0.362	1.336
TOOLE	1.147	1.352	1.656	1.559	1.240	1.325	1.253	0.771	0.360	2.319	0.810
TREASURE	0.640	.000	0.753	2.953	0.817	0.035	0.560	1.464	.000	0.830	.000
VALLEY	1.010	0.933	1.500	1.050	0.801	0.962	0.430	0.738	1.028	0.402	0.967
WHEATLAND	0.671	0.736	0.703	1.102	0.976	0.580	1.536	0.500	2.365	.000	.000

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RT-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-MONTANA-											
WIBAUX	0.849	1.342	.000	.000	0.923	1.085	1.011	0.738	.000	3.037	.000
YELLOWSTONE	1.033	1.011	1.180	1.564	0.886	0.779	1.007	0.808	0.894	0.995	0.865
-N. DAKOTA-											
ADAMS	0.941	0.658	1.429	.000	0.854	0.891	0.657	1.612	0.508	0.271	0.031
BARNES	1.215	1.080	1.366	0.701	1.065	1.131	0.808	1.043	1.088	1.681	0.101
BENSON	0.912	1.071	0.842	0.832	0.904	0.976	0.578	0.933	1.829	1.945	1.598
BILLINGS	0.441	.000	0.658	.000	0.327	0.507	.000	2.117	1.718	.000	.000
BOTTINEAU	0.888	0.834	1.053	0.659	0.973	1.129	0.720	0.932	.000	0.787	1.336
BOWMAN	0.841	1.021	0.213	1.945	1.195	1.262	1.282	0.820	0.489	1.050	0.756
BURKE	1.005	1.763	0.592	.000	0.977	0.933	1.190	1.661	.000	2.164	0.305
BURLEIGH	1.021	0.998	0.993	0.939	0.864	0.945	0.774	0.663	0.537	0.837	0.516
CASS	0.917	0.964	0.866	1.509	0.868	0.725	0.893	0.816	0.576	0.682	0.663
CAVALIER	0.694	0.814	0.777	0.571	0.747	0.748	0.760	0.518	.008	1.035	0.366
DICKEY	0.838	1.239	0.314	0.819	1.019	1.156	0.667	0.794	0.803	0.504	0.409
DIVIDE	1.372	1.567	0.399	2.252	1.027	1.078	1.001	1.110	1.352	1.318	0.691
DUNN	0.846	0.525	1.137	0.840	0.852	0.909	0.687	0.992	0.391	2.469	0.618
EDDY	0.828	1.553	0.423	.000	0.8[illegible]3	0.744	0.707	2.060	1.083	0.893	0.348

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT RR(a)	GI-RR(b)	RT-RR(c)	UT-RR(d)	CARDIO(e)	ISCHEM(f)	CEREBR(g)	RESPIR(h)	CIRRHS(i)	MV ACC(j)	SUI-HOM(k)
-N. DAKOTA-											
EMMONS	0.993	1.021	1.064	0.552	1.0:0	0.066	1.023	0.274	0.739	1.087	.000
FOSTER	0.910	0.026	0.762	0.660	1.167	0.803	2.360	0.746	.000	0.786	0.959
GOLDEN VALLEY	0.595	0.496	0.723	1.172	0.969	1.095	0.690	0.169	.000	1.321	0.529
GRAND FORKS	0.978	0.991	0.946	1.009	0.925	1.039	0.572	0.054	0.764	0.385	0.571
GRANT	1.159	1.256	1.015	1.741	1.293	1.320	1.483	0.766	0.395	0.678	0.269
GRIGGS	1.041	1.604	0.061	.000	0.867	0.754	0.766	1.740	0.392	1.352	0.298
HETTINGER	0.997	1.296	1.471	1.010	1.208	1.278	1.169	1.171	1.001	1.204	.000
KIDDER	0.939	0.674	1.029	.000	1.089	0.010	0.722	1.255	.000	0.705	0.730
LA MOURE	0.971	1.096	1.309	0.954	1.176	1.397	0.011	0.463	.000	0.036	0.023
LOGAN	0.089	0.752	1.749	0.937	1.0A9	1.279	0.998	0.475	.000	0.257	0.341
MC HENRY	0.971	1.256	0.992	0.354	0.912	0.973	0.714	0.702	0.502	1.433	1.172
MC INTOSH	1.075	1.709	0.769	1.210	0.936	1.014	0.461	0.041	0.333	0.454	0.022
MC KENZIE	1.199	1.205	0.025	1.959	0.027	0.566	1.013	1.101	0.949	1.369	0.195
MC LEAN	0.015	1.037	0.665	1.140	1.154	1.396	0.092	0.650	0.030	1.318	0.467
MERCER	0.914	0.408	1.142	2.092	0.994	1.200	0.675	0.953	.000	0.672	0.056
MORTON	1.025	1.003	0.064	1.172	0.985	1.100	0.721	0.539	0.346	1.195	0.584
MOUNTRAIL	1.050	1.396	0.724	1.613	1.002	1.098	1.078	1.477	0.652	2.562	1.258
NELSON	0.663	0.452	0.654	1.569	1.215	1.354	0.781	1.046	.000	0.717	0.089
OLIVER	0.594	1.127	.000	.000	0.934	0.759	0.726	1.591	.000	1.397	0.565
PEMBINA	0.965	1.078	1.050	0.237	1.137	0.978	1.589	0.541	0.526	1.468	0.115

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RI-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-N. DAKOTA-											
PIERCE	0.794	1.062	0.531	1.564	0.899	0.911	0.745	0.755	0.672	1.495	0.467
RAMSEY	1.158	1.216	0.993	0.974	0.999	0.978	1.116	0.544	0.970	0.827	0.636
RANSOM	1.010	1.033	0.792	1.093	1.140	1.181	1.394	0.580	0.777	0.790	0.411
RENVILLE	0.875	0.917	0.486	0.855	1.270	1.459	0.833	0.568	.000	1.775	.000
RICHLAND	0.968	1.167	0.728	1.174	0.942	0.842	1.327	1.174	0.241	0.687	0.403
ROLETTE	1.178	1.329	0.604	3.421	0.832	0.934	0.420	1.332	0.792	1.067	0.526
SARGENT	0.614	0.605	0.708	1.123	1.016	1.021	1.147	0.544	1.032	1.102	.000
SHERIDAN	0.943	0.756	0.754	0.921	1.016	1.043	1.170	0.613	.000	1.291	0.374
SIOUX	0.498	0.273	0.807	3.236	0.983	1.055	0.636	1.908	5.001	1.284	1.200
SLOPE	0.918	.000	1.022	7.595	1.122	1.151	0.285	.000	.000	0.746	.000
STARK	1.011	1.144	0.722	1.511	1.257	1.376	1.206	0.625	0.743	0.926	0.335
STEELE	0.700	0.357	0.698	0.800	0.965	0.704	1.113	1.710	.000	0.925	.000
STUTSMAN	0.879	1.118	0.884	0.932	0.982	1.048	0.850	0.889	0.282	0.875	0.771
TOWNER	1.102	0.941	0.563	.000	1.128	1.246	1.079	0.421	.000	1.566	0.304
TRAILL	0.929	1.113	0.559	0.269	0.937	0.863	1.126	1.713	0.821	1.359	0.143
WALSH	0.992	0.882	0.732	0.771	0.966	0.960	1.029	1.155	0.381	0.980	0.731
WARD	0.933	1.120	0.824	1.182	0.905	0.957	0.841	0.644	0.730	0.723	0.458
WELLS	0.944	0.919	0.791	1.720	1.108	1.235	0.899	0.586	0.255	0.939	0.610
WILLIAMS	0.877	1.187	0.469	0.482	1.101	1.138	0.904	0.894	0.377	1.206	0.243

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT NM(a)	GI-NM(b)	RE-NM(c)	UT-NM(d)	CARDIO(e)	ISCHEM(f)	CERBR(g)	RESPIR(h)	CIRRHS(i)	MV ACC(j)	SU-HOM(k)
-UTAH-											
BEAVER	0.997	0.640	0.605	.000	0.870	0.859	0.955	0.279	1.095	1.405	0.767
BOX ELDER	0.934	0.922	0.559	1.112	0.976	0.847	1.059	0.905	0.192	0.867	0.911
CACHE	0.609	0.764	0.289	0.560	0.870	0.765	1.186	0.641	0.443	0.558	0.492
CARBON	0.826	1.106	1.061	0.427	0.960	1.188	0.615	0.714	0.784	1.394	1.319
DAGGETT	.000	.000	.000	.000	0.760	0.711	0.643	1.099	.000	1.266	.000
DAVIS	0.803	0.550	0.656	0.665	0.800	0.832	0.708	0.710	0.408	0.490	0.466
DUSHESNE	0.509	0.632	0.470	0.785	0.530	0.549	0.620	0.730	0.924	1.177	0.929
EMERY	0.791	0.759	1.055	1.250	0.819	0.782	0.825	0.446	0.319	0.520	0.911
GARFIELD	0.324	0.493	.000	.000	0.765	0.430	0.642	0.169	0.637	1.833	2.381
GRAND	1.313	1.743	2.607	.000	0.949	0.731	1.325	1.250	0.439	1.229	0.229
IRON	0.870	1.176	0.649	1.447	0.787	0.721	0.835	0.933	0.778	0.755	0.440
JUAB	0.600	0.537	.000	.000	1.133	0.871	1.293	0.754	.000	2.041	.000
KANE	0.677	0.676	0.902	1.083	0.736	0.757	0.401	1.249	.008	1.310	.000
MILLARD	0.551	0.748	0.591	0.399	0.777	0.789	0.758	1.171	0.589	1.419	.000
MORGAN	0.800	0.900	1.001	1.235	0.895	1.069	0.606	0.617	.000	1.083	0.785
PIUTE	0.810	0.446	1.422	2.305	1.032	1.860	0.861	1.541	.000	0.815	1.046
RICH	0.491	0.410	.000	2.257	1.247	1.060	1.077	1.129	.000	0.595	0.815
SALT LAKE	0.840	0.829	0.747	0.730	0.834	0.820	0.833	0.736	0.711	0.711	0.899
SAN JUAN	0.534	0.350	0.758	.000	0.362	0.265	0.232	1.206	0.848	2.193	0.426
SANPETE	0.613	0.539	0.486	1.022	1.046	1.018	0.859	0.828	0.371	0.765	1.153
SEVIER	0.469	0.280	0.395	0.266	1.000	0.800	1.235	0.689	0.553	1.249	1.157

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RT-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-UTAH-											
SUMMIT	0.741	1.064	0.536	0.638	1.976	0.910	1.426	0.720	1.181	1.015	1.624
TOOELE	0.860	0.995	0.803	.000	1.123	1.272	0.837	0.571	0.982	0.967	1.016
UINTAH	0.791	0.762	0.703	0.661	0.637	0.739	0.416	0.381	1.753	1.629	1.441
UTAH	0.822	0.852	0.630	0.339	0.819	0.787	0.723	0.801	0.639	0.674	0.343
WASATCH	0.581	0.784	0.330	1.305	0.776	0.734	0.763	1.019	0.725	0.765	0.443
WASHINGTON	0.659	0.698	0.286	0.434	0.791	0.780	0.831	0.532	0.295	0.981	0.803
WAYNE	0.918	1.900	0.446	1.775	0.852	0.587	1.164	0.267	.000	.000	.000
WEBER	0.871	0.864	0.672	0.837	0.936	0.965	0.858	0.868	1.260	0.764	1.009
-WYOMING-											
ALBANY	0.977	0.812	1.055	1.258	0.951	0.888	0.721	0.574	0.828	0.860	0.862
BIG HORN	0.805	0.893	0.865	0.271	0.838	0.946	0.495	0.762	0.390	1.308	0.674
CAMPBELL	0.694	0.877	0.709	.000	1.066	1.063	0.829	1.139	0.540	2.599	1.086
CARBON	0.912	0.917	0.945	1.457	0.871	0.804	1.025	0.525	0.884	1.655	1.873
CONVERSE	0.829	0.465	0.694	1.315	0.817	0.849	0.729	0.517	0.246	2.929	1.264
CROOK	1.018	1.196	1.168	0.842	0.999	0.885	0.895	0.979	1.044	0.211	1.225
FREMONT	1.030	0.875	1.152	1.281	0.889	0.867	0.757	1.024	1.706	2.488	0.756
GOSHEN	0.841	0.685	1.300	0.868	0.867	0.882	1.118	0.418	0.162	1.028	0.265
HOT SPRINGS	1.013	1.180	1.046	.000	1.159	1.339	0.988	1.235	2.250	2.917	1.107
JOHNSON	1.091	0.984	1.496	.000	0.924	0.858	1.192	2.256	1.400	1.181	0.984
LARAMIE	1.014	0.955	1.168	0.940	0.898	1.001	0.615	0.792	1.248	0.925	1.018
LINCOLN	0.737	0.484	0.738	0.910	0.804	0.696	1.115	0.530	0.494	2.418	0.326

(continued)

TABLE C-2. (Continued)

STATES BY COUNTY	TOT MN[a]	GI-MN[b]	RT-MN[c]	UT-MN[d]	CARDIO[e]	ISCHEM[f]	CEREBR[g]	RESPIR[h]	CIRRHS[i]	MV ACC[j]	SU-HOM[k]
-WYOMING-											
NATRONA	0.920	0.770	1.193	1.075	1.024	1.003	0.889	1.468	0.756	1.314	1.294
NIOBRARA	1.102	0.563	1.377	.000	0.720	0.616	0.961	0.761	0.588	0.829	1.024
PARK	0.750	0.499	1.036	1.469	1.072	0.999	1.230	0.630	0.268	1.578	1.046
PLATTE	0.766	0.409	0.925	.000	1.030	0.923	1.200	0.503	0.567	1.260	0.591
SHERIDAN	0.848	0.802	0.806	0.433	0.991	0.861	1.218	0.929	0.760	1.133	1.336
SUBLETTE	0.742	0.766	0.974	.000	0.794	0.852	0.639	0.844	.000	1.072	2.223
SWEETWATER	0.631	0.754	0.625	0.541	0.856	1.035	0.570	0.710	1.103	2.432	1.450
TETON	0.784	0.666	0.832	.000	0.724	0.789	0.586	0.431	1.245	1.210	1.203
UINTA	0.581	0.918	0.620	0.371	0.743	0.737	0.696	0.686	0.686	1.045	0.450
WASHAKIE	1.117	1.059	1.560	0.520	1.063	0.952	1.018	1.666	1.481	1.952	0.722
WESTON	0.823	0.395	1.776	1.449	1.136	1.252	0.835	1.171	0.360	1.630	0.963

(a) Total malignant neoplasms.

(b) Malignant neoplasms of the gastrointestinal system.

(c) Malignant neoplasms of the respiratory tract.

(d) Malignant neoplasms of the urinary tract.

(e) Major cariovascular disease.

(f) Ischemic heart disease.

(g) Cerebrovascular disease.

(h) Respiratory disease.

(i) Cirrhosis.

(j) Motor vehicle accidents.

(k) Suicides and homicides.

APPENDIX D

WATER SUPPLIES IN POTENTIALLY IMPACTED COMMUNITIES

TABLE D-1. INVENTORY OF PUBLIC WATER SUPPLIES: IMPACTED COMMUNITIES

State	County	Community or Area Served	Retail Pop.	Supply Type	Supply Source
Colorado					
	Adams	Aurora	110,000	Combined Surface and Well	
				Surface:	S. Platte R.
				Ground:	Cherry Creek Well
	Adams	Sable Water District (Aurora)	4,500	Purchased	Denver Water Bd.
	Adams	Brighton	8,500	12 Wells	local wells
	Adams	Lockbuie Mobile Home Park	1,000	Well	local well
	Adams	Commerce City	34,000	11 Wells	local wells
	Adams	Denver	9,000	Purchased	--
	Adams	Denver (Crestview Metro Water and Sanitation)	19,000	Purchased, Surface and Well combined	
				Purchased:	Denver Water Bd.
				Surface:	Clear Creek
				Ground:	3 Wells
	Adams	Federal Heights	5,000	Purchased	

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Supply Type	Supply Source
Colorado					
	Adams	Thronton	60,000	Combined Surface and Ground	
				Surface:	Clear Creek
				Ground:	18 Wells
	Adams	Westminster	35,000	Combined Surface and Ground	
				Surface:	Clear Creek Stanley Lake
				Ground:	Well
	Adams	Westminster (Shaw Heights Water District)	5,000	Purchased No information given	*
		Northglenn			
	Arapahoe	Englewood	1,470	Purchased	Denver Water Bd.
	Arapahoe	Greenwood Village	3,500	Purchased	Denver Water Bd.
	Arapahoe	Littleton	1,000	Purchased	Denver Water Bd
	Delta	Orchard City	3,000	Groundwater:	Springs
	Delta	Delta (Town of)	6,000	Surface	Grand Mesa Lake S. Grand Mesa L.

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Supply Type	Supply Source
	Delta	Paonia	2,000	Ground	Springs
	Denver	Denver Cherry Cr. Water and San. Dist.	3,100	Purchased	Denver Water Bd.
	Denver	Denver Clover Water and San. Dist.	6,400	Purchased	Denver Water Bd.
	Denver	Denver-City of Glendale	2,200	Ground	Local wells
	Elbert	Elizabeth	1,000		
	La Plata	Durango	12,000	Surface	Florida R. Animas R.
	La Plata	Durango-Tamaron Public Util. Dist.	1,300	*	*
	La Plata	Durango-Purgatory Water and San. District	1,000	Ground	3 local wells
	Las Animas	Trinidad-Monument Lake Park	1,000	Surface	Monument Lake
	Las Animas	Trinidad	11,000	Ground	North Lake Monument Lake

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Supply Type	Supply Source
	Moffat	Craig	4,400	Surface	Yampa R.
	Rio Blanco	Meeker	1,600	Surface	White River No. White River No.
	Rio Blanco	Rangely	1,800	Surface	White River
	Routt	Hayden	1,000	Surface	Yampa River
	Routt	Steamboat Springs	2,800	Surface	Fish Creek
	McCone	Circle	--	--	--
North Dakota	Burleigh	Bismarck	35,000	Surface	Missouri R.
	McLean	Garrison	1,700	Ground	Wells 1,4,5,6

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Supply: Type	Supply: Source
	Mercer	Beulah	1,344	Ground	Well 1,2
North Dakota	Mercer	Hazen	1,600	Ground	Well 1,2,3
	Morton	Mandan	11,000	Surface	Missouri R.
	Carbon	Helper	2,200	Ground	Spring Canyon Fish Creek Spr. UP & L Well Colt
	Carbon	Price	12,000	Surface and Ground	
				Surface:	Price R. Wt.
				Ground:	Colton Springs Upper Colton Springs Upper & Lower Well
	Carbon	Wellington	1,050	Purchased	City of Price

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Supply: Type	Supply: Source
	Emery	Huntington	1,000	Ground	Big Bear Canyon Little Bear Canyon
Wyoming					
	Campbell	Gillette	10,000	Ground	Approx. 25 wells
	Carbon	Rawlins	10,000	Surface and Ground Surface: Ground:	 Sage Creek Res. N. Platte River Sage Creek Basin
	Lincoln	Kemmerer	3,000	Surface	Hams Fork River
	Sheridan	Sheridan	8,000	Surface	Big Goose Creek
Utah					
	Emery	Ferron	1,000	Surface	Millsite Reservoir

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Treatment Method(s)	Lab Tests
Colorado					
	Adams	Aurora	110,000		
				Coagulation, Filtration, Disinfectant	Chem/Physical
				Disinfectant only	Chem/Physical
	Adams	Sable Water District (Aurora)	4,500	Prechlorination	None
	Adams	Brighton	8,500	Disinfection only	None
	Adams	Lockbuie Mobile Home Park	1,000	Disinfection only	None
	Adams	Commerce City	34,000	Disinfection only	Chem/Physical
	Adams	Denver	9,000	--	--
	Adams	Denver (Crestview Metro Water and Sanitation)	19,000		
				--	
				Coagulation, Sedimentation, Filtration, Taste and Odor control, Ammoniation, Disinfection	Chem/Physical
				Disinfection only	
	Adams	Federal Heights	5,000	Bug Treated Water	--

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Treatment Method(s)	Lab Tests
Colorado					
	Adams	Thronton	60,000		
				Prechloration, Coag. Sediment, Filtration, Disinfection	Chem/Physical
				Sedimentation, Disinfection	Chemical
	Adams	Westminster	35,000		
				Prechloration, Coag. Sedimentation, Filtration, taste and odor for both	
				Disinfection only	
	Adams	Westminster (Shaw Heights Water District)	5,000	*	
		Northglenn			
	Arapahoe	Englewood	1,470	Disinfection	None
	Arapahoe	Greenwood Village	3,500	--	None
	Arapahoe	Littleton	1,000	--	None
	Delta	Orchard City	3,000	Disinfection	Chemical

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Treatment Method(s)	Lab Tests
	Delta	Delta (Town of)	6,000	Prechlorination, Coag., Sedimentation, Disinfection (both)	Chem/Physical
	Delta	Paonia	2,000	No information reported	--
	Denver	Denver Cherry Cr. Water and San. Dist.	3,100	--	--
	Denver	Denver Clover Water and San. Dist.	6,400	--	--
	Denver	Denver-City of Glendale	2,200	Disinfection only	Chemical
	Elbert	Elizabeth	1,000		
	La Plata	Durango	12,000	Coag., Sediment., Filtration, Fluoridation Disinfection	Physical
	La Plata	Durango-Tamaron Public Util. Dist.	1,300	*	*
	La Plata	Durango-Purgatory Water and San. District	1,000	Disinfection only	None

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Treatment Method(s)	Lab Tests
	Las Animas	Trinidad-Monument Lake Park	1,000	Sedimentation, Filtration, Disinfection	
	Las Animas	Trinidad	11,000	Coag., Sedimentation, Filtration, Taste and Odor, Fluoridation, Disinfection	Chem/Physical
	Moffat	Craig	4,400	Prechloration, Coag., Sedimentation, Filtration, Taste and Odor, Fluoridation, Disinfection	Chem/Physical
	Rio Blanco	Meeker	1,600	Coagulation, Sediment, Filtration, Disinfection (both sources)	
	Rio Blanco	Rangely	1,800	Coagulation, Sediment, Filtration, Fluoridation, Disinfection	Chem/Physical
	Routt	Hayden	1,000	Coagulation, Sediment, Filtration, Fluoridation, Disinfection	Physical
	Routt	Steamboat Springs	2,800	Sedimentation, Fluoridation, Disinfection	None
	McCone	Circle	--	--	--

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Treatment Method(s)	Lab Tests
North Dakota	Burleigh	Bismarck	35,000	Filtration, Softening, Taste and Odor Control, Iron Removal Fluoridation, Disinfection	Chem/Bacterial
	McLean	Garrison	1,700	Aeration, Precipitation, Filtration, Iron Removal, Fluoridation, Disinfection	None
	Mercer	Beulah	1,344	Filtration, Softening, Fluoridation, Disinfection	None
	Mercer	Hazen	1,600	Filtration, Iron Removal, Fluoridation, Disinfection	None
	Morton	Mandan	11,000	Aeration, Coagulation, Sedimentation, Filtration, Taste & Odor, Iron Removal, Fluoridation, Disinfection	Chemical
	Carbon	Helper	2,200	Fluoridation, Disinfection Fluoridation, Disinfection Disinfection	None

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Treatment Method(s)	Lab Tests
	Carbon	Price	12,000	Coag., Sedimentation, Filtration	None
				Disinfection	
				Disinfection	
				Disinfection	
				Disinfection	
	Carbon	Wellington	1,050	Disinfection	None
	Emery	Huntington	1,000	None given	None
Wyoming					
	Campbell	Gillette	10,000	Aeration, Filtration, Softening, Taste and Odor Control, Iron Removal, Disinfection	Chem/Physical
	Carbon	Rawlins	10,000		
				Fluoridation, Disinfection	Chem/Bact/Phys
				Fluoridation, Disinfection	
				Fluoridation, Disinfection	Chem/Bact/Phys

(continued)

TABLE D-1. (Continued)

State	County	Community or Area Served	Retail Pop.	Treatment Method(s)	Lab Tests
	Lincoln	Kemmerer	3,000	Prechlorination, Coag., Sediment, Filtration, Taste & Odor Control, Fluoridation, Disinfection	Chem/Bact/Phys
	Sheridan	Sheridan	8,000	Prechlorination, Coag., Sedimentation, Filtration, Taste & Odor control, Disinfection	Chem/Bact
Utah					
	Emery	Ferron	1,000	Coagulation, Sedimentation, Filtration, Disinfection	None