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Uranium Mining and Milling Work Force Characteristics in the Western US

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URANIUM MINING AND MILLING WORK FORCE CHARACTERISTICS IN THE WESTERN US

by

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ABSTRACT

This report presents the results of a survey of the socioeconomic characteristics associated with 11 uranium mine and mill operations in 5 Western States. Comparisons are made with the socioeconomic characteristics of construction and operating crews for coal mines and utility plants in eight Western States. Worker productivity also is compared with that in similar types of coal and uranium mining operations.

We found that there existed no significant differences between the socioeconomic characteristics of construction and operating crews and the secondary employment impacts associated with uranium mines and mills when compared with those associated with coal mines and utility plants requiring similar skills at comparable locations. In addition, our survey includes a comparison of several characteristics associated with the households of basic and nonbasic work forces and concludes that significant changes have occurred in the last 5 yr. Accordingly, we recommend additional monitoring and updating of data used in several economic forecasting models to avoid unwarranted delays in achieving national energy goals.

I. *INTRODUCTION*

The Los Alamos Scientific Laboratory (LASL)* conducted this survey of available documentation of uranium-related socioeconomic impacts in response

*LASL conducted this survey under the auspices of the US Department of Energy's Regional Issues Identification and Assessment (RIIA) program.

to a request for assistance from the South Dakota State Planning Bureau. Because mining and milling of uranium ore deposits in the Western US are expected to expand rapidly in both number and size in the next decade, the study was broadened to provide a generic understanding of activities in several Western States.

We immediately discovered that a considerable amount of documentation had been developed in recent years about the socioeconomic impacts of coal mining and the construction and operation of coal-fired electric generating plants. In contrast, very little documentation could be found about the social characteristics of uranium mine and mill workers or the direct and secondary economic impacts they bring to local governments in sparsely-populated areas of the Western US.

Not surprisingly, opinions among industry and state officials contacted in the course of this survey differed drastically in the absence of quantifiable data. Colorado officials referred to high employee turnover, family abuse, drinking, and drug abuse as being far greater among uranium miners than among coal miners. Wyoming officials cited no differences at all because, in some cases, both reside in the same community and commonly change employment from one resource activity to another. Many of these officials strongly defended their use of existing statistical data derived from coal studies for use in planning for uranium activities. Others, including some industry officials, apparently were not so sure that use of these data was viable.

Our examination of 11 Environmental Impact Statements (EIS) on file at the Environmental Protection Agency's (EPA) Regional Office in Denver, Colorado, noted significant differences in the assumptions about the work force, their marital status, family size, and the direct and secondary economic impacts associated with a project. Many reports have cited data developed for coal mine and power plant construction as the basis for projecting socio-economic impacts from uranium production. Others have used different multipliers and population data that could not be identified as to their source, whereas still others have documented their information from uranium company records. It appears that state and federal officials reviewing these documents either agree with the information or have no basis to challenge the basic assumptions used by the companies. However, it was this lack of adequate information that caused South Dakota officials to challenge the projections provided by the Tennessee Valley Authority (TVA) for its proposed uranium mine and mill operation at Edgemont, South Dakota. Therefore, although initial request for the survey originated in South Dakota, LASL approached this question on a regional basis in an effort to discover any fundamental differences in the work force characteristics of uranium mine and mill workers. Also, we endeavored to determine whether differences were more than a result of location and isolation of certain uranium mining sites far from any population centers.

The survey methodology placed considerable emphasis on the commonalities between coal and uranium mining activities in the Northern Great Plains and the associated population patterns found in that area. Using such information as a baseline, contrasts in uranium mining in the plateau regions of western Colorado, New Mexico, and eastern Utah were cited. The latter regions are noted for their remote locations and, in some cases, for their reliance on an Indian work force with the associated unique socioeconomic and population characteristics found on Indian reservations.

II. COMPARATIVE SURVEY OF THE BASIC WORK FORCE

We examined 11 EIS published between 1977 and 1979 representing active and proposed mines and mills in five states. Four of the eleven projects are located in Wyoming, three in Utah, two in New Mexico, and one each in Colorado and South Dakota.

Six of the statements involved mines and/or mills with a design capacity of 2000 tons/day or larger. The remaining five involved mines or mills with a design capacity of 600-1700 tons/day. Table I summarizes several household characteristics of the basic work force set forth in the 11 EIS reports. Not all reports provided the same degree of detail. This may be explained in part by the nature of the proposed action. For example, an EIS for a new mine or mill generally provided much more socioeconomic detail than an EIS required for renewing an operating license for a facility that had been in place for many years.

A review of the household information set forth in Table I indicates that a wide range of assumptions were incorporated into the socioeconomic projections of the reports. Where assumptions tend to agree, they usually find their source in the same company involved in two or more EIS reports or by reference to a document known as the Construction Worker Profile,[1] hereafter referred to as the "Profile."

TABLE I

BASIC WORK FORCE HOUSEHOLD CHARACTERISTICS

Publication Number	Project Name	Project Type	Construction: % Head Hshld	Construction: #/Hshld	Construction: % Single	Construction: # Peak Jobs	Operation: % Head Hshld	Operation: #/Hshld	Operation: % Single	Operation: # Peak Jobs
NUREG-0129	Rocky Mtn Energy: Bear Creek, Wyoming	Mill	60	3.7	40	190	90	3.7	10	220
TVA-DOI Final EIS	TVA: Dalton Pass, New Mexico	UG Mine 2400 T/D	50 (80% Navajo)	5.0 Navajo 3.0 Other	50	-	50	5.0 3.0	50	550
EPA-91242	TVA/Mobile: Crown Point, New Mexico	UG Mine 1200 TID	50 (Navajo) 65 (other)	5.0 3.0	50 35	-	50 (Navajo) 50 (other) 80 (other commuters)	5.0 3.0	50 (Navajo) 50 (other) 20 (other commuters)	250
NUREG-0453	Atlas Corp: Moab, Utah	Mill 1200 T/D	-	-	-	-	85	3.9	15	161
TVA Draft EIS	TVA: Edgemont, South Dakota	S/ug Mine Mill 750 T/D	75	3.0		303	75	3.0	25	213
NUREG-0504	Plateau Resource: Shooter Canyon, Utah	Mill 750 T/D	20	3.6	80	225	46	3.6	54	100
USDA-FS-R2 DES (ADM) FY 78-03	Homestake Co.: Pitch Project, Colorado	UG Mine and Mill 600 T/D	-	2.14	-	286	-	3.47 (Miners) 3.97 (Mill)	-	150
NUREG-0357	Utah International: Lucky MC, Wyoming	Mill 200 T/D				140				100
NUREG-0505	Minerals Exploration Co.: Sweetwater Uranium Project, Wyoming	Mill 3000 T/D	-	2.0 (all are workers)	-	150	-	2.5 (all are workers)	-	289
NUREG-0494	Energy Fuels Nuclear Corp: White Mesa, Utah	Mill 2000 T/D	-	0.9 (all are workers)	-	250	-	2.1 (all are workers)	-	85

T/D = tons per day.
Other = Non-Indian

The Profile, published in 1975, has been a valuable resource for many researchers at a time when little was known about work force characteristics in the Western States. It is based on a survey of 3168 construction workers at 14 mine and utility construction projects in 8 Western States. The responses provide information about workers' marital status, household size and age, place of residence, previous residence, occupation, etc.

Some officials in Western States continue to rely heavily on this Profile as the basis for evaluating projections of the socioeconomic impacts associated with uranium mining and milling.[2] Accordingly, for the purposes of this limited survey, the Profile is used as the baseline document for evaluation and discussion of work force characteristics associated with proposed uranium mining and milling activities.

The marital status of the construction workers cited in the EIS reports as set forth in Table I may be compared with the statistics presented in the Profile (see Table II). Curiously, not one EIS report used the data set forth in the Profile as the basis for describing the marital status of the construction employees. Yet four of eight EIS reports that described their operating crews, compared them closely to the family characteristics of the construction crews cited in the baseline document. However, it is significant that instead of assuming that about 20% of the construction workers were single (Table II), the assumptions used in the EIS reports ranged from 35-80%. We recognize however, that only two of the EIS reports providing construction crew projections are geographically located in the Northern Great Plains and, therefore, it may be argued that the data are not representative of the typical work force in the region. Consequently, we examined this characteristic more fully.

The seemingly high percentage of single construction workers given in the EIS reports may be better understood by examination of Table III. This table, taken from the baseline document, shows the percentage of married nonlocal workers with family present. By interpretation, we observe that 37% of the nonresident married construction workers do not bring their families and may very well live in housing similar to single workers. This may explain, in part, the high percentage of single workers used in some EIS reports. This observation is supported by a recent publication prepared by a consortium of five North Dakota utility companies,[3] which projected a transitional ratio of married to single workers over a construction period of several years. In North Dakota, unmarried workers represent about 48% of the initial construction

TABLE II

MARITAL STATUS AND NUMBER OF CHILDREN UNDER 18 YEARS
OF LOCAL AND NONLOCAL CONSTRUCTION WORKERS--ALL PROJECTS

	Percentage Local Workers	Percentage Nonlocal Workers
Single	23.3	18.5
Divorced or widowed	5.9	6.1
Married, no children	16.7	21.5
Married, one child	13.6	15.0
Married, two children	17.3	16.7
Married, three children	10.7	10.0
Married, four children	6.9	7.4
Married, more than four children	5.5	4.6
TOTAL	100.0	100.0

SOURCE: Construction Worker Profile

work force. Added to this number is another 30-40% of the nonlocal population who do not bring their families. Then, as the construction period progresses, a larger proportion of the work force brings their families because of new housing facilities or because certain crafts are required that bring in highly-skilled professional workers able to afford housing for their families.

Some of the transition documented in North Dakota may result from several construction projects taking place on different time schedules in the same labor area. However, one of the consortium members observed that the ratio of workers without families to married workers with families seemed to respond directly to employer management decisions related to the provision of bachelor quarters and facilities for single workers and married workers without their families.[4] Quality bachelor quarters lead to more workers without families. The official noted that in 1974, when Basin Electric participated in the survey for the Profile, it and other utility companies had minimal experience with socioeconomic mitigation techniques. Therefore, more recent company involvement with mitigation efforts has resulted in dramatic changes in the work force family characteristics. It is now believed that the degree of management involvement in providing quality bachelor housing and service facilities directly relates to the growing number of single workers or married workers who choose not to bring their families. The provision of quality housing directly improves worker productivity, reduces employee turnover, and reduces

TABLE III

PERCENTAGE OF MARRIED NONLOCAL WORKERS WITH FAMILY PRESENT

Project Number	Project Name	Percentage of Married Nonlocal Workers
1	Coronado, 1,2,3,	65.6
2	Craig 1,2--Yampa Power Plant	57.3
3	Hayden 2	57.8
4	Colstrip 1,2	66.7
5	Center--Milton R. Young	51.9
6	Leland Olds	55.2
7	San Juan 1	66.7
8	Emery	46.2
9	Huntington 2	62.0
10	Jim Bridger 2,3	77.6
11	Texaco Lake Expansion	62.7
12	Sun Oil--Cordero Mine	50.0
13	Texas Gulf Sulphur	54.8
14	Wyodak	75.7
	AVERAGE ALL PROJECTS	63.1

SOURCE: Construction Worker Profile

the associated boomtown effects caused by a highly transient population associated with poor housing conditions.

Another observation documented in North Dakota and also noted by state officials in Montana and Wyoming is the existence of smaller households among married construction and nonlocal operation employees. The North Dakota Consortium reported that "the average family size for relocating households was reduced from 2.15 to 2.00* based on [their own] construction worker profile. All components of the family size were also reduced with the exception of [the category] Other Family Members [non-children] which increased. The most significant family components--elementary and secondary school age population--had the greatest reduction. The elementary component was reduced from 16.9 per one-hundred households to 10.1 per one-hundred, while the secondary component was reduced from 9.2 per one-hundred to 2.3 per one-hundred relocating households."[5]

*Computed on the basis of married workers and single workers not living in Company bachelor facilities.

The North Dakota observation presented as Table IV represents a significant departure from the findings in the Profile as provided in Tables V and VI. The contrast between the Profile and North Dakota observation becomes even greater when compared with the data presented in Table VII, also taken from the Profile. According to Table VII, both newcomer groups averaged 158 children per 100 families.

Does the recent study in North Dakota represent an isolated example or has there been a change in the construction worker families elsewhere? Discussions with state officials in Wyoming suggest similar observations. They cite projects near Wheatland and Gillette, Wyoming, as recent examples of company investment in impact mitigation measures designed to respond to changing needs of the work force.

To avoid high project overrun costs, several companies have made significant investments in worker housing and service facilities. The new town of Wright, Wyoming, is a case in point: Atlantic Richfield Company made large investments to provide quality bachelor facilities and is currently constructing over 100 homes to be purchased by mine workers. Similarly, at Wheatland, Wyoming, the Basin Electric Power Cooperative has made large investments in housing and service facilities for construction workers. Both locations have observed a worker pattern comparable to that in North Dakota.

At Douglas, Wyoming, we observed that uranium miners and mill workers living in the community could not be distinguished from coal miners or other permanent newcomers living in the community.[6] The family sizes are small and the work force includes older workers with few children at home or young families with few children. Both the elementary and secondary schools have student counts much below those expected for a typical midwestern city of comparable size.

On the other hand, construction workers were as a group much younger than the majority of permanent workers. None of the companies provided bachelor quarters in Converse County and only one major company subsidized or financed housing for their employees. Because of the lack of housing and even recreation facilities, a very high percentage of the single construction workers and young married workers live in the city of Casper in an adjacent county. Unfortunately, specific demographic data will not be available in Converse County until after the 1980 US Census count. However, the observations in North Dakota also may be compared with monitoring studies underway by the TVA.[7]

TABLE IV

NORTH DAKOTA UTILITIES
INTER-INDUSTRY TECHNICAL ASSISTANCE TEAM (ITAT), JULY 1979

The family size fo the entire relocating construction worker household was 1.709, whereas the family size of the entire construction household relocating to Mercer County was 1.574. The family size of the relocating construction household for the Mercer County Communities was:

Beulah	1.409
Hazen	2.214
Zap	1.723
Staton	2.125
Golden Valley	1.906
Pick City	1.429

Other pertinent characteristics of the Mercer County construction work force for the period are:

Weekly Commuters	17.2%
Daily Commuters (Excludes local work force)	35.2%
Single Households	59.2%
Multiple Households	41.8%

ITAT publishes each month a detailed "construction worker profile," which describes the characteristics of the active work force level in Mercer County. Daily commuters travel over 80 miles each way in van pools and large, interstate, self-contained highway buses.

TABLE V

AVERAGE FAMILY SIZE OF MARRIED LOCAL AND NONLOCAL CONSTRUCTION WORKERS--ALL PROJECTS

	Local Workers	Nonlocal Workers
Average Family Size	3.970	3.784

SOURCE: Construction Worker Profile

TABLE VI

AVERAGE POPULATION INFLUX PER 100 NONLOCAL CONSTRUCTION WORKERS

Name	Project Number	Worker Single, Widowed, or Divorced	Worker Married, but Family Absent	Family Present			Total Population Influx per 100 Nonlocal Construction Workers
				Worker	Spouse	Children	
1 Coronado	1,2,3	8.7	30.4	60.9	60.9	69.6	230.5
2 Craig	1,2 Yampa Power Plant	27.2	30.8	42.0	40.0	57.4	199.4
3 Hayden	2	22.8	31.1	46.2	46.2	64.4	210.7
4 Colstrip	1,2	34.0	24.7	41.2	41.2	94.8	235.9
5 Center--Milton R. Young		25.0	36.1	38.9	38.9	69.4	208.3
6 Leland Olds		17.1	37.1	45.7	45.7	78.1	223.7
7 San Juan	1	21.7	21.7	56.5	56.5	73.9	230.3
8 Emery		13.3	46.7	40.0	40.0	73.3	213.3
9 Huntington	2	10.6	34.8	54.7	54.7	93.8	248.6
10 Jim Bridger	2,3	21.3	14.0	64.7	64.7	123.0	287.7
11 Texaco Lake Expansion		34.2	24.6	41.2	41.2	56.1	197.3
12 Sun Oil--Cordero Mine		65.3	17.3	17.3	17.3	28.0	145.2
13 Texas Gulf Sulphur		32.9	25.7	41.3	41.3	67.7	208.9
14 Wyodak		21.6	18.2	60.2	60.2	67.0	227.2
AVERAGE ALL PROJECTS		24.6	26.5	48.9	48.9	78.9	227.8

SOURCE: Construction Worker Profile

TABLE VII

AVERAGE NUMBER OF CHILDREN IN VARIOUS
AGE CATEGORIES (FOR EACH 100 FAMILIES)
CURRENTLY AFFECTED COMMUNITIES

Age Category	Long-Time Residents	Newcomer Construction Workers	Other Newcomers
Under 5	39	56	62
5-11	62	57	55
12-14	28	18	21
15-17	26	17	15
18-19	13	6	4
20-24	8	3	1
25 or over	2	1	0
TOTAL	178	158	158

SOURCE: Construction Worker Profile

As presented in Appendix A, the TVA project monitoring information represents nine separate construction projects in rural areas of Tennessee. Although developed far distant from the Northern Great Plains, the value of these data is the descriptive detail of the TVA socioeconomic monitoring program. Six of the projects provide three or more summary reports for different time periods. Comparative data with the findings in North Dakota are listed near the top of each page opposite the column heading titled "Total Movers" and at the bottom of each page titled "Movers" and "School-age Children."

The Tennessee monitoring system tends to support the changes observed in the Northern Great Plains. TVA projects started in 1968-70 appear to have a married-to-single ratio similar to the Profile. However, projects started since 1976 reported a married-to-single ratio approaching 50-50, as has been observed in the Western States.

The significance of this observation is the smaller total population influx and the associated need for a wide range of family-oriented public services and facilities during the construction period. Further, as the operational phase takes over with the typically smaller manpower requirements, married construction workers either stay or are replaced by other married workers in operational jobs. In any event, the ratio of married to single workers in Tennessee tends to follow the pattern of the Western States in recent years and may be symptomatic of a national trend in energy development projects.

Other characteristics of the construction work force observed in several states include the employment of wives of young workers either as manual laborers on construction crews or, for example, on city street repair crews. Apparently, the high cost of living in impacted areas, the lack of children in the household, and the acceptance of women in many formerly male job categories contribute to this observation. Remote locations, "cabin fever," and loneliness also are viewed by some state officials interviewed as factors in high employee turnover among both married and single workers at some locations in New Mexico, Utah, and Colorado.

Uranium and coal mining on most Western Indian reservations present a very different worker profile. A recent study of coal development on Indian lands describes prevailing tribal attitudes, values, and expected impacts.[8] For example, tribes want the jurisdictional autonomy of a sovereign power to control development of their resources. They are determined to secure as much as 95% Indian employment on energy development projects. Their large, available work force must be trained to assume more and more jobs. The Navajo tribal practice of lifetime assignment of home sites makes Indians generally unwilling to move to central locations to work in mines or mills, thus a willingness to commute unusually long distances. Consequently, boomtown effects not necessarily related to energy development generally will be limited to off-reservation sites except in the tribal headquarters community, where increased governmental services will attract a growing number of young families. Non-Indians employed on the reservations in energy-related jobs generally will be required to live off the reservation or on land leased to the development company. Boomtown effects on the leased land will become the responsibility of the energy company and are expected to be minimal at best. Clearly, uranium mining on Indian lands results in socioeconomic characteristics that are uniquely different from those found in non-Indian areas of the Northern Great Plains.

III. COMPARATIVE SURVEY OF THE NONBASIC WORK FORCE

Nonbasic employment may be expressed as a percentage of the direct employment provided by a major basic industry such as a uranium mine or mill. Secondary (nonbasic) employment multipliers were given in 10 of the original

11 EIS reports summarized in Table VIII. These site-specific multipliers provide a range of 25-190% of the direct employment during the construction phase. The operational phase varied even more with a range of 50-260% of the direct employment level.

The multipliers summarized in Table VIII seem to fit into four groups. One group of especially low percentage figures is associated with sites on Indian reservations or as in the case of the uranium mill in Sweetwater County, Wyoming, where the majority of the employees reside in an adjacent county.

The second group of projects tends to use multipliers that appear low during the construction period but move to a higher percentage relationship in the operational phase. This group appears to account for lag time effects, meaning the elapsed time before desired services and goods can be offered by a stabilized local business community.

The third group has not differentiated between work phases but does provide multipliers that tend to agree with those in the second group in the operational phase. The last group has only one member, the Bear Creek Mill near Douglas, Wyoming, which cites multipliers that differ significantly from all other projects.

Table IX provides a summary of selected nonbasic to basic employment multipliers estimates and estimation techniques used before 1976.[9] These studies represent several kinds of construction projects at various locations in the US.

The range of multipliers given in Table IX aligns fairly closely with the multipliers used for the uranium EIS reports. Footnote (a) in Table IX suggests that modification of the multiplier as the economic size of the region varies is fundamental to site-specific analysis. It provides that no single multiplier is derived for all locations and for all time periods.

A recent publication by the Missouri River Basin Commission[10] devotes nearly 150 pages to describe various methodologies used to assess impacts and to predict population growth in a region. Secondary multipliers or the ratio of basic to nonbasic employment may be derived by examination of total employment and per capita income set forth in the several methodologies available for economic analysis.

Three commonly-applied methods used to complete an economic analysis of a potential or existing impacted region are (1) the economic base approach,

TABLE VIII

NONBASIC WORK FORCE HOUSEHOLD CHARACTERISTICS

Publication Number	Project Name	Project Type	% Head Hshld	Non-Head Hshld	% Single	Basic-Nonbasic Multiplier	School Age Children Basic and Nonbasic
NUREG 0129	Rocky Mtn. Energy: Bear Creek, Wyoming	Mill 1000 T/D	60	30	10	1.91 Construction 2.61 Operating	1.2
TVA-DOI	TVA: Dalton Pass, New Mexico	UG Mine 2400 T/D	-	-	-	0.74-0.78	1.3
EPA-91242	TVA/Mobile: Crown Point, New Mexico	UG Mine 1200 T/D	-	-	-	0.73-0.76	2.0 Navajo - Other
NUREG-0453	Atlas Corp: Moab, Utah	Mill 1200 T/D	-	-	-	1.00	1.94
TVA Draft EIS	TVA: Edgemont, South Dakota	S/UG Min and Mill 750 T/D	-	-	-	1.5	0.75
NUREG-0504	Plateau Resource: Shooter Canyon, Utah	Mill 750 T/D	50	-	50	1.5	-
USDA-FS-R2 DES (ADM) FY78-03	Homestake Co.: Pitch Project, Colorado	UG Mine and Mill 600 T/D	-	-	-	-	-
NUREG-0357	Utah International: Lucky MC, Wyoming	- Mill 2000 T/D	-	-	-	-	-
NUREG-0532	United Nuclear: Morton Ranch, Wyoming	Mill 2000 T/D	-	-	-	0.50/Construction 1.50/Operating	-
NUREG-0505	Minerals Exploration Co.: Sweetwater Uranium Project, Wyoming	Mill 3000 T/D		-	-	0.25/Construction 0.50/Operating	-
NUREG-0494	Energy Fuels Nuclear Corp.: White Mesa, Utah	Mill 2000 T/D	-	-	-	0.30/Construction 0.90/Operating	-

T/D = tons per day
Other = Non-Indian

TABLE IX

SELECTED NONBASIC/BASIC EMPLOYMENT MULTIPLIER ESTIMATES AND ESTIMATION TECHNIQUE[9]

Study	Nonbasic/Basic Employment Multiplier	Estimation Technique
Booz, Allen and Hamilton, Inc. (1974)	0.45 - 2.00	(not reported)
Chamber of Commerce of the United States (1973)	0.68	Case study
Colony Development Operation (1974)	0.5 - 1.0 1.5	(not reported)
Gilmore and Duff (1975)	0.8 - 2.2	Ratio
Hildebrand and Mace (1953)	1.25	Least squares regression
Moody and Puffer (1970)	1.14	Least squares regression
THK Associates	2.00	(not reported)
Thompson (1959)	1.31	Least squares regression

[a]Varies with economic size of region.
[b]Construction phase.
[c]Operations phase.

(2) an input-output analysis, and (3) an econometric approach. The three methodologies are described in more detail in Appendix B. An example of the economic base approach has been developed by the Argonne National Laboratory (ANL) through the integration of a series of computer models known as SEAM (The Social and Economic Assessment Model).[11] These models can be used either independently or interactively. One submodel known as the Impact Projection Model (EMPIMP) provides annual estimates of nonbasic employment requirements created by the presence of a new energy or industrial facility. A description of ANL's impact projection model is incorporated in more detail in Appendix C.

The TVA also has applied an economic base model in their determination of the probable indirect effects of the decommissioning of the Edgemont, South Dakota, uranium processing mill. The circumstances in South Dakota have been complicated by planned construction of one or more new mines and a uranium mill simultaneously with the decommissioning of an old uranium mill site. The description of the model, however, does not incorporate the combined activity. TVA's approach is described in Appendix D.

The Wyoming Department of Administration and Fiscal Control also has used the economic base analysis approach to measure the impact of economic growth on Wyoming's regional economy.[12] The forecasting document relies on basic employment as the unit of measure to provide an indicator of economic opportunity and the prime motivation for changes in population, especially in the service sector. However, it finds that basic employment as a proxy may be insensitive to excess capacity in the service sector or fails to provide recognition to the place of residence of seasonal employees and commuters. Because of such considerations, the nonbasic or service component of total employment is estimated using the labor income of the basic component. The Wyoming methodology is described in Appendix E.

An understanding of the Wyoming labor income methodology is important to an evaluation of a publication describing the Wyoming uranium industry because the concern in South Dakota originated with that publication.[13] Table 20 of that publication (presented in this report as Appendix F) estimates the direct and induced uranium-related employment in 2-yr intervals between 1972 and 1978. The five-county total of induced employment in 1978 projects a multiplier of 2.53 or suggests indirect employment equal to 253% of the direct employment. In the same year, Fremont County indicates an induced employment equalling 285% of the direct employment and Converse County, 342%.

The foregoing contrasts with another survey of all workers in Fremont County,[14] which was conducted by the Wyoming Department of Economic Planning and Development (the same sponsor for both reports) and documents 7520 basic jobs and 8000 nonbasic jobs. These totals were adjusted for place of residence in the county and result in a multiplier of 1.06, or less than one-half of the size of the multiplier derived in the Wyoming Uranium Industry report.

Still another survey, recently completed in Converse County by the Wyoming Industrial Siting Administration, disagrees drastically with the summary presented in Appendix F. The siting study counted a total of 3863 basic jobs in all industrial classifications and 2732 nonbasic jobs. This assessment results in a secondary multiplier of 0.71 or 71% compared to 342% given in the earlier report.

Can all sets of numbers be correct? Wyoming officials in three separate agencies do not think so. The Department of Economic Planning and Development, the Department of Administration and Fiscal Control, and the Industrial Siting Administration independently have developed comparable employment records. The most comprehensive record is provided by the publication of the Wyoming Division of Research and Statistics[15] for the Industrial Classification of Employment Forecast Year 1978 (see Appendix G).

There are 10 industrial classifications presented in Appendix G. Petroleum production employment is included with the totals for mining. Also, Converse County totals include a coal mine and Fremont County totals include a large iron ore mine. Further, it should be recognized that the data presented in Appendix G have not been adjusted as to the place of residence of the worker, thus, direct comparison is not possible. Nevertheless, a comparison of the totals of all industrial classifications for Converse County given in Appendix G with the extremely high total uranium-related employment for Converse County presented in Appendix F permits some measure of evaluation. A similar comparison can be made for Fremont County totals. The methodology used in the Wyoming Uranium Industry projections was patterned somewhat after the methodology described in Appendix E. The multipliers derived by using the labor income of the basic component were dependent on information from the Wyoming Employment Security Commission and the US Bureau of Economic Analysis. The published conclusions depended upon the accuracy of several forecasts and apparently were not compared for reasonableness with other available data such as that set forth in Appendix G.

Subsequent surveys done in two of the five counties tend to support the accuracy of the information presented in Appendix G and identify the very large error in Appendix F. However, these subsequent studies did support the reasonableness of the direct uranium employment presented in Appendix F. Accordingly, the methodology or data used to project the nonbasic employment would appear to account for the abnormally high projections presented in Appendix F and to provide reinforcement of the conclusions described in the next section (IV).*

*This entire matter has been discussed with the principal researchers involved in the study of the Wyoming Uranium Industry report. Agreement was reached as to problems with the methodology and a recognition of the lack of some of the comparative data now available. It is clearly the intention of our survey to resolve a problem of documentation and not to discredit an earlier report.

IV. A COMPARATIVE ANALYSIS OF WORK FORCE REQUIREMENTS FOR URANIUM MINES, MILLS, AND TRANSPORTATION

A. Mines

Are uranium mines more labor-intensive than coal mines of similar type and annual tonnage? A review of the Wyoming Mineral Development and Monitoring System[16] provides a comparison of work forces for coal and uranium extraction.

The review disclosed that 8 underground uranium mines in Wyoming produced an average of 1163 tons of uranium ore per worker year. This compares with 4000 tons of underground coal per worker year at two Wyoming mines and an average of 1832 tons of underground coal per worker year in Colorado.* (See Ref. 17.) Similarly, 13 surface uranium mines in Wyoming are projected to average 2361 tons of ore per worker year compared to an average of 21 329 tons per worker year projected at 25 Wyoming surface coal mines. For further comparison, 22 Colorado surface coal mines are projected to average 9716 tons per worker year or less than one-half the Wyoming surface coal productivity, yet over four times the Wyoming surface uranium production.

This disparity between uranium and coal can be explained to some degree by the different minerals being mined. Coal is mined in seams and after the overburden is removed, often virtually everything leaving the mine is coal. By contrast, the uranium deposits are more spotty in the ore body being addressed. Each truckload of uranium ore is passed through a scanner device to determine if the load is suitable for transport to the mill or if it should even be saved in a stockpile of low grade ore for possible future processing.

A recent publication in New Mexico provides an example.[18] It reported that the amount of ore received at the uranium mills did not reflect the total amount of material removed from the mines. In 1977, New Mexico mines removed 5 912 333 tons of material, although only 4 209 000 tons of ore were received at the mills. That is a difference of nearly 29%.

Another explanation of the disparity in the productivity is the differences in the size of equipment. Wyoming officials noted that open pit coal mines use 75 cubic yard buckets on their draglines compared to much smaller

*The Colorado underground coal records were based upon 27 mines throughout Colorado because the underground coal records in Wyoming were too limited to provide a representative sample. (See Ref. 24.)

front end loaders and ore trucks in use at many uranium mines. Still, some open pit uranium mines in New Mexico operated by the Anaconda Company use much of the same equipment as used in coal mines.

The significance of the productivity issue is the size of the work force required. Uranium mines projected to deliver 2000 tons of ore per day will require a much larger work force than a coal mine with a similar daily tonnage projection. Consequently, projections of possible labor force requirements based on annual tonnage on a regional or national scale must be modified accordingly.

B. Mills

The milling of uranium ore is also highly labor-intensive. A review of the 10 uranium milling operations (Table I) in Wyoming, ranging in size from 1500-3200 tons of ore capacity per day, suggests that no logical conclusions could be derived that would enable us to predict manpower requirements. However, 7 of the 10 operations did fit into an employment pattern requiring 1 worker for approximately every 20 tons of milling capacity reported. Nevertheless, economies of scale were not apparent, for example, between mills using similar acid leach processes with a design capacity of 1700 tons per day and another with a capacity of 3000 tons per day. This observation may be a result of incomplete information caused by disclosure restrictions as was the case in the recent study of the Wyoming uranium industry.[19]

Uranium mill design has changed over time. Recently, modifications were made to a mill in New Mexico that was first licensed in 1953. The modifications to one facet of the operation replaced 40 employees per shift with mechanized equipment, thus requiring less than 1 full-time attendant to monitor the process. Therefore, proposals to develop new milling operations must be evaluated in terms of the new technologies that can be incorporated into the process.

C. Transportation

Trucks usually handle the transportation of uranium ore from the mine to the mill. Highway transportation of uranium ore, especially through towns, presents both an environmental and road safety hazard to affected communities. At present, a mine in New Mexico ships uranium ore by rail to a mill approximately 50 miles away. Rail shipment of ore is uncommon, although a similar operation once supplied the now closed mill at Edgemont, South Dakota.

The end product of the milling process is a concentrated, semirefined uranium ore known as "yellowcake." Typically, yellowcake is transported away from the mill in specialized containers carried by large highway trucks for further processing at several locations elsewhere in the US. A very large mill producing 2000 tons of yellowcake each year will ship a tractor trailer load about every other day.

In contrast, coal is generally transported by trucks or large conveyor belts from the mine to a nearby loading terminal. There it is further ground into smaller lumps for mine mouth conversion at an electrical generating plant or loaded onto unit trains for rail shipment away from the immediate area of the mining community.

The employment requirements of the railroad companies at the mine mouth and along the major coal train routes are no small matter. The socioeconomic concerns of Edgemont, South Dakota, about proposed uranium mining and milling are further aggravated by a huge buildup of railroad employees needed to operate and maintain coal trains passing through that particular railroad division point.* The coal trains originate in northeastern Wyoming and serve markets in Southern and Eastern States.

V. CONCLUSIONS

This survey has examined documentation supplied by 11 uranium Environmental Impact Statements (EIS) in an effort to identify any unique characteristics of the uranium mining and milling work force or the associated socioeconomic impacts resulting from the activity. The measure of difference was determined by a comparison of EIS data to the coal mines and utility-related Construction Worker Profile on one hand and, on the other hand, more current studies and reports completed in several states.

The general conclusions of this survey are:

- Uranium mining and milling projects employ construction and operating work forces that display socioeconomic characteristics not significantly different from coal mine and utility plant construction and operating work forces requiring similar skills at comparable locations.

*Howard L. Kallio of Burlington Northern Railroad in Denver, Colorado, reported that there were 423 company employees living in the Edgemont Community in November 1979.

- The 1975 study known as the Construction Worker Profile provides an upper limit on the characteristics of family size, school-age children, and the ratio of married to single workers appropriate for energy project planning in the decade of the 1980s.

- Additional monitoring of the work force characteristics of selected projects presently under construction or recently made operational would provide valuable work force information to improve the data base used for subsequent energy project planning for the Western States.

- Secondary employment induced by the uranium mining and milling industry is similar to that expected from coal mining or utility plant construction and operations that employ a similar size work force in the same economic unit.

- High employee turnover and various social problems among uranium workers as noted by some state officials are a function of mine site locations in remote areas and/or are directly related to front-end investments by industry affecting the quality of housing and service facilities for both single and married workers.

- Multipliers used in socioeconomic forecasting models need to be reviewed to assure that the assumptions about the household characteristics, secondary employment, and related data reflect apparent changes recently observed by a variety of planners in the Western States.

- Uranium mining is much more labor-intensive than a comparable surface or underground coal mine reporting equal annual tonnage figures. Documentation of labor force requirements for uranium mills did not reflect an adequate pattern of economies of scale.

- Projected employment levels and population changes associated with a local or regional analysis should be tested against a number of statistical indicators developed at the state and federal level to avoid unwarranted institutional opposition resulting in delays or major constraints to the timely achievement of national energy goals.

APPENDIX A

TENNESSEE VALLEY AUTHORITY
SOCIOECONOMIC MONITORING AND MITIGATION SUMMARY

Project Name	Paradise	Cumberland	Cumberland	Cumberland	
Date of Survey	Jan. 1968	Sept. 1968	Sept. 1969	May 1971	
Total Employees	2000	544	1450	2900	
Employees Surveyed	2000	544	1100	1500	
Expected Peak	2000	2900	2900	2900	
Total Movers					
Number	643	158	435	1035	
% Total Employment	32	29	30	36	
Primary Towns Impacted And Number Of Employees Moving There	Drakesboro Central City Greenville Madisonville	Erin-66 Clarksville-22 Cumberland Cty-31 Tennessee Rdg-16 Waverly-11	Erin-140 Clarksville-69 Cumberland Cty-97 Tennessee Rdg-31 Waverly-23	Erin-294 Clarksville-212 Cumberland Cty-230 Tennessee Rdg-74 Waverly-51 Dover-41	Erin-99 Clarksville-69 Cumberland Cty-74 Tennessee Rdg-28 Waverly-13 Dover-12
Housing Type Selected					
House-Bought	34 (5%)	25 (16%)	65 (15%)	155 (15%)	75 (22%)
Rented	181 (28%)	50 (32%)	144 (33%)	300 (29%)	75 (22%)
Total	215 (33%)	75 (48%)	209 (48%)	455 (44%)	150 (44%)
M. Home Bought	66 (10%)	23 (14%)	100 (23%)	228 (22%)	78 (23%)
Rented	55 (9%)	11 (7%)	30 (7%)	155 (15%)	45 (13%)
Total	121 (19%)	34 (21%)	130 (30%)	383 (37%)	123 (36%)
Apartment	113 (18%)	10 (6%)	26 (6%)	73 (7%)	36 (11%)
Other	194 (30%)	39 (25%)	70 (16%)	124 (12%)	31 (9%)
Grand Total	643 (100%)	158 (100%)	435 (100%)	1035 (100%)	340 (100%)
Movers					
With Families	317 (49%)	90 (57%)	296 (68%)	683 (66%)	224 (66%)
Without Families	326 (51%)	68 (43%)	139 (32%)	352 (34%)	116 (34%)
School-Age Children	410	94	356	668	145
Number Per Family	1.3	1.0	1.2	1.0	0.7

APPENDIX A (cont.)

TENNESSEE VALLEY AUTHORITY
SOCIOECONOMIC MONITORING AND MITIGATION SUMMARY

Project Name	Watts Bar	Watts Bar	Watts Bar	Watts Bar	
Date of Survey	March 1973	July 1974	May 1976	Oct. 1977	
Total Employees	475	1700	2800	3429	
Employees Surveyed	400	1500	2500	3129	
Expected Peak	3700	3700	3700	3500	
Total Movers					
Number	95	420	860	1070	
% Total Employment	20	25	31	[illegible]1	
Primary Towns Impacted And Number of Employees Moving There	Spring City-35 Decatur-12	Spring City-147 Ten Mile-44 Kingston-35 Decatur-29 Athens-27 Harriman-18 Dayton-16	Spring City-253 Athens-87 Decatur-84 Ten Mile-63 Kingston-60 Dayton-45 Sweetwater-34 Harriman-29	Spring City-318 Decatur-111 Athens-102 Ten Mile-94 Dayton-67 Kingston-66 Sweetwater-64 Rockwood-33	
Housing Type Selected					
House-Bought	25 (26%)	122 (29%)	233 (27%)	310 (29%)	
Rented	14 (14%)	61 (15%)	122 (14%)	'51 (14%)	
Total	39 (40%)	183 (44%)	355 (41%)	461 (43%)	
M. Home Bought	21 (22%)	109 (26%)	165 (19%)	160 (15%)	
Rented	22 (23%)	67 (16%)	151 (18%)	216 (20%)	
Total	43 (45%)	176 (42%)	316 (37%)	376 (35%)	
Apartment	5 (6%)	40 (9%)	140 (16%)	151 (14%)	
Other	8 (9%)	21 (5%)	49 (6%)	82 (8%)	
Grand Total	95 (100%)	420 (100%)	860 (100%)	1070 (100%)	(100%)
Movers					
With Families	66 (70%)	311 (74%)	592 (69%)	686 (64%)	
Without Families	29 (30%)	109 (26%)	268 (31%)	384 (36%)	
School-Age Children	27	191	439	590	
Number Per Family	0.4	0.6	0.7	0.9	

APPENDIX A (cont.)

TENNESSEE VALLEY AUTHORITY
SOCIOECONOMIC MONITORING AND MITIGATION SUMMARY

Project Name	Hartsville	Hartsville	Hartsville	Hartsville	Hartsville
Date Of Survey	Sept. 1976	Mar. 1977	Sept. 1977	March 1978	Sept. 1978
Total Employees	1231	1757	3450	4400	5500
Employees Surveyed	1231	1757	3200	3900	5600
Expected Peak	6100	6100	6100	6100	6100
Total Movers					
Number	170	362	924	1251	1588
% Total Employment	14	21	27	28	28
Primary Towns Impacted and Number Of Employees Moving There	Gallatin-50 Hartsville-31 Lebanon-38	Carthage-15 Castalian Sprng-24 Gallatin-83 Hartsville-51 Lafayette-17 Lebanon-56	Carthage-36 Castalian Sprng-43 Gallatin-180 Hartsville-134 Henersonville-43 Lafayette-68 Lebanon-136 Nashville-48	Carthage-48 Castalian Sprng-66 Gallatin-218 Hartsville-188 Hendersonville-67 Lafayette-88 Lebanon-171 Nashville-53	Carthage-66 Castalian Sprng-62 Gallatin-261 Hartsville-264 Hendersonville-91 Lafayette-108 Lebanon-197 Nashville-81
Housing Type Selected					
House-Bought	60 (35%)	119 (33%)	250 (27%)	345 (27%)	489 (31%)
Rented	22 (13%)	71 (20%)	189 (21%)	235 (19%)	289 (18%)
Total	82 (48%)	190 (53%)	439 (48%)	580 (46%)	778 (49%)
M. Home Bought	20 (12%)	41 (11%)	115 (12%)	132 (11%)	162 (10%)
Rented	20 (12%)	45 (12%)	117 (13%)	140 (11%)	182 (11%)
Total	40 (24%)	86 (23%)	232 (25%)	272 (22%)	344 (21%)
Apartment	34 (20%)	63 (18%)	188 (20%)	204 (16%)	251 (16%)
Other	14 (8%)	23 (6%)	65 (7%)	195 (16%)	215 (14%)
Grand Total	170 (100%)	362 (100%)	924 (100%)	1251 (100%)	1588 (100%)
Movers					
With Families	105 (62%)	237 (65%)	601 (65%)	821 (66%)	1093 (69%)
Without Families	65 (38%)	125 (35%)	323 (35%)	430 (34%)	495 (31%)
School-Age Children	70	159	428	572	828
Number Per Family	0.6	0.7	0.7	0.7	0.8

APPENDIX A (cont.)

TENNESSEE VALLEY AUTHORITY
SOCIOECONOMIC MONITORING AND MITIGATION SUMMARY

Project Name	Hartsville	Sequoyah	Sequoyah	Sequoyah	Sequoyah
Date Of Survey	March 1979	Oct. 1970	July 1972	Aug. 1974	Feb. 1977
Total Employees	6300	1100	2200	1600	2800
Employees Surveyed	6600	847	1477	1300	1900
Expected Peak	6800	3100	3100	3100	3100
Total Movers					
Number	2000	187	513	474	1142
% Total Employment	31	17	23	30	41
Primary Towns Impacted And Number of Employees Moving There	Carthage-93 Castalian Sprng-65 Gallatin-326 Hartsville-350 Hendersonville-102 Lafayette-129 Lebanon-242 Nashville-87	Chattanooga-29 Hixson-45 Soddy-Daisy-83	Chattanooga-73 Hixon-113 Red Bank-15 Soddy-Daisy-216	Chattanooga-63 Dayton-12 Hixson-107 Red Bank-21 Soddy-Daisy-192	Chattanooga-221 Dayton-25 Hixson-340 Red Bank-113 Soddy-Daisy-312
Housing Type Selected					
House-Bought	588 (29%)	56 (30%)	95 (19%)	128 (27%)	296 (26%)
Rented	377 (19%)	28 (15%)	76 (14%)	48 (10%)	135 (12%)
Total	965 (48%)	84 (45%)	171 (33%)	176 (37%)	431 (38%)
M. Home Bought	222 (11%)	46 (25%)	130 (25%)	130 (28%)	159 (14%)
Rented	229 (12%)	25 (13%)	102 (20%)	59 (12%)	176 (15%)
Total	451 (23%)	71 (38%)	232 (45%)	189 (40%)	335 (29%)
Apartment	319 (16%)	30 (16%)	77 (15%)	84 (18%)	213 (31%)
Other	268 (13%)	2 (1%)	33 ([illegible]%)	25 (5%)	20 (2%)
Grand Total	2003 (100%)	187 (100%)	513 (100%)	474 (100%)	1142 (100%)
Movers					
With Families	1390 (69%)	138 (73%)	376 (73%)	349 (74%)	784 (69%)
With Families	613 (31%)	49 (27%)	137 (27%)	125 (26%)	358 (31%)
School-Age Children	1089	124	276	216	586
Number Per Family	0.8	0.9	0.7	0.6	0.7

APPENDIX A (cont.)

TENNESSEE VALLEY AUTHORITY
SOCIOECONOMIC MONITORING AND MITIGATION SUMMARY

Project Name Date of Survey	Bellefonte April 1975	Bellefonte May 1976	Bellefonte Aug 1977	Phipps Bend May 1978	Phipps Bend Mar. 1979
Total Employees	900	2200	3500	1100	2000
Employees Surveyed	650	1350	2100	830	1600
Expected Peak	4200	4200	4200	3600	3600
Total Movers					
Number	279	736	1167	124	373
% Total Employment	31	33	34	11	19
Primary Towns Impacted And Number of Employees Moving There	Scottsboro-167 Hollywood-34 Huntsville-15 Stevenson-10	Scottsboro-433 Hollywood-89 Huntsville-37 Dutton-23 Section-18 Guntersville-13 Bridgeport-11 Stevenson-10	Scottsboro-634 Hollywood-127 Huntsville-67 Section-30 Stevenson-30 Chattanooga-23	Church Hill-16 Kingsport-36 Rogersville-21 Surgoinsville-24	Church Hill-67 Kingsport-74 Rogersville-71 Surgoinsville-54 Mount Carmel-19 Jonesboro-12
Housing Type Selected					
House-Bought	30 (11%)	158 (22%)	269 (23%)	40 (32%)	97 (36%) 133 (36)
Rented	51 (18%)	112 (15%)	157 (13%)	20 (16%)	43 (16%) 71 (19)
Total	81 (29%)	270 (37%)	426 (36%)	60 (48%)	140 (52%) 20 (55)
M. Home Bought	71 (25%)	177 (24%)	302 (26%)	16 (13%)	35 (13%) 44 (12)
Rented	66 (24%)	155 (21%)	196 (17%)	12 (10%)	18 (7%) 29 (8)
Total	137 (49%)	332 (45%)	498 (43%)	28 (23%)	53 (20%) 73 (19)
Apartment	40 (14%)	99 (13%)	196 (17%)	19 (15%)	55 (21%) 71 (19)
Other	21 (8%)	35 (5%)	47 (4%)	17 (13%)	19 (7%) 25 (7)
Grand Total	279 (100%)	736 (100%)	1167 (100%)	124 (100%)	267 (100%) 373 (100)
Movers					
With Families	144 (52%)	517 (70%)	822 (70%)	85 (69%)	195 (73%) 261 (70%)
Without Families	135 (48%)	219 (30%)	345 (30%)	39 (31%)	72 (27%) 112 (30%)
School-Age Children	108	348	569	52	119 168
Number Per Family	0.8	0.7	0.7	0.6	0.6 0.6

APPENDIX A (cont.)

TENNESSEE VALLEY AUTHORITY
SOCIOECONOMIC MONITORING AND MITIGATION SUMMARY

Project Name	Browns Ferry	Browns Ferry	Browns Ferry	Yellow Creek	Yellow Creek	
Date Of Survey	Oct. 1969	April 1971	July 1973	June 1978	Dec. 1978	June 1979
Total Employees	2500	3200	2100	980	1300	2145
Employees Surveyed	1700	2500	1800	760	1100	1600
Expected Peak	3200	3200	3200	4300	4300	4300
Total Movers						
Number	425	795	410	158	301	404
% Total Employment	17	25	20	16	18	19
Primary Towns Impacted And Number Of Employees Moving There	Athens-225 Decatur-46 Tanner-31 Huntsville-16 Rogersville-12 Florence-10 Moulton-10	Athens-436 Decatur-130 Tanner-45 Huntsville-34 Rogersville-19 Florence-18 Killen-10	Athens-154 Decatur-67 Tanner-20 Huntsville-24 Rogersville-14 Florence-19 Killen-14 Tuscumbia-13	Florence-14 Sheffield-6 Corinth-10 Iuka-72 Savannah-11	Florence-23 Sheffield-8 Tuscumbia-18 Burnsville-10 Corinth-26 Iuka-108 Savannah-23 Counce-11	Flo-31 MS-12 Tusc-22 Burnsville-12 Corinth-26 Iuka-135 Savan-34 Counce-11
Housing Type Selected						
House-Bought	81 (19%)	100 (13%)	172 (42%)	32 (21%)	95 (32%)	147 (36%)
Rented	157 (37%)	146 (18%)	93 (23%)	34 (21%)	59 (20%)	77 (19%)
Total	238 (56%)	246 (31%)	265 (65%)	66 (42%)	154 (52%)	24 (55%)
M. Home Bought	68 (16%)	155 (19%)	83 (20%)	25 (22%)	55 (18%)	75 (19%)
Rented	43 (10%)	157 (20%)	22 (5%)	13 (12%)	30 (10%)	40 (10%)
Total	111 (26%)	312 (39%)	105 (25%)	53 (34%)	85 (28%)	135 (29%)
Apartment	51 (12%)	116 (15%)	25 (6%)	21 (13%)	38 (12%)	39 (10%)
Other	25 (6%)	121 (15%)	15 (4%)	18 (11%)	25 (8%)	26 (6%)
Grand Total	425 (100%)	795 (100%)	410 (100%)	158 (100%)	301 (100%)	404 (100%)
Movers						
With Families	340 (80%)	506 (64%)	347 (85%)	96 (61%)	186 (62%)	
Without Families	85 (20%)	289 (36%)	63 (15%)	62 (39%)	115 (38%)	
School-Age Children	306	396	208	73	159	
Number Per Family	0.9	0.8	0.6	0.8	0.9	

APPENDIX B

AN EXCERPT: A GUIDE TO METHODS TO ASSESS IMPACTS ON THE HUMAN ENVIRONMENT[10]

There are seven components of an assessment process: economic, demographic, facilities/services, land use, fiscal, social, and cultural. The economic analysis considers employment, income, and the labor market. Three commonly-applied methods used to complete an economic analysis are the economic base, input-output, and econometric approaches.

The following is a descriptive statement about each method.

I. ECONOMIC BASE APPROACH

The economic base approach is popular because it is relatively easy to implement. The economic base (often called the export base) is that part of the local economy that responds to demand that originates outside the local economy. Total employment in a county can be categorized as basic and nonbasic as follows: basic employment is that employment responding to demand (or other forces, for example, political decisions) that are external to the local economy, and nonbasic employment is that employment that responds to levels of demand originating within the local economy.[20] An example of this approach has been developed by the ANL.

Another assessment approach described by the Missouri Basin Commission is "the input-output technique that focuses on the transactions that take place between industries. Each of the transactions involve both a purchase and a sale and input-output is organized around a table that summarizes that information. Unfortunately, if a transaction table does not already exist, its compilation from primary data is an expensive and time-consuming proposition." Third, the econometric approach "relies on a combination of economics and statistics. It is the standard method used in approaching description and analysis of the national economy. The approach is organized around three sets of accounts identified as (1) the production account, (2) the income account, and (3) the expenditure account. Its principal shortcoming for application to rural areas of the West is that the data required for the [three accounts] does not exist at the substate level. A substantial effort is required, therefore, to create the relevant data series before the actual econometric analysis can even begin."[21]

APPENDIX C

IMPACT PROJECTION MODEL (EMPIMP)

The impact projection model forecasts the annual changes in employment and population as a result of any given new energy or industrial project and superimposes these estimates on the population projections for the subject county. The data base for this model consists of the following county information:

- Population projections to the year 2000 by age, sex, and race from the Demographic Projection Model (DEMPRO);
- Labor force participation rates for basic and secondary employees by age and sex;
- Employment, by sector, from 1970 Census and 1972 City/County Data Book;
- Energy facility employment requirements by year and type; and
- Household characteristics and labor participation rates of spouse for transitory construction workers.

The user specifies the new energy or industrial project to be evaluated, the year in which facility construction begins, and the name of the county (or group of counties) in which it is to be located. The model determines the annual construction and operations work force requirements for the life of the facility. The secondary employment requirements indirectly created by the new project are estimated using an employment multiplier derived from export-base theory. The multiplier relates secondary jobs to basic jobs and is computed in one of two ways in a submodel to EMPIMP. The multiplier relationship is estimated either by dividing total secondary jobs in the subject county by total basic jobs or by pooling data on secondary and basic jobs from among homogeneous counties and regressing the basic on the secondary figure. Regardless of the method chosen to estimate the multiplier, the estimates of secondary jobs created with each annual increment in basic employment are lagged to reflect the delay that occurs between the stimulus and response.

Given annual estimates of expected new basic and secondary positions, the model determines the number of workers within commuting distance of the site who are not currently employed but available to work. Thus, the model does not assume that existing jobs will be vacated as a result of the new project. The available labor force is obtained by first subtracting the labor force participation rates (LFPR) by age and sex in the subject county from those prevailing nationally and multiplying the number of men and women within commuting distance by the results for each age category. This pool of available labor is further refined by classifying the men and women in each age category as potential basic or secondary employees using existing state employment data.

Inmigration of new workers and their households is assumed to occur only in those years when the number of new jobs exceeds the available local labor force. The model determines the number of basic and secondary jobs unfilled during a given year, the average household size of inmigrants, and the number of dependents in these households likely to accept work and computes both the number of households and the number of people likely to move to the area. If the number of new direct and indirect jobs falls over time, the model assumes that the inmigrants will be the first to be released and leave the area.

The model produces an annual estimate of the change in population size and composition as a result of the existence of the new facility. It merges the inmigrants with the population estimated for that year by DEMPRO and provides an annual characterization of the total population from 1970 to the year 2000.

APPENDIX D

TENNESSEE VALLEY AUTHORITY ECONOMIC BASE MODEL

It is common practice to access the indirect economic effects of autonomous governmental policy with the economic base model. In the model, a dichotomy is postulated between nonbasic activity, oriented toward serving the needs of the local economy, and basic (autonomous) activity, oriented toward serving the needs of external economies. In theory, growth is explained as originating in a maintained increase in the demand for basic sector output that increases regional income. Nonbasic sector output then increases by some multiple of the growth in basic activity, and local income is further increased through a multiplier process. Applied studies thus have as their goal the estimation of a multiplier value.

In the present study, a multiplier is estimated that would be useful in the determination of the probable indirect effects of the decommissioning of the Edgemont, South Dakota, uranium processing mill. The regression model used in the study is the partial adjustment model laid out by Nerlove.[22] Here, the assumption is made that the firms in each respective industry attempt to adjust their employment levels toward a desired level, but constraints, including the persistence of habit, prevent the adjustment in any one period. The result is inertia, or sluggishness in the adjustment of nonbasic activity to changes in basic activity levels and other variables. Houthakker and Taylor[23] note that the habit persistence model is preferred over earlier formulations because "it is derived from an underlying theory expressed in continuous time and thus avoids the arbitrariness common to models initially expressed as difference equations."

The estimating equation for the habit persistence model is differentiated from the static model through the inclusion of the lagged value of the dependent variable in the former. The "adjustment coefficient," indicating the rate of adjustment in nonbasic activity through time toward its equilibrium value is calculated as unity less the coefficient of the lagged dependent variable. A lag coefficient near zero implies that adjustments will be almost instantaneous. The coefficient of the lagged value of the dependent variable is, therefore, directly related to the inertial property of nonbasic sector activity growth.

The equation is:

$$N_t = a_0 + a^1 \ N_{t-1} + a_2 \ X_t + a_3 \ \text{TIME} + E_t,$$

where N_t = nonbasic employment in period $\underline{t}$ (including service producing activity plus state and local government),

N_{t-1} = N_t lagged one period,

X_t = basic employment in period t (including mining, contract construction, and federal civilian government activity),

TIME = time, and

E_t = a vector of residuals.

The parameters in the above equation are estimated by the application of the ridge regression (RR) estimator to an annual time series (for the years 1960-1978) of US Bureau of Labor Statistics (BLS)* data for South Dakota.** The RR estimator has been suggested for use in controlling the inflation and general instability inherent in coefficients estimated with a nonorthogonal data matrix,[24] a statistical problem that has been suggested in multiplier models similar to that used in the present study.[9,25] The estimated equation is[7]

$$N_t = \underset{(-1.18)}{-1465.78} + \underset{(11.35)}{0.4752} \ N_{t-1} + \underset{(12.07)}{0.8011} \ X_t + \underset{(5.64)}{0.7556} \ \text{TIME},$$

K = 0.100 and $RR^2 = 0.9850$,‡ where the t-ratios are in parentheses.

The nonbasic sector short run multiplier, i.e., the $\Delta N/\Delta X$, is estimated in the equation to be ($\partial N/\partial X = 0.80$). Regression results indicate that the nonbasic sector multiples, along with the remaining coefficients, have very small confidence intervals because their standard errors are very small and,

*The government data series reported by BLS is not separated into its federal civilian and local government components. In the study, these data are fabricated into each component based on their proportions of recent civilian government employment security data.

**Data for the actual impacted area are not available in a time series that is of sufficient length for statistical analysis. Thus, the South Dakota multiplier serves as a proxy for that of Edgemont.

‡Discussed in Ref. 7, the RR^2 statistic is the rescaled coefficient of determiration, and k is the ridge regression constant.

thus, their t-ratios are very large. Further, the nonbasic sector multiplier appears to be reasonable when compared to those estimated (or calculated) in other studies. Selected economic base studies contain nonbasic sector multiplies estimates that range from 0.45 to 2.00. It should be noted that the total employment short run multiplier is defined as 1.80 because

$$T = N + X = \text{total employment},$$
$$\Delta T = \Delta N + \Delta X, \text{ and}$$
$$\frac{\Delta T}{\Delta X} = \frac{\Delta N}{\Delta X} + \frac{\Delta X}{\Delta X}.$$

Other information to be gleaned from the regression equation includes the adjustment coefficient and the long-run multiplier. As noted above, the adjustment coefficient is calculated as unity less the coefficient of the lagged dependent variable, or (1-0.4752) = 0.5248. Here, it is implied that nonbasic employment will completely adjust to any given change in basic employment in 1.9 yr (1.9 = 1/.5248) because the adjustment coefficient is the rate of adjustment in nonbasic activity through time. The long-run multiplier for total employment is defined as unity plus the short-run nonbasic sector multiplier (0.8) divided by the adjustment coefficient (0.5248). The long-run multiplier is calculated as (1 + 1.52) = 2.52.

APPENDIX E

WYOMING ECONOMIC BASE ANALYSIS APPROACH[12]

The employment totals in Table III and the subsequent industrial classifications in Table IV were obtained from historical and comparative sources in Wyoming. Labor force expectations of the survey firms were used to estimate the basic component of total employment. Secondary figures were estimated using the historical relationships between these two components, observed in the employment figures of the Regional Economic Information Service[26] published by the Bureau of Economic Analysis (BEA). This data source relies almost exclusively on the Wyoming Employment Security Commission's ES202 Data file.[27] The figures represent employment by place of work (both covered and noncovered) for proprietors and wage earners. The figures represent average annual employment by place of work for both wage earners and proprietors. For the technical reader, population forecasts do not directly follow total employment because residence and multiple job adjustments must be applied. However, the employment forecasts provided in Tables III and IV do maintain the same definition as these estimates.

Only a few widely-different methods exist for forecasting the impact of growth on a regional economy. Input-output analysis, intersectional flows, and economic base theory delineate the available methodologies. Because the former methods require extensive estimation procedures, Economic Base Analysis was used to measure the impact of economic growth in the forecast period. This methodology monitors the economic changes in those industries that produce goods and services primarily for export from the county, therefore, the term basic or export component. Changes in the region's remaining industries are measured by determining the historical relationship between the two components. For example, if employment is the measure of economic growth in the basic sector, then either the ratio estimator, regression, or covariance designs can be used to determine the associated historical growth in the remaining or service industries. Whether the basic jobs are filled locally or by outsiders, the new jobs generate additional regional income through the salaries paid to new workers. The additional employees and their income generate demand for locally-produced goods and services. This additional demand for local goods and services leads to increased employment in service-related industries.

Statistical tests and the backcasting techniques discussed earlier were used to quantify this relationship for each county in the state.

The corresponding assumptions necessary for the implementation of this method are as follows.

- As a basic activity increases in a region, this increase induces a change in the nonbasic activities.

- Import leakages (that is, demand for goods brought into the region) remain at a proportional level. More explicitly, it is assumed that as a basic activity increases, the income generated is not spent entirely on imports. Rather, the proportion of import spending remains the same.

Because this method of forecasting demographic and economic events uses the basic component of the county to determine total employment change, a large number of constants or parameters (one for each sector and county) must be ascertained before program execution. A consensus doesn't exist on the appropriate estimation of these parameters or even the proper methodology in which they can be employed. For example, in determining secondary or service employment from construction projects, either the income of these construction workers or merely their actual numbers could be used to measure the size of induced employment (that is, income multipliers vs employment multipliers). To determine the appropriate values and methods within the original program, the backcasting test was used for this calibration. This provision in the program allows the user to substantiate estimation and competing logic and select the method that performs best.

The preferred unit of measure is employment because this proxy provides an indicator of economic opportunity. Economic opportunity would be the prime motivation for changes in population especially in the service sector. Because ultimately we are attempting to assess the impact on population of changes in employment, this unit of measure is a priori the more easily defensible. As employment in an export industry increases, this would imply an improvement in the demand for the export industry's goods and, therefore, an expansion of output. As the output of basic industry expands, the nonbasic industries that provide the necessary services in the area also will expand. However, employment in nonbasic industries may be insensitive to changes in export employment if uniform excess capacity exists in the county. After adjustments for place of residence, seasonal employees and commuters will not have a strong, induced effect on nonbasic industries because their demand for local goods and services will not be measured in the county of origin. This would entail significant distortion of service-related growth among the counties.

Employment as a proxy also ignores the significance of different types of expansions in the basic sectors on wage rates and productivity. Because of these considerations, the nonbasic or service component of total employment was estimated using the labor income of the basic component. To determine this relationship, the historical employment records for each county and broad industrial sector were divided into basic and nonbasic classifications by using location quotients from the BEA. Location quotients measure the degree of specialization of an industry in a region by comparing that industry's percentage employment of the total region to its percentage nationwide.

$$LQ_{ij} = \frac{(\text{county employment in industry } j) \div (\text{total employment in county } i)}{(\text{national employment for industry } j) \div (\text{total national employment})}$$

The basic employment for each sector (j) and county (i) between the years 1970 and 1977 then was computed by the product:

(1) $B_{ij} = ((LQ_{ij}-1)/LQ_{ij})T_{ij}$,

where

$i = 1, 2, \ldots, 23$

$j = 1, 2, \ldots, 10$

B_{ij} = basic component for sector and county

T_{ij} = total employment as reported by BEA.

The appropriate income multipliers to be used during the forecast periods then were calculated using the following estimator for each county and sector:

(2) $$\hat{B}_{ij} = \frac{\sum_{k=1}^{n}(S_{ijk}-\bar{S}_{ij})(BI_{ik}-\overline{BI}_i)}{\sum_{k=1}^{n}(BI_{ik}-\overline{BI}_i)^2} \qquad \begin{array}{l} i = 1, \ldots, 23 \\ j = 1, \ldots, 10 \\ n = 8. \end{array}$$

The determination of service employment in each sector and county can therefore be represented as:

(3) $S_{ij} \hat{=} A_{ij} + B_{ij}BI_i$,

where

S_{ij} = forecast of service employment sector

BI_i = estimate of basic labor income from firm survey in thousands of dollars.

This ratio provided the components that were used to estimate the relationship between the service employment and basic labor income for each county. The results suggested that the basic to service employment ratio and wage rates vary among counties and different industrial groups. Under these circumstances, the use of empirical "income multipliers" to estimate service employment produced more favorable results. This was confirmed when the program estimates of total employment were compared to the values as reported by BEA for 1977. At least in the case of forecasting, the increased attention to detail of statistical methods seems to perform better than the more general approach of simulation.

Another advantage of the estimator described above is the distinction of a marginal as opposed to an average parameter. The parameter, B_{ij}, can be defined as the number of additional service employees per thousand dollars of additional basic labor income. The use of average figures gives spurious results because its value is so dependent on the time period in which it is measured. The marginal technique captures the changing nature of the service sector over time and, therefore, allows for relative growth in the appropriate sector. This method appears reasonable when one considers that an additional basic employee in Sweetwater County today would find economic conditions different than one would in 1970. It seems unreasonable to forecast his impact on the service sector using the same ratio now as used before. Average analysis tends to overstate impact in counties where impact is transitory. This is the case especially for sectors whose excess capacity or inventory can adequately service additional demand. On the other hand, the average method would underestimate impact in sectors that are labor-intensive and better able to expand service without extensive capital investment.

APPENDIX F

DIRECT AND INDUCED URANIUM-RELATED EMPLOYMENT AND TOTAL EMPLOYMENT, BY COUNTY AND FOR THE STATE OF WYOMING, 1972-1978

	1972	1974	1976	1978
Carbon County				
Direct Uranium Employment	509	D	D	1 258
Induced Uranium Employment	222	NA	NA	1 011
Total Uranium-Related Employment	731	NA	NA	2 269
Total Employment	5 709	6 282	7 033	8 569
Percentage Uranium-Related Employment	12.8	NA	NA	26.5
Converse County				
Direct Uranium Employment	27	D	D	980
Induced Uranium Employment	51	NA	NA	3 361
Total Uranium-Related Employment	78	NA	NA	4 341
Total Employment	2 864	3 096	4 412	5 626
Percentage Uranium-Related Employment	2.7	NA	NA	77.2
Fremont County				
Direct Uranium Employment	1 078	790	1 220	1 815
Induced Uranium Employment	1 936	1 910	3 449	5 190
Total Uranium-Related Employment	3 014	2 700	4 669	7 005
Total Employment	10 277	10 711	12 597	14 808
Percentage Uranium-Related Employment	29.3	25.2	37.1	47.3
Johnson County				
Direct Uranium Employment	0	0	0	60
Induced Uranium Employment	0	0	0	180
Total Uranium-Related Employment	0	0	0	240
Total Employment	2 157	2.499	2 889	2 582
Percentage Uranium-Related Employment	0	0	0	93
Natrona County				
Direct Uranium Employment	320	307	324	222
Induced Uranium Employment	203	NA	NA	1 235
Total Uranium-Related Employment	523	NA	NA	1 457
Total Employment	20 015	22 528	26 847	32 071
Percentage Uranium-Related Employment	2.6	NA	NA	4.5
Five-County Subtotals				
Direct Uranium Employment	1 965	1 511	2 544	4 335
Induced Uranium Employment	2 442	2 684	5 847	10 977
Total Uranium-Related Employment	4 398	4 195	8 391	15 312
Percentage Uranium Related-Employment	11.3	9.8	16.5	24.1
TOTAL EMPLOYMENT, STATEWIDE	130 609	147 885	171 000	192 485
Percentage Uranium-Related Employment	3.4	2.8	4.9	8.0

NA = not available because of disclosure provisions.
D = county detail cannot be provided because of disclosure provisions, although totals are all-inclusive.

SOURCES: Wyoming Employment Security Commission, Department of Administration and Fiscal Control, and Quality Development Associates estimates.

APPENDIX G

INDUSTRIAL CLASSIFICATION OF EMPLOYMENT, FORECAST YEAR 1978

	Agriculture	Mining	Const	MFG	Transport	Trade	Finance	Service	Government	Others	Totals
ALBANY	389	32	533	533	628	2 213	370	1 703	4 102	651	11 154
BIG HORN	953	614	223	422	230	545	79	348	1 139	544	5 097
CAMPBELL	607	2 597	1 741	130	611	1 870	215	1 070	1 075	500	10 416
CARBON	647	1 764	924	433	915	1 541	195	1 065	1 938	651	10 075
CONVERSE	484	1 238	612	52	436	1 032	134	349	748	391	5 476
CROOK	630	285	171	131	110	213	25	78	453	212	2 308
FREMONT	1 042	3 644	751	472	743	2 945	318	2 115	3 111	941	16 081
GOSHEN	1 317	91	300	305	191	1 019	97	512	1 120	540	5 491
HOT SPRG	202	318	201	6	96	367	53	707	480	197	2 627
JOHNSON	438	275	253	91	91	387	53	293	558	327	2 767
LARAMIE	955	111	2 075	1 667	3 373	5 526	1 353	4 596	12 875	1 921	34 452
LINCOLN	734	1 382	404	301	498	892	90	289	853	383	5 828
NATRONA	440	6 104	2 961	1 663	2 168	7 952	1 289	4 772	4 684	2 046	34 079
NIOBRARA	420	30	56	33	36	266	39	124	251	173	1 428
PARK	1 200	854	638	740	384	1 908	173	1 665	2 026	825	10 413
PLATTE	760	351	342	68	171	581	62	435	720	379	3 870
SHERIDAN	868	701	1 052	448	483	2 715	300	1 346	2 524	1 027	11 464
SUBLETTE	407	165	389	24	122	304	33	138	411	237	2 239
SWTWATER	215	5 846	3 289	342	1 408	2 991	290	1 834	2 292	916	19 423
TETON	216	21	561	110	125	1 348	125	1 821	734	556	5 518
UINTA	355	474	132	243	515	903	90	324	1 406	428	4 868
WASHAKIE	597	200	254	444	228	759	97	442	754	367	4 143
WESTON	350	543	64	213	230	496	51	231	617	364	3 159
WYOMING	14 226	27 641	17 937	8 872	13 792	38 774	5 532	26 255	44 871	11 577	212 477

NOTE: "Agriculture" includes farm proprietors; "Other" includes nonfarm proprietors

REFERENCES

1. Old West Regional Commission, "The Construction Worker Profile," (December 1975).

2. John Goodier, Director of the Minerals Division, Wyoming Department of Economic Planning and Development, telephone interview, December 1979; and staff of the South Dakota State Planning Bureau, telephone interviews during the course of the survey.

3. Inter-Industry Technical Assistance Team, "Mercer County Socioeconomic Impact Mitigation Assessment," Vol. V (July 1979).

4. Bob Valeu, Coordinator of the Basin Electric Power Cooperative, telephone interview, December 1979.

5. "Mercer County Socioeconomic Impact Mitigation Assessment," Vol. V, from pp. 5-5a.

6. John Zaborac, Planner for the City of Glenrock and Converse County, telephone interview, December 1979; and Mike Sierg, Planner for the City of Douglas and Converse County, telephone interview, January 1980.

7. George De Veney, Tennessee Valley Authority, Knoxville, Tennessee, (November 1979).

8. Donald A. Rapp and William T. Roberts, "Coal Development on Indian Lands," under contract to the Denver Research Institute, for the Office of Technology, US Congress Assessment, US Congress, OTA-C-78-348 (December 1978).

9. W. Cris Lewis, "Export Base Theory and Multiplier Estimation: A Critique," Annals of Regional Science 10 (2), 60 (July 1976).

10. Missouri River Basin Commission, "A Guide to Methods for Impact Assessment of Western Coal/Energy Development" Chap. 3, (January 1979).

11. Argonne National Laboratory, Division of Energy and Environmental Systems, "Summary Description of SEAM: The Social and Economic Assessment Model," Technical Memo (April 1978).

12. Wyoming Department of Administration and Fiscal Control, Division of Research and Statistics, "Wyoming Population and Employment Forecast Report," Second Semiannual Ed. (June 1979), pp. 13-17.

13. Wyoming Department of Economic Planning and Development, Mineral Division, "Wyoming's Uranium Industry--Status, Impacts, and Trends" (September 1978).

14. T. Ruso, Wyoming Department of Economic Planning and Development, telephone interview, January 1980.

15. "Wyoming Population and Employment Forecast Report."(See Appendix G)

16. "Wyoming Minerals Development and Monitoring System," update (October 1979).

17. Colorado Department of Natural Resources, "Colorado Coal Directory and Source Book" (1978).

18. New Mexico Energy and Mineral Department, "An Overview of the New Mexico Uranium Industry" (January 1979), p. 5.

19. "Wyoming's Uranium Industry,...," p. 5-1.

20. "A Guide to Methods for Impact Assessment of Western Coal/Energy Development," p.20.

21. Ibid., pp. 22 and 24.

22. Marc Nerlove, "Distributed Lags and Demand Analysis for Agricultural and other Commodities, US Department of Agriculture (1958).

23. H. Houthakker and L.D. Taylor, Consumer Demand in the United States, 1929-1970, 2nd Ed. (Harvard University Press, Cambridge, Massachusetts, 1970).

24. A. E. Hoerl and R. W. Kennard, "Ridge Regression: Biased Estimation for Nonorthogonal Problems," Technometrics 12, 55-67 (February 1970).

25. Stephen J. Weiss and Edwin C. Gooding, "Estimation of Differential Employment Multipliers in a Small Regional Economy," Land Economics 44, 235-244 (1968).

26. "Industrial Classification of Employment, Forecast Year 1978," Regional Economic Information Service report, Bureau of Economic Analysis, US Department of Commerce, Washington, DC (April 1979).

27. Wyoming Employment Security Commission's ES202 Data File, State and County Summary of Covered Employment and Total Payrolls by Industry, Quarterly Report, Casper, State of Wyoming.

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