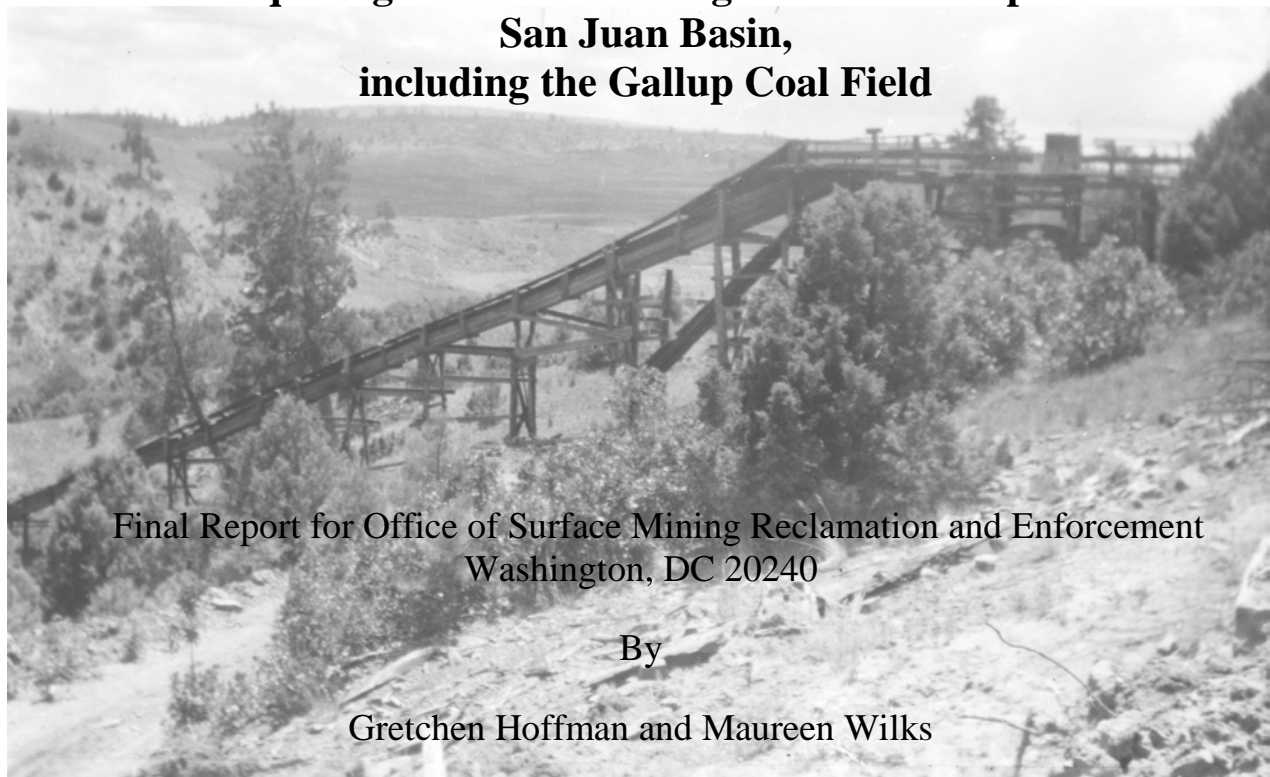


**Acquiring & Georeferencing Coal Mine Maps:  
San Juan Basin,  
including the Gallup Coal Field**



Final Report for Office of Surface Mining Reclamation and Enforcement  
Washington, DC 20240

By

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**Open-file Report 549**  
This supersedes Open-file 530

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*Cover Photo*

Chute at Erler Coal Mine, Monero Coal Field, Rio Arriba County, NM

*Source*

Photo held by Bureau of Land Management in Farmington, NM 87401

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## Introduction

This report on the abandoned coal mines in the San Juan Basin coal fields of northwest New Mexico brings together all the known mine and coal geology maps, coal reports, and coal mine photographs in this area, including maps reported in Hoffman and Wilks (2010) on the Gallup coal field. The first mention of coal in New Mexico was in 1803 (Jones, 1904, p. 211). It was not until the early 1880's and the building of railroads across the United States that coal in the Monero and Gallup fields was developed. The railroads and local fuel needs kept many of the mines open after World War II. A few of the small underground mines continued to operate until the late 1960s- early 1970s. With the change to diesel for the railroads and natural gas for home heating, and more stringent regulations most of the small coal operations ceased to exist.

There are 19 recognized coal fields in the San Juan Basin: Gallup, Chaco Canyon, Bisti, Star Lake, Chacra Mesa, Navajo, Barker Creek, Hogback, Toadlena, Newcomb, Fruitland, La Ventana, Standing Rock, Crownpoint, San Mateo, South Mount Taylor, East Mount Taylor, Rio Puerco, and Zuni. Outliers on the northeastern side of the basin include the Tierra Amarilla and Monero fields.

Information about the individual coal fields of the San Juan Basin has been well documented by Hoffman (1996) *Coal Resources of New Mexico*, New Mexico Bureau Mines Mineral Resources (NMBMMR), Resource Map 20, Nickelson's (1988) NMBMMR, Bulletin 111, *One hundred years of coal mining in the San Juan Basin*, New Mexico, and Shomaker et al., (1971), *Strippable low-sulfur coal resources of the San Juan Basin*, NMBMMR Memoir 25. Below are brief summaries taken from the above references about the main coal fields in the San Juan Basin: Figures 1-7 are reproduced from the ArcGIS project and show the locations of all the known mines in the San Juan Basin area.

### *McKinley County*

**Standing Rock:** This field is northwest of the San Mateo field, and the arbitrary boundary between the two fields is the western border of R8W. Coals in this field are within the Menefee Formation, Cleary Coal Member. Mining in the Standing Rock field has consisted of small open pits until 2008 when Lee Ranch Coal opened El Segundo surface mine northwest of Lee Ranch mine and extended a rail spur to this operation.

**Crownpoint:** The Crownpoint field is the largest coal field (930mi<sup>2</sup>) in the San Juan Basin, encompassing the Crevasse Canyon Formation exposures from northeast of the Gallup field to the west edge of the San Mateo field. Coal occurs in both the Dilco Coal and Gibson Coal members within this area. The first mine to open was the Crownpoint mine, operating from 1918 to 1951. The mine supplied coal for the Navajo Indian schools and agency facilities at the town of Crownpoint. Fourteen small mines are known to have operated in this field.

**Gallup:** The Gallup field has been a significant coal producing area since the early 1880s. Underground mining began at this time with the construction of the railroad through the area and continued until the 1950s. The earliest coal mine in the Gallup area was the Gallup (Gibson) Mine in 1882. Most of the coal mined in the Gallup area is within the Dilco Coal Member of the Crevasse Canyon and in Gibson-Cleary Coal Member of the Menefee and Crevasse Canyon formations, undivided. A few operations extracted coal from beds within the Gallup Sandstone. Large-scale surface mining began in the 1960s and continued until the end of 2009 when the

McKinley mine, northwest of Gallup closed. As of 2009 over 248 million short tons of coal have been produced from the Gallup area and remaining estimated resources are over 810 million st.

Zuni: This coal field is the southern extension of the coal-bearing sequences seen in the Gallup field. Coal in the Zuni field is within the Dilco Coal Member of the Crevasse Canyon Formation, the Gallup Sandstone, and the Carthage Member of the Tres Hermanos Formation. The need for coal to heat the Zuni Agency schools and administration buildings at Blackrock led to the opening of the first coal mine in 1905. Two adjacent mines were opened in 1913 and operated until 1958 when the agency changed to other, cleaner fuels.

#### *McKinley-San Juan Counties*

Chaco Canyon: Small drifts and pits operated by the Navajo Indians are the only mines in the Chaco Canyon area. This field extends from the eastern Navajo Reservation boundary along the Menefee Formation outcrop. Coal beds are in the upper coal member of the Menefee Formation near surface and Cleary Coal Member at depth. Only two named mines are mentioned in the literature; the Blake mine and Pueblo Bonita mine, but Shomaker et al. (1971) mentions several abandoned coal mines at the mouth of Tsaya Canyon.

#### *McKinley-San Juan- Sandoval Counties*

Star Lake: Star Lake is a continuation of the Bisti field and extends east-northeast for about 55 mi following the trend of the Fruitland Formation outcrop. Several small pits were developed by Navajos along the coal outcrop for home heating fuel. There were numerous coal development projects in the 1960's including federal leases and preference right leases that are no longer active. Lack of transport hampered efforts to develop this field. A railroad line to transport the coal could not obtain the right-of-way and the necessary environmental and political sanctions.

Chacra Mesa: The coals of Chacra Mesa include the coal -bearing sequences of the Cleary Coal Member and upper coal member of the Menefee Formation. The field includes 12 townships, namely T17N in Ranges 4-7 W; T18N in Ranges 3-8W; and T19N Ranges 7 and 8W. The first underground mine was opened in 1933; only 3 mines are known from the area.

San Mateo: This field is northwest of Mount Taylor volcanic complex and southeast of the Chacra Mesa field. It includes exposures of the upper coal and Cleary Coal members of the Menefee Formation. Several small abandoned mines produced coal for local use. In the late 1970s Santa Fe Mining Company began extensive exploration in the San Mateo field. The company acquired two state leases (1981) and began shipments of coal from the Lee Ranch surface mine in 1984. Santa Fe sold their coal properties to Hanson Natural Resources PLC in 1994. Lee Ranch is now operated by Lee Ranch Coal a subsidiary of Peabody Energy.

#### *Rio Arriba County*

Monero: The Monero field on the northeast side of the San Juan Basin is defined by outcrops of the Mesaverde Group that extend southward from the New Mexico-Colorado State line for approximately 26 mi. Coal mined in this field is within the Menefee Formation. Two mines, the Monero and the San Luis were operating at Monero in 1893. From 1899 through 1907

35,000-51,000 tons of coal was produced from the Monero field supplying coal to the narrow gauge and lumber railroads in the area. The last mine in the Monero area closed in 1962.

Tierra Amarilla: This small field is an outlier of the coal-bearing Menefee Formation approximately 12 mi east of the edge of the San Juan Basin, southeast of the town of Tierra Amarilla. Very little mining took place except for local use. Four prospects or small mines have been located in this area. Production from these mines was limited and for domestic use.

#### *Sandoval County*

La Ventana: This field is on the southeastern edge of the San Juan Basin. The La Ventana area includes the Cleary Coal and upper coal members of the Menefee Formation. The first coal mines in the La Ventana field, the Senorito and the San Pablo were developed from 1884 to 1900. The last of the small operations closed in 1969. Many of the early mines supplied coal to the nearby metal mines in the Nacimiento Mountains. In the 1920s-1930s coal mines in the area supplied coal to a railroad from Bernalillo to La Ventana, but the railroad followed the course of the Rio Puerco and had constant problems with washouts. From 1978 to 1984 a small surface operation (Arroyo No. 1) on State land, mined coal from the Cleary Coal Member. In 1976, Ideal Basic looked at supplying coal to their cement plant east of Albuquerque from mining upper coal member beds southeast of Cuba. Exploration drilling and a mine plan were submitted to the State, but there was no development.

#### *Sandoval-Bernalillo Counties*

Rio Puerco: The Rio Puerco field is an irregular outcrop belt of Mesaverde Group coal-bearing rocks in the Rio Puerco valley, an outlier of the San Juan Basin. This field is approximately 15 mi southeast of the East Mount Taylor field. Coal is present both within the Dilco and Gibson Coal Members of the Crevasse Canyon. The field is within Rio Puerco fault zone and the coal-bearing outcrops are in narrow steeply-dipping fault blocks. Mining in the Rio Puerco began in the 1920s and continued into the 1940s. Eight small mines have been reported in the coal field with a total production of just under 40,000 st, mainly from the Canoncito and Ferro mines.

#### *Sandoval-Cibola Counties*

South Mount Taylor-East Mount Taylor: The coal-bearing Dilco and Gibson Coal Members of the Crevasse Canyon Formation outcrop on the flanks and in the foothill mesas of Mount Taylor and Mesa Chivato. Coal has been mined on a small scale on the northeast walls of Seboyeta Canyon. Strip mining in the area is precluded because the coal crops out on steep slopes.

#### *San Juan County*

Bisti: Coal in this field occupies an area from the eastern Navajo Reservation boundary near Bisti eastward along the Fruitland Formation trend to the eastern line of T21N, R9W. The Bisti field is approximately 35 mi long and is arbitrarily separated from the Star Lake field at the boundary between R9W and R8W. The first coal was probably mined by Navajo Indians at the exposed outcrops. The Public Service Company of New Mexico (PNM) was the first to be interested in acquiring large acreages of coal in 1961. Exploration flourished in the 1960s-1970s and several leases and preference right leases (PRLA) were acquired by several companies along

the Bisti-Fruitland trend. Seven PRLAs are still active (2012) in the Bisti field, either in appeal or adjudication. The only small mine to open in the area was the De-Na-Zin surface mine operated by the Sunbelt Mining Company from 1980-1988, The Bisti field represents the largest undeveloped surface-minable coal resource in the San Juan Basin

**Navajo:** This field is defined by the Fruitland Formation exposures within the Navajo Indian Reservation, a distance of approximately 35 mi from the San Juan River south to Hunters Wash and Coal Creek and east to the boundary of the reservation. The Navajo mine began operations in 1963 as a surface mine. BHP Billiton is currently surface mining, and reclaiming in three areas within the Navajo mine property. The Navajo mine has produced over 344 million tons of coal since 1963; all production goes to the Four Corners generating station operated by Arizona Public Service Company. There are several small underground operations shown on a mine map for the Navajo mine (1981, see georeferenced map), but little is known about these mines as they are on the Navajo Reservation.

**Barker Creek:** This coal field is the northwestern most Menefee Formation field in the New Mexico part of the San Juan Basin, extending from the Colorado-New Mexico state line to T31N. The remote location, being on the Ute Mountain Ute Indian Reservation and the high-angle dip of the beds along the Hogback monocline limit the development of coal in this field. The coal beds are thin within both the Cleary Coal Member and upper coal member of the Menefee Formation. A few mines could have been developed underground, however only two mines, the Helper mine and Fisherick prospects are known from the literature.

**Hogback:** The Hogback is defined by the continuation of the Menefee Formation outcrop on the west side of the San Juan Basin south of the Barker Creek field from T30N south to T26N. Mining was first reported by the Territorial Mine Inspector in 1907-1908. The early mines operated from the 1900's into the 1950's. The last mine ceased operation in 1976. A total of 18 mines are known to exist along the Hogback monocline; all were mining coal from the upper coal member of the Menefee Formation.

**Fruitland:** The Fruitland field includes the Fruitland Formation exposures from the San Juan River north to the New Mexico-Colorado state line. Small coal mines were opened in the Fruitland field in the 1890s and early 1900s to supply fuel for domestic use. Very little large-scale mining took place before 1958. Today most of the surface minable resources of the Fruitland field are within the lease areas of the San Juan and La Plata mines (San Juan Coal Company, a subsidiary of BHP Billiton). The La Plata mine operated as a surface mine from 1986 to 2002 and supplied coal to the San Juan generating station. The San Juan mine operated as a surface mine from 1963 to 2001 when the operation converted to an underground longwall mine. The San Juan mine continues to supply coal to the San Juan generating station operated by Public Service of New Mexico.

**Newcomb:** The Newcomb field is on the Navajo Indian Reservation, encompassing the southwestern edge of the Menefee Formation. The strike of the outcrops changes from north-south to northwest-southeast, following the Chaco River drainage. Coals in the Newcomb field are within the upper coal member, near the top of the Menefee Formation, and are overlain by the Cliff House Sandstone. Many of these coal beds have been burned and form masses of red

clinker (Shomaker, et al., 1971). In several localities the coal beds can be 4-8 ft thick. Very few coal mines are documented for this area; only the Toadlena No. 2 mine is mentioned in the literature. This mine operated from 1952 to 1958 in a 5 ft thick coal bed.

### Rationale for Study

Depending on the location, many of these old underground mines are within city limits and underlie areas where there has been surface development of housing tracts, schools, and shopping centers. Others are near major highways and may impact future development. As a result of past and future urban growth above these underground coal mines numerous environmental and public safety issues are now facing future development between Farmington and Shiprock along US Highway 64 and the city of Gallup including subsidence issues, environmental concerns from underground coal mine fires, and determining the exact location of abandoned mines and mine lands in and surrounding the city. To address the specific safety and environmental concerns detailed knowledge of the underground mine workings and location of mine openings, shafts, and adits are needed by regulatory agencies, developers and concerned citizens. A layer in the ArcMap project shows city boundaries from the Census Bureau's TIGER/line files. This layer helps the user see the relationship between abandoned mines and populated areas.

The compilation presented in this DVD allows access to the raw data through an Access Database and for the georeferenced mine maps in an ArcMap Project. PDF's of all the mine maps, mine reports, and jpeg images are accessible in the database or directly from folders on the DVD. The location, geology, mine development and coal production data are linked to coal mine locations in the ArcMap project from the Access database. Not all mines could be located by latitude and longitude, and these exist only in the Access database. Where coal maps are available, the pdf is hyperlinked to the mine location in ArcMap.

## **Coal Mine Database**

(CoalMines.mdb)

The Coal Mine database presents coal data from the 374 known mines in the San Juan Basin. Data includes:

- Location data
- PDF (OCR'd) Reports from the Abandoned Mine Land Survey in 1980
- PDF's of the Mine Map where available
- Geologic information (Host rock, host formation, rock type)
- Mine Development & Production data
- Production from Territorial Mine Inspector or State Mine Inspector Reports
- Photographs with accompanying captions.
- References



## Methodology

The database for this project is a subset of the CoalMines database for inactive mines housed at the New Mexico Bureau of Geology. The basis for most of the information in the database is from the work done for the Abandoned Mine Lands Survey (AML) conducted in the late 1970s by geologists at the New Mexico Bureau of Geology and Mineral resources (then the New Mexico Bureau of Mines and Mineral Resources). During this project locations were field checked, openings photographed, and located on topographic maps. The histories of the mines were compiled by Howard Nickelson who had worked for the Conservation Division of the US Geological Survey in Carlsbad, New Mexico (see preface in Nickelson, 1988).

Locations for the mine records in the database are primarily from Nickelson (1988); these locations are given in the PLSS (Township, Range, and Section) with distances from North line and East line of the section at the beginning of each mine description. Although the AML survey located the mines on topographic maps, the published data in Nickelson (1988) was used as the final source when there was a discrepancy in location. From these sources the points were located on topographic maps and then latitude and longitude were determined by hand. For this study the locations were rechecked and latitude and longitude determined by projecting the data points into All Topo and adjusting when needed.

Mine locations and names of the mines, production information, ownership, were checked against data in the MILS data set (Causey, J. D., 1998). MILS data was brought into ArcMap and the points were compared with the points projected from CoalMines database locations. In some cases the MILS dataset used the center of a section for the location, when no more accurate location was available. The Nickelson (1988) location was used when there was a discrepancy.

The NMBG Coal Data Library houses printouts from the MILS including references for their mine data. Discrepancies between MILS and data entered into the CoalMines database were checked by going back to the original source of the data, such as Sears (1925) or the US Geological Bulletin 860 series (Sears, 1934, Hunt, 1936, Dane, 1936) or mine inspector reports.

The Territorial (1882-1911) and State Mine Inspector (1912-1962) were verified for mine names, owners, mine development and production data. The production data included in the CoalMines database is from these reports. Geologic and other information about these inactive mines was gleaned from Sears, (1925, 1934), Hunt, (1936), Dane, (1936), or Hayes and Zapp (1955) on various areas of the San Juan Basin. Many of these publications and others listed for individual mines (References field) have maps showing mine locations for the time period. These references helped to locate many of the mines when locations from Nickelson were vague.

The AML survey produced individual mine notes (Nickelson, 1979) with field photographs, historical information, and problems that needed reclamation. These have been scanned and are linked to open individual pdfs for the associated mine from the CoalMines database (“Open AML Notes” control on form). Mine fires or subsidence is noted on the Environmental tab of the CoalMines database form and further information is noted in the Mine History field on the Mine Development tab. Analyses on mine samples found in the literature are listed in fields on the Environmental tab form. This data was compiled from a variety of sources and references are listed for the individual mine. A complete reference is accessible from the main CoalMines form through a control button (Open Reference Table).

The Geologic Information Center (GIC) houses the old coal mine maps and these have been scanned and catalogued in the NM Map database, managed by Maureen Wilks. The most complete map available for a mine was used for georeferencing in the ArcMap project. Each map

was brought into ArcMap and referenced by points on the map to the respective point on the topographic base maps. Further description of how these maps were georeferenced is in the map layer properties description. If a mine map is available, a pdf can be opened through a control button on the CoalMines database form (Location data tab, CoalMaps\_GICfrm subform, Open Map PDF control button).

Within the CoalMines database there is an audit trail to track changes for each record. In the upper right hand corner of the form a control button (View Changes to Record) allows the user to view the changes for each record. In the query objects the DeletedRecords\_from\_AuditTable query allows the user to see records that have been deleted and generally a reason has been entered in the Comment field to indicate the reason for deletion. Deletion of a record generally occurs if a record is a duplicate or no reference can be found for the entry.

## **Arc Project**

(MineMap.mxd, MineMap\_rdr.pmf)

### **Description of layers in ArcMap and ArcReader projects.**

The ArcMap project coordinate system is NAD1927 Lambert Conformal Conic. This projection was chosen because the quadrangle maps for the San Juan Basin were created in NAD27 and the US Geological Survey uses this projection for their State Base Map series. Each layer within the ArcMap project is described below. This data is also found in the properties of each layer within ArcMap. Metadata is found through ArcCatalog.

**Coal Mine Locations:** Coal mine locations from the CoalMines database that are located by latitude and longitude. These points are related to the location, geology, mine development and production tables in the CoalMines database by the Coalmine\_ID and data can be seen with the information icon placed on the point. Coal mines that have associated mine maps have hyperlinks to pdfs and can be accessed using the lightning bolt icon.

**County Coal Layers:** Layers are grouped by county. McKinley County has two layers groups one for Gallup and for the Crownpoint fields. Following is a description of the sub layers:

**Mine Maps Sub Layer:** All the mine maps for a county are grouped under this layer. Mine maps for the different fields were scanned as tiff images, and then indexed to have the fewest number of colors and reduce the size of the tiff file. To georeference the tiff, the appropriate mine was selected from the Coal Mine Locations layer and zoomed to the selection. The map was fit to the display area; if a visual scale was on the map, it was measured to determine if the scale of the display matched that of the map. Points on the map that could be matched with the underlying topographic map, such as section corners, centers, and quarters along section boundaries were matched with the georeferencing tool. The map was then rectified. Using the rectified image, the map was clipped, either by setting maximum and minimum extents to eliminate no data areas or with a mask. After clipping, the colormap (indexing) was reapplied and the display was set to have 20% transparency.

**AML Maps Sub Layer:** Quadrangle maps with locations from the Abandoned Mine Land study done in the late 1970s- early 1980s. Maps were scanned as Tiffs, palletized and georeferenced, using the topographic maps brought in from All Topo. The georeferenced maps were clipped using a mask and the colormap reapplied.

**Topographic Maps:** Digital georeferenced topographic maps generated from All Topo. These are either individual or combined 7.5 min. quadrangles projected in the NAD27 Lambert Conformal Conic and brought into the project. These base maps were used for georeferencing of mine maps and AML maps.

**Counties:** Outline of the counties within the San Juan Basin. This is clipped from a Tiger/line shapefile from 2010 census data for the entire state of New Mexico download from New Mexico Resource Geographic Information System Program: <http://rgis.unm.edu/browsedata>

**Surface coal mine permit areas:** Surface coal mine permit areas in the San Juan Basin. This shapefile is from the Energy Minerals, and Natural Resources Department, Mining and Minerals Division in Santa Fe, NM. Attributes for this shapefile indicate operator and status of mine area.

**Coal Fields- San Juan Basin:** Coal areas within the basin and a few outliers extracted from the NM Mining districts map, McLemore, et al. (2005). There is some modification of the areas to comply with field definitions of Shomaker et al., (1971).

**Coal Units San Juan Basin:** Shapefile of Late Cretaceous coal-bearing units from the NM Bureau of Geology NM state geologic map. Coverage is limited to the basin and outliers.

**Surface Ownership:** Surface ownership for San Juan Basin was clipped from BLM (2008) coverage. Shapefile acquired from New Mexico Resource Geographic Information System Program -RGIS:<http://rgis.unm.edu/browsedata>

**Mineral Ownership- US Government:** Clipped shapefile of mineral ownership from BLM shapefile acquired from New Mexico Resource Geographic Information System Program – RGIS: <http://rgis.unm.edu/browsedata>

**Townships:** Clipped shapefile from BLM, NM State Office acquired from New Mexico Resource Geographic Information System Program –RGIS: <http://rgis.unm.edu/browsedata>

**Highways:** Census Bureau's Tiger/line files from 2010. Clipped to project area and modified with fields to classified data as Interstate, US Highways, or State Roads. Download from New Mexico Resource Geographic Information System Program –RGIS: <http://rgis.unm.edu/browsedata>

**Areas of Population:** City, town and village boundaries from Census Bureau's TIGER/line files, 1994 for New Mexico clipped to San Juan Basin area using township shapefile. Download from New Mexico Resource Geographic Information System Program –RGIS: <http://rgis.unm.edu/browsedata>

## DVD Directory - SJBMines

### Folders:

24K Quads

- All Topo

Base (county, township, highway layers)

Coal Permits

Data

- PDF's (AML Reports) - by county
- Photos
- CoalMines\_SJB.mdb – Access database

Mines – county folders with mine maps

NMCoalMap (coal areas and coal units)

Ownership – surface and minerals

MineMap.mxd (ArcMap Project)

MineMap.pmf (Arc Reader Project)

GeoreferencedMaps.doc

OFR 549\_SanJuanBasinMines.pdf (Final Report)

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Figure 1

# San Juan Basin Coal Areas and Mines

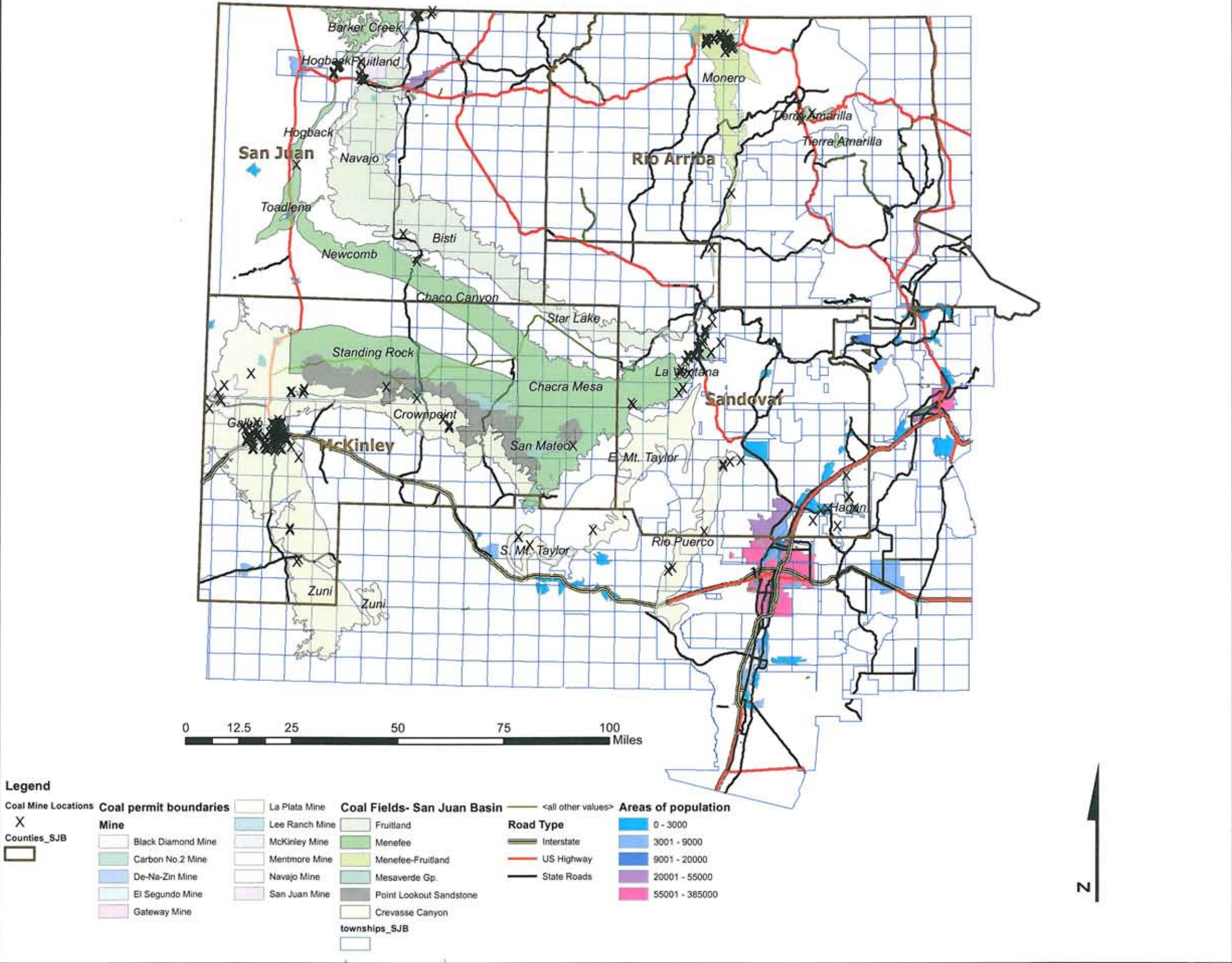




Figure 2

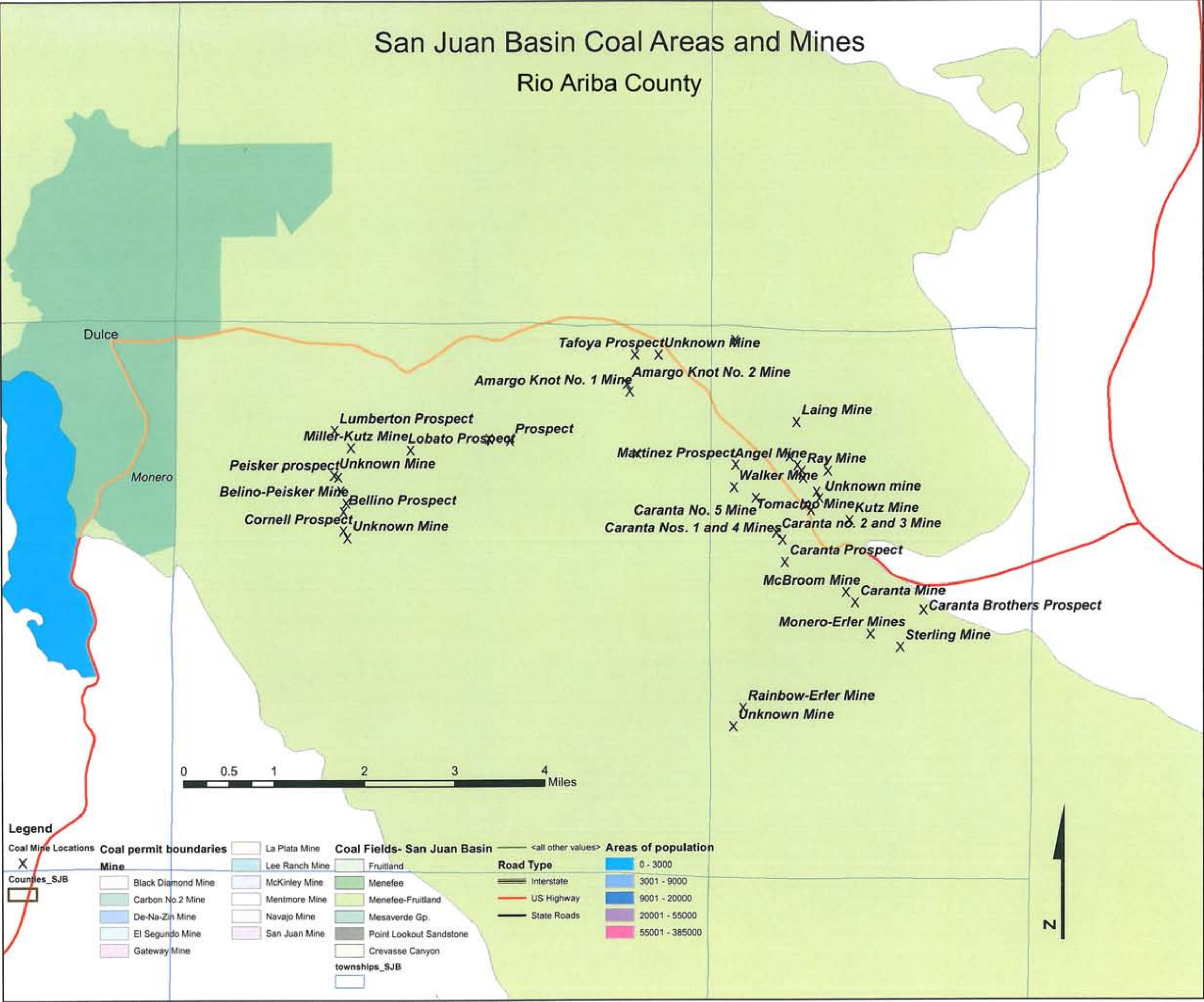




Figure 3

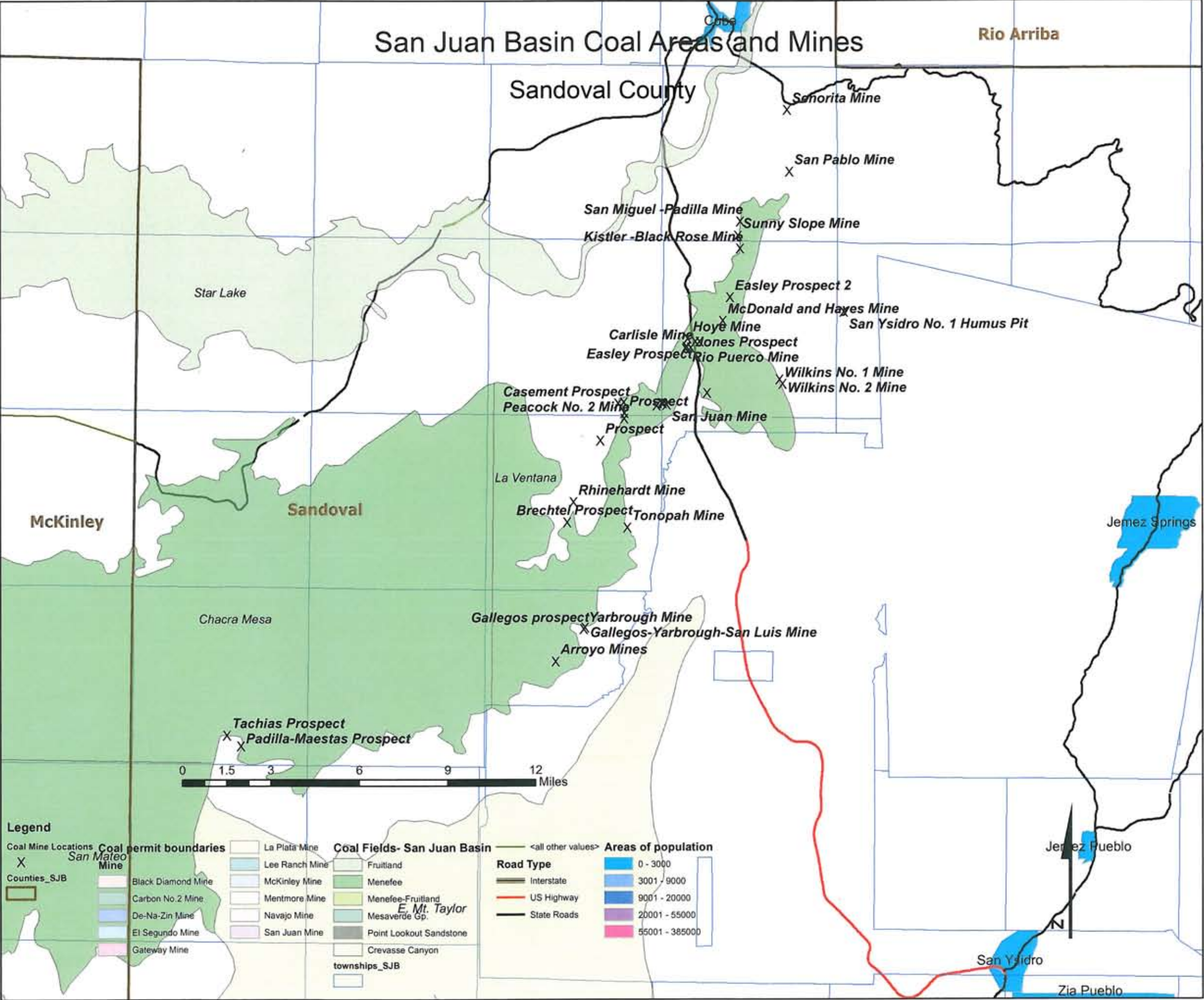


Figure 4

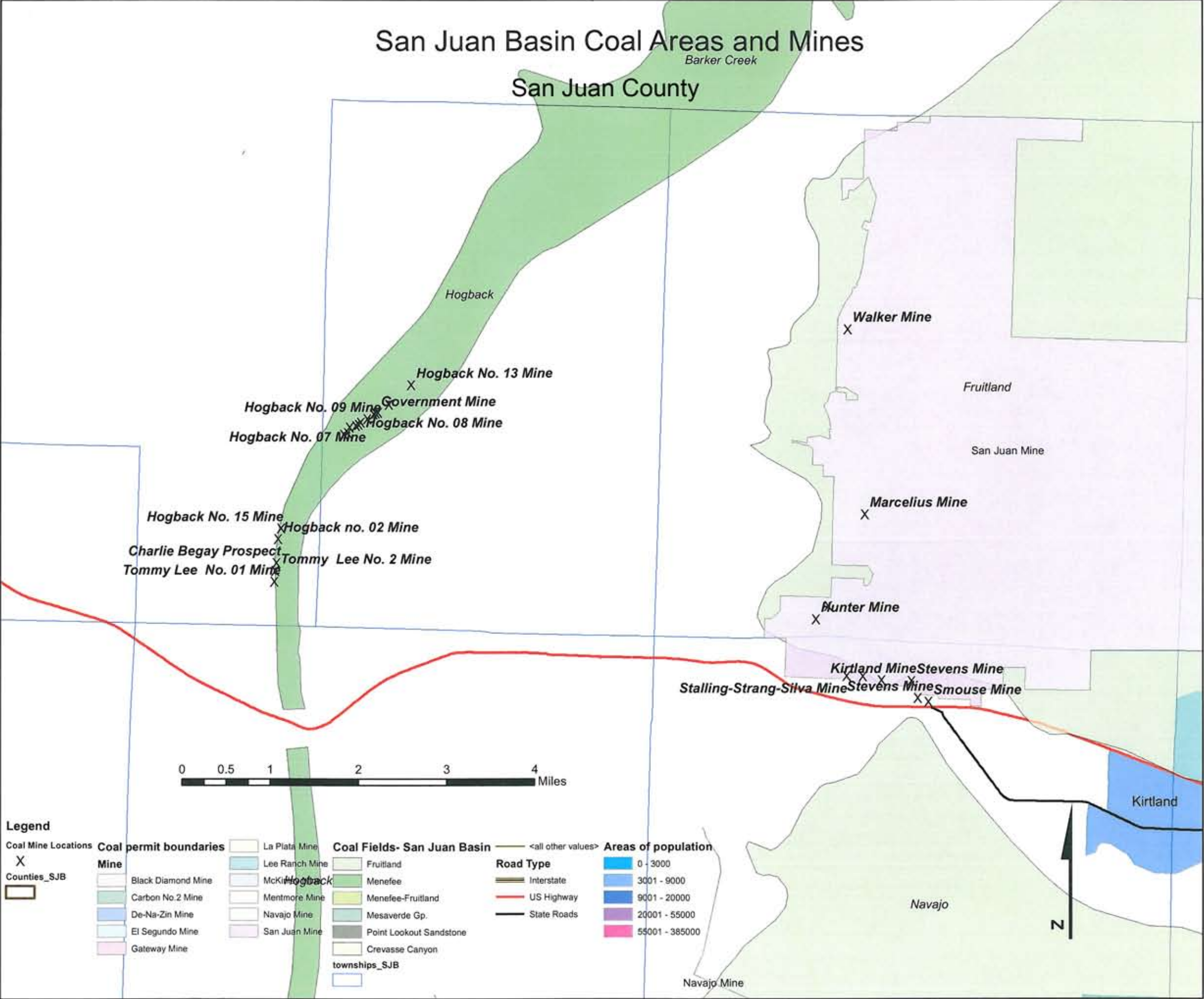




Figure 5a

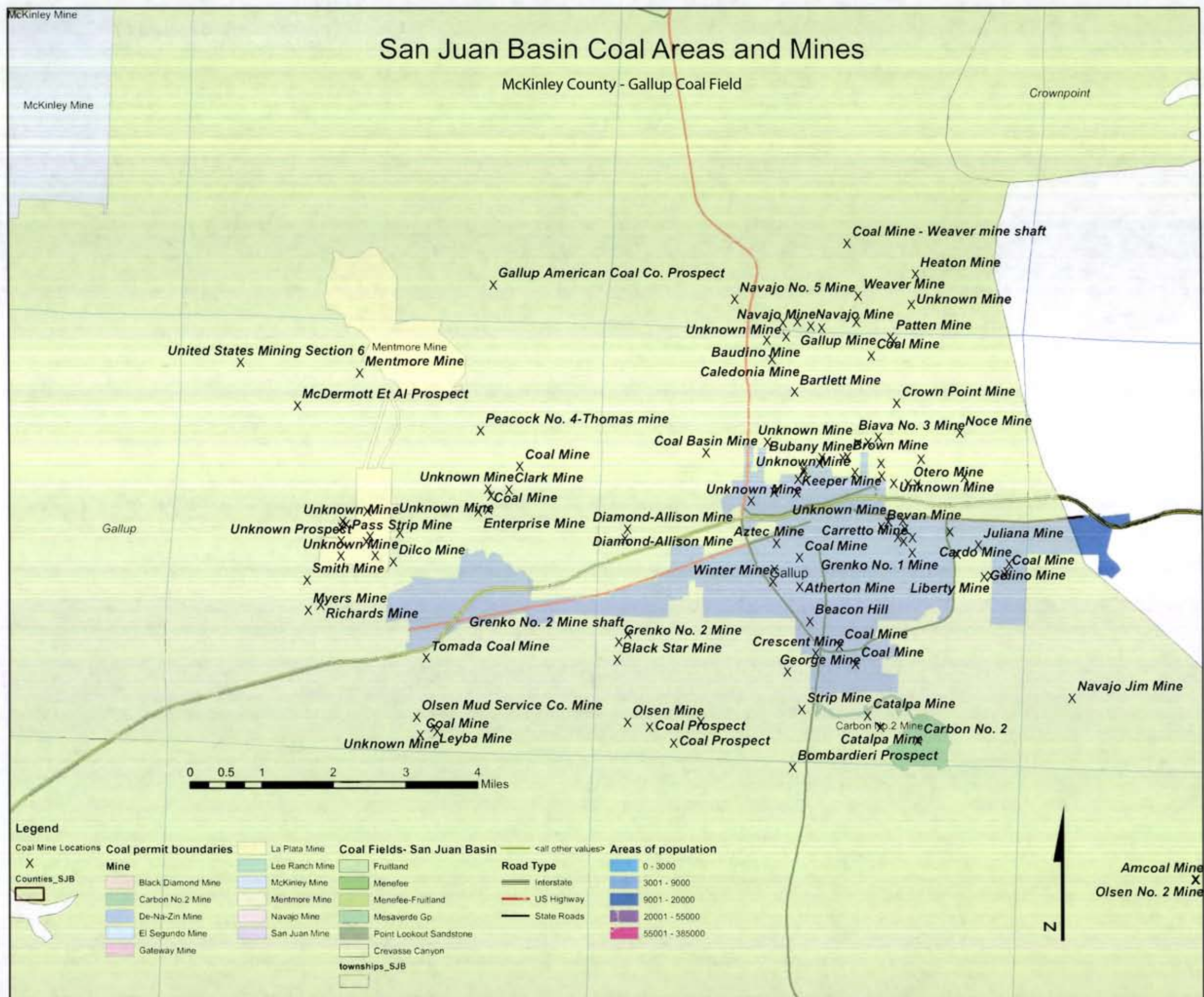




Figure 5b

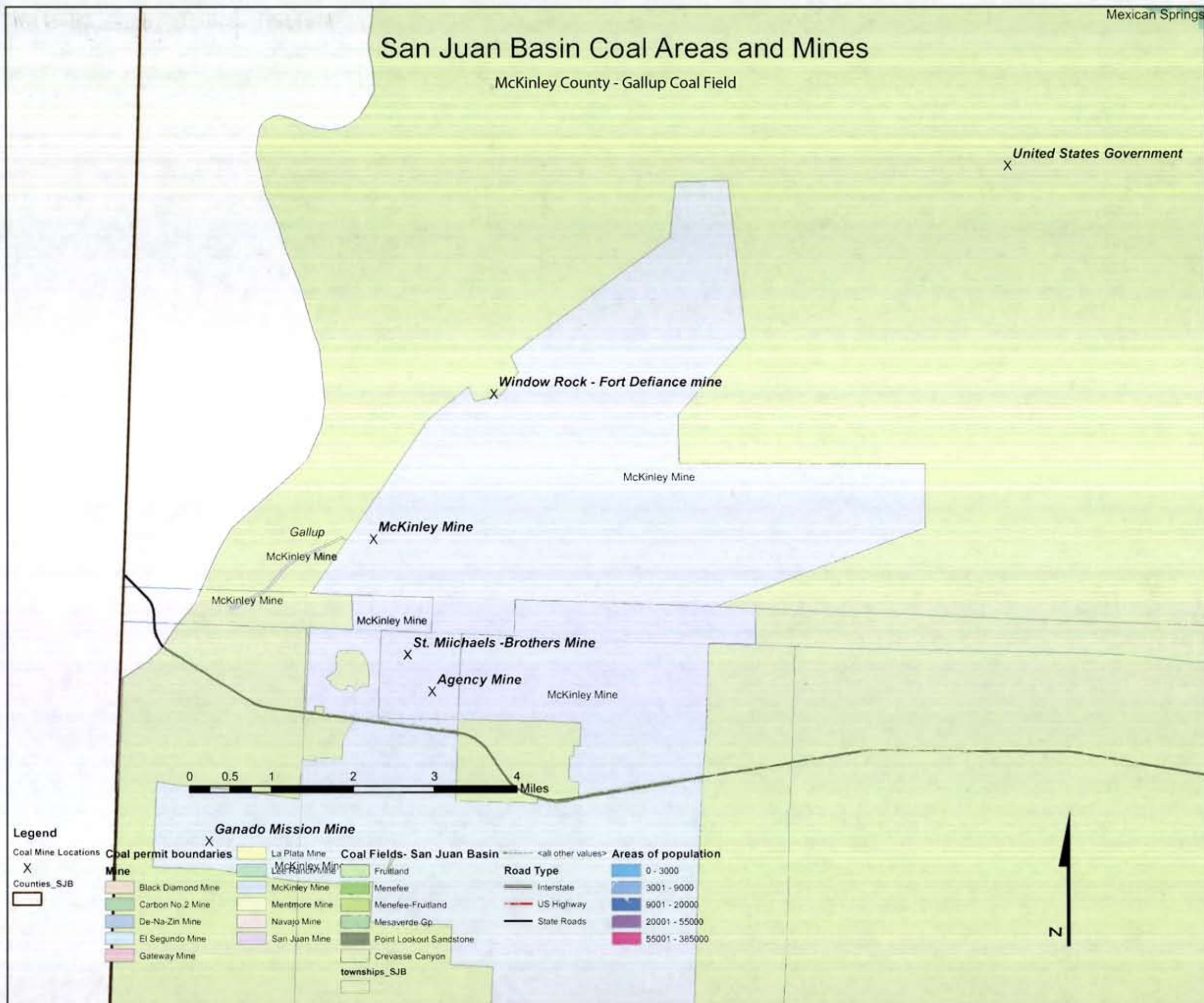




Figure 6

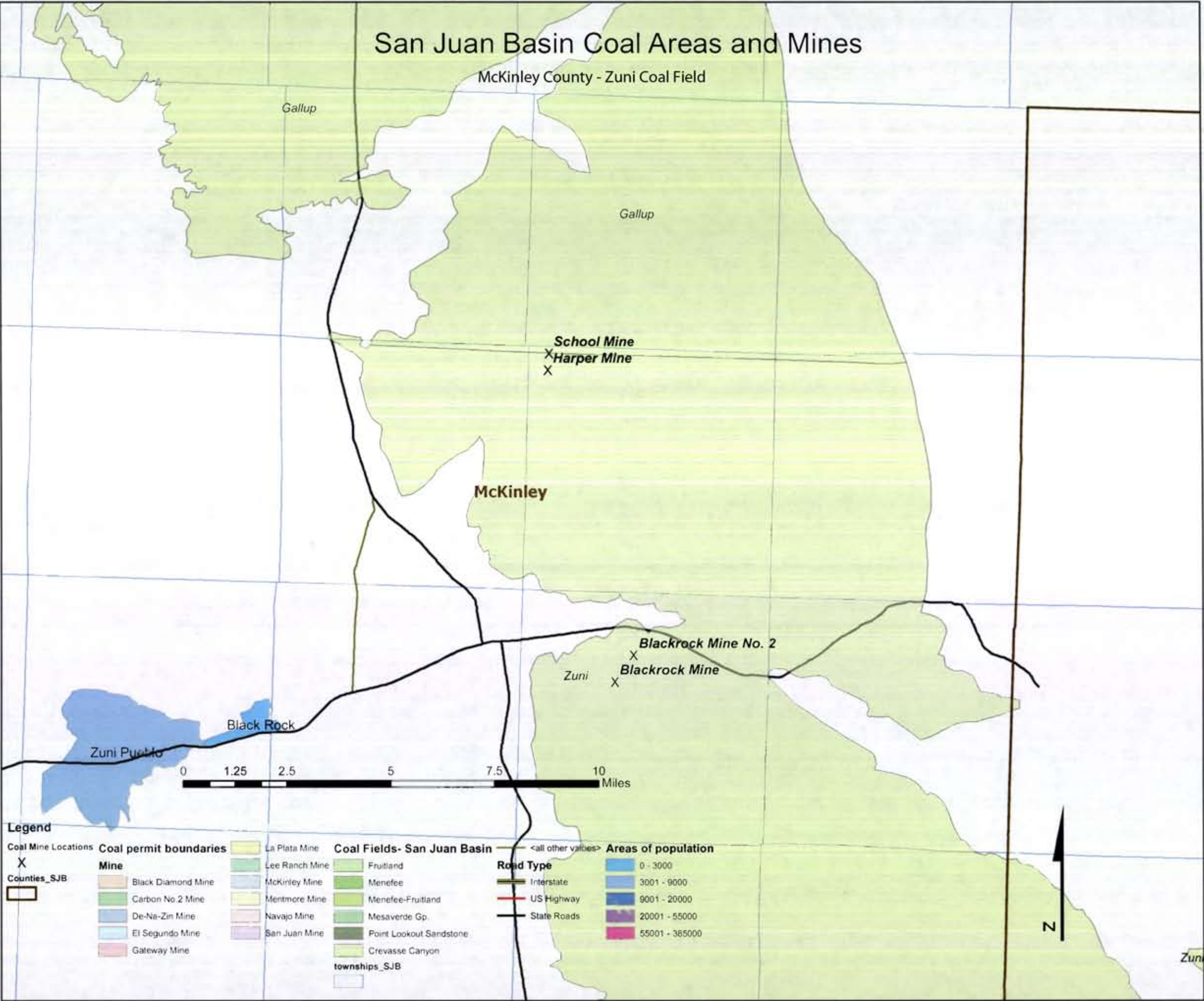




Figure 7

