OPEN-FILE REPORT 82-2

PRELIMINARY REPORT ON POTENTIAL SITES SUITABLE FOR RELOCATION AND/OR REPORCESSING OF THE GRAND JUNCTION AND RIFLE URANIUM MILL TAILINGS PILES

with assistance from
Robert M. Kirkham and the
Four Corners Research Institute

1876

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Prepared by the
Colorado Geological Survey
Department of Natural Resources

State of Colorado

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DOI: https://doi.org/10.58783/cgs.of8202.opyo8375

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1. EXECUTIVE SUMMARY

This report describes the procedure and results of a regional search for sites that appear to be suitable for the relocation and/or reprocessing of the Grand Junction and Rifle uranium mill tailings piles. This search identified nine potential sites within the study area that are herein offered to the Candidate Site Review Committee for further consideration. All nine sites can be used for joint disposal of the uranium tailings in both Grand Junction and Rifle. Disposal of any individual pile at any of the nine sites may also be considered by the Committee. It is the responsibility of the Candidate Site Review Committee to determine which of these sites should be recommended to the U.S. Department of Energy for detailed evaluation of their suitability for uranium tailings disposal. This should include consideration of sites for joint disposal as well as disposal in separate sites.

General locations of the nine potential sites are shown on Plate 2 along with regional land ownership. All sites are entirely on Federal lands administered by the Bureau of Land Management. The sites fall within five general geographic locations. Two Road, McDonald Creek, and 6 & 50 Reservoir sites lie west of Mack near the Utah-Colorado border. East Salt Creek and Camp Gulch sites are north of Mack near the Mesa-Garfield County Line. Halls Basin and Cheney Reservoir sites are found southeast of Grand Junction west of and below Grand Mesa. Lucas Mesa site lies east of DeBeque across the Colorado River. Flatiron Mesa site is south of Rifle on the northeast flank of Battlement Mesa.

Detailed site maps are included with the individual site descriptions in Section 4. Site boundaries as designated herein are not permanently fixed. Some sites are very large, and only part of the outlined area may be needed for the actual repository. Other factors, such as land use, economic aspects, geotechnical problems, and environmental considerations, may make it necessary to slightly revise site boundaries during the later detailed investigations.

A comprehensive site selection process was used to identify the recommended potential sites. Geotechnical characteristics were a primary element of this analysis. All potential sites appear to be geotechnically acceptable for tailings disposal, based on information available for the preparation of this report. Additional geotechnical data will need to be collected and evaluated during later phases to assure long-term containment of the tailings. A number of other factors, such as transportation and land use, were also considered in the analysis. Sites with obvious severe transportation hazards were automatically eliminated. Likewise, sites judged to be in prime growth areas, near heavily populated areas, or in prime irrigated agricultural areas were also dropped. Sites in National Parks, National Monuments, Wildlife Refuges, wilderness areas, and wild and scenic river areas were also eliminated.

The geotechnical suitability of each potential site was comparatively evaluated using a rating matrix. Individual site scores and relative geotechnical rankings are as follows:

1.	Two Road site (A)	128
2.	McDonald Creek site (B)	121
3.	Camp Gulch site (D)	120
4.	East Salt Creek site (E)	117
5.	Cheney Reservoir site (G)	116
6.	Flatiron Mesa site (I)	112
7.	6 & 50 Reservoir site (C)	109
8.	Lucas Mesa site (H)	108
9.	Halls Basin site (F)	105

A major geotechnical concern that affects the suitability of an area for tailings disposal is the potential for future erosion. Areas with severe erosion potential are not acceptable tailings repository sites, and these areas were automatically eliminated from further consideration in this investigation. The most favorable repository locations have a low or moderate erosion potential, such as that found on Two Road, McDonald Creek, East Salt Creek, Cheney Reservoir, Lucas Mesa, and Flatiron Mesa sites. Certain areas with a high erosion potential, such as 6 & 50 Reservoir, Camp Gulch, and Halls Basin sites, may prove to be suitable for tailings disposal if the sites are carefully protected by properly designed and constructed structures.

Transportation aspects of this project are a critical element that will require careful consideration by the Candidate Site Review Committee. The tailings pile in Grand Junction is literally surrounded by densely populated areas, and any truck route from this tailings pile will necessarily travel through these areas on heavily used roads. This is an especially serious problem for any haul route traveling north, east, or west from Grand Junction. Fortunately, the Grand Junction tailings pile is conveniently located near the railroad, and rail transport of the tailings may be feasible. The two tailings piles in Rifle (the old and new piles) are situated on the edge of town. Truck haulage, except for a route running north through Rifle, will not pose as serious a problem here as in Grand Junction. The Rifle tailings piles are readily accessible to both the railroad and Interstate 70. If relocation of the Grand Junction tailings pile to the Rifle area or the Rifle piles to the Grand Junction area is considered by the Committee, rail transport can avoid the highway congestion problems in the DeBeque Canyon area and in other potentially hazardous and troublesome areas along the haul route.

Rail transport to an unloading facility, followed by truck or conveyor haulage to the disposal site is feasible for all but one of the potential sites. Rail transport is not practical for moving the Rifle tailings piles to the Flatiron Mesa site. This site is only a short distance from the Rifle tailings piles, and truck or conveyor transport is the only effective means to accomplish tailings relocation.

The major positive and negative aspects of each potential site are as follows:

Two Road Site--good long-term (10,000 years) stability; excellent geotechnical characteristics, but the possibility of recent structural deformation needs further evaluation; riprap may need to be hauled to site; very remote; fairly long truck haul route, but road is not heavily used; possible conflict with Bureau of Reclamation desalinization project; moderate potential for conflicts with oil and gas development.

McDonald Creek Site--good long-term stability; good geotechnical characteristics, but the possibility of recent structural deformation needs further evaluation; very remote; riprap may need to be hauled to site; fairly long haul route, but roads not heavily used; slightly over one mile to a perennial creek but it is in a different drainage; possible conflict with Bureau of Reclamation desalinization project; moderate potential for conflicts with oil and gas development.

6 & 50 Reservoir Site--moderate long-term stability; acceptable geotechnical characteristics; moderate gullying on site; remote; reservoir with good wildlife habitat that is used for hunting is less than 1 mile from site; moderate potential for conflicts with oil and gas development; near small parcel of private land.

Camp Gulch Site--moderate long-term stability; good geotechnical characteristics; geologic structures in area may increase bedrock fracturing; riprap may need to be hauled to site; very remote; considerable road construction needed to reach site; truck route through Loma area; near gas field with moderate potential for conflicts; possible conflicts with proposed Colorado-Ute power plant.

East Salt Creek Site--good long-term stability; good geotechnical characteristics; geologic structures in area may increase bedrock fracturing; riprap may need to be hauled to site; remote; near gas field with moderate potential for conflicts; truck route through Loma area.

Halls Basin Site--moderate long-term stability; acceptable geotechnical characteristics; intense gullying on site, but this can be readily mitigated through proper engineering and construction; good riprap sources adjacent to site; irrigation ditch less than 1/2 mile; very remote; considerable road construction required to reach site; moderate highway safety hazard associated with truck haul from Grand Junction; surrounded by private land that may experience future subdivision development.

Cheney Reservoir Site--good long-term stability; good geotechnical characteristics; good riprap source on site; less than one mile to reservoir and creek with excellent wildlife habitat; very remote; considerable road construction required; moderate highway safety hazard associated with truck haul from Grand Junction; near private land.

Lucas Mesa Site--good long-term stability; acceptable geotechnical characteristics, but erosion rates of mesa flank must be carefully evaluated; good riprap on site; just over one mile to an irrigation ditch and the Colorado River; very remote; very steep haul route; possible to use a conveyor; near private lands.

Flatiron Mesa Site--good to excellent long-term stability; good geotechnical characteristics, but erosion rates of mesa flank must be carefully evaluated; good riprap on site; less than one mile to Beaver Creek, a public water supply for Rifle; very remote; very steep haul route; direct truck haul from Rifle is feasible; possible to use a conveyor; near private lands.

None of the sites are completely ideal when all relevant factors are considered. The Candidate Site Review Committee must compare and weigh the advantages and disadvantages of each site to determine which sites are the most favorable for continued evaluation for long-term containment of the uranium tailings. It must be emphasized that this investigation is of a regional nature and therefore is preliminary. Detailed evaluation of all relevant factors will be necessary during later studies by the U.S. Department of Energy.

2. INTRODUCTION

2.1. Purpose of Site Selection Report

Uranium ore was processed at a number of mills in Colorado during the 1940s, 1950s, and 1960s. Tailings from this milling were often dumped in unsuitable environments and now pose potential health hazards to the general public. Such hazards will persist into the future and possibly worsen because of increasing urban pressures and dispersion of the tailings materials by geologic, hydrologic, and meteorologic forces. The uranium mill tailings at Grand Junction and Rifle pose such a hazard. These tailings piles lie adjacent to and are within the floodplain of the Colorado River.

In 1981 the Colorado Department of Natural Resources entered into an agreement with the Colorado Department of Health to cooperate in the evaluation of alternate site areas for the disposal of the Grand Junction and Rifle uranium tailings. This evaluation is part of a larger project conducted by the U.S. Department of Energy (DOE) and entitled Uranium Mill Tailings Remedial Action Program (UMTRAP). This program, in response to the Uranium Mill Tailings Radiation Control Act of 1978, provides for the stabilization, disposal, and control in a safe and environmentally sound manner of inactive uranium tailings throughout the country. To aid in the accomplishment of this program, the Department of Energy requested that the State of Colorado identify candidate sites for the removal and permanent disposal of the Grand Junction and Rifle tailings piles. As part of this identification process, the Colorado Geological Survey, in conjunction with Mr. Robert M. Kirkham and the Four Corners Research Institute, prepared this report.

The Preliminary Site Selection Report describes the State of Colorado's site selection process and presents background data and information regarding potential disposal sites for the Grand Junction and Rifle tailings piles. This data and information includes a description of the engineering and environmental factors that should be considered as a part of the site selection process. Additionally, the report describes geotechnical characteristics of each site and ranks the sites according to a geotechnical grading matrix. The sites discussed in this report appear to be geotechnically feasible, however, additional detailed studies are essential to verify this initial evaluation.

This report is intended for use by the Candidate Site Review Committee as a basis for their review and evaluation. The report should not be considered a final evaluation, but should be considered as an initial step in the site selection process.

2.2 History of the Grand Junction and Rifle Uranium Mill Tailings Piles

The mill at Grand Junction operated from June 1951 until March 1970 for the production of strategic minerals. During this time a total of 2.2 million tons of uranium-vanadium ores were processed by the Climax Uranium Company. In 1972 at a cost of about $125,000, some remedial action to minimize blowing dust was performed on the Grand Junction tailings pile.

The tailings pile was sold in mid-1976 to Shumway, Inc., the present owner of the pile.

There are two separate mills and tailings disposal facilities at Rifle: Old Rifle Site and New Rifle Site. The Old Rifle Site was built in 1924 to recover vanadium and was operated until 1932 when it was shut down. The plant was reactivated in 1942 when the demand for vanadium increased and was altered in 1946 to permit recovery of uranium. The mill, owned by Union Carbide Corporation, processed over 760,000 tons of ore until 1958 when the mill was replaced with the new facilities. The New Rifle site operated from July 1958 until December 1972 and is still under license. The mill had a capacity of 1,000 tons per day and produced a total 2.7 million tons of uranium tailings. At the present time Union Carbide Corporation is extracting vanadium at the mill.

2.3. Preferred Method of Tailings Disposal

Landa (1980) notes that uranium tailings constitute a technologically enhanced source of natural radiation exposure by virtue of the physical and chemical processing of the ore and redistribution of the contained radionuclides by wind and water transport. The philosophy expressed by Lush and others (1978) is worth considering as to the long-term containment of uranium mill tailings:

> "The development of a long-term waste management philosophy requires the acceptance of a basic set of management criteria. Our societies' approach has, as its basic tenets, that the present generation of waste managers should leave the wastes in such a manner that there is no foreseeable threat to future generations and future generations will not have to be involved in the care of the wastes. Implied is that the future bleed rate of contaminants from waste management sites should not exceed present regulatory levels, and not rely on continued monitoring to demonstrate that fact."

Radionuclides must be controlled for thousands of years by selecting disposal sites that optimize natural geologic, hydrologic, meteorologic, and geochemical conditions. To achieve this containment, the U.S. Nuclear Regulatory Commission (NRC) promulgated the recently enacted Uranium Mill Licensing Requirements, and the Colorado Department of Health (CDH) formulated "Rules and Regulations Pertaining to Radiation Control." In Part II Criterion 3, the CDH indicates that the "prime option" for disposal is placement of the tailings in trenches below the present ground surface. Additionally, the CDH and NRC recommend that dewatering of tailings by process devices and/or in-situ drainage systems be considered and that the tailings be covered with a minimum of 3 meters of material.

The Colorado Geological Survey considers disposal of dewatered tailings in trenches excavated into thick, relatively impervious shale as the most effective, practical method to meet the long-term containment objectives and the CDH and NRC regulations. The sites discussed in this report were chosen and evaluated with regard to this method of tailings disposal. If alternative methods are considered, the sites must be fully re-evaluated.

2.4 REGIONAL PHYSIOGRAPHY AND GEOLOGY

2.4.1. Physiography

The area of investigation in this report is entirely within the Colorado Plateau Physiographic Province. In the Grand Junction-Rifle area, the province is divided into two parts; the Canyonlands section to the south and the Uinta Basin section to the north (Lohman, 1965). These two sections are separated from one another by the Book Cliffs, a prominent topographic escarpment formed by the Mesaverde Group. The Canyonlands section in this area is characterized by monoclinal folds, upwarped plateaus and lava-capped mesas. The Unita Basin section north of Grand Junction and Rifle exhibits a mature stream-eroded upland surface known as the Roan Plateau. Principal physiographic elements within the study area include the Colorado River Valley, Gunnison River Valley, Uncompahgre Plateau, Grand Mesa, Battlement Mesa, and Roan Plateau (Figure 1).

The radioactive tailing piles at Grand Junction and Rifle are in the Colorado River Valley, which can be subdivided into three areas. The relatively narrow DeBeque Canyon portion of the Colorado River Valley separates the broad open Grand Valley to the west from the steeply walled, but flat bottomed valley to the east that lies between the Roan Plateau and Battlement Mesa. The cliffs which form the walls of DeBeque Canyon are made up of the Mesaverde Group and resistant members of the Wasatch Formation.

DeBeque Canyon gives way westward to Grand Valley, an area where the Colorado River encounters the Mancos Shale, an easily eroded formation. Grand Valley is bounded by the Book Cliffs on the north and northeast, by the Uncompahgre Plateau on the south and southwest, and by Grand Mesa on east. The valley averages about 12 miles in width. The northern half of the Grand Valley is characterized by several levels of long, deeply dissected pediments or old channel deposits which sweep down from the base of the Book Cliffs towards the Colorado River (Sinnock, 1981). This area contains five of the nine potential sites: Two Road, McDonald Creek, 6 & 50 Reservoir, Camp Gulch, and East Salt Creek sites. The southern half of Grand Valley is dominated more by Colorado River terraces composed of alluvial gravel fill. The Grand Junction tailings pile lies upon one of these low alluvial terraces adjacent to the Colorado River.

The Uncompahgre Plateau, located south and southwest of Grand Valley, is an elongate-shaped plateau which plunges northwest. Parts of this plateau rise more than 4,000 ft above the Colorado River. No potential sites are located on this plateau.

East and southeast of Grand Valley lies Grand Mesa, a basalt-capped plateau some 10,000 ft above sea level. The western edge of Grand Mesa is a steep escarpment that grades to multi-level gravel-capped pediments which slope downward towards the Gunnison River (Sinnock, 1981). Two potential sites, Halls Basin and Cheney Reservoir sites, are located west of and below Grand Mesa. The Cheney Reservoir site is on a low lying pediment surface, and the Halls Basin site is within an eroded basin between two pediment surfaces.

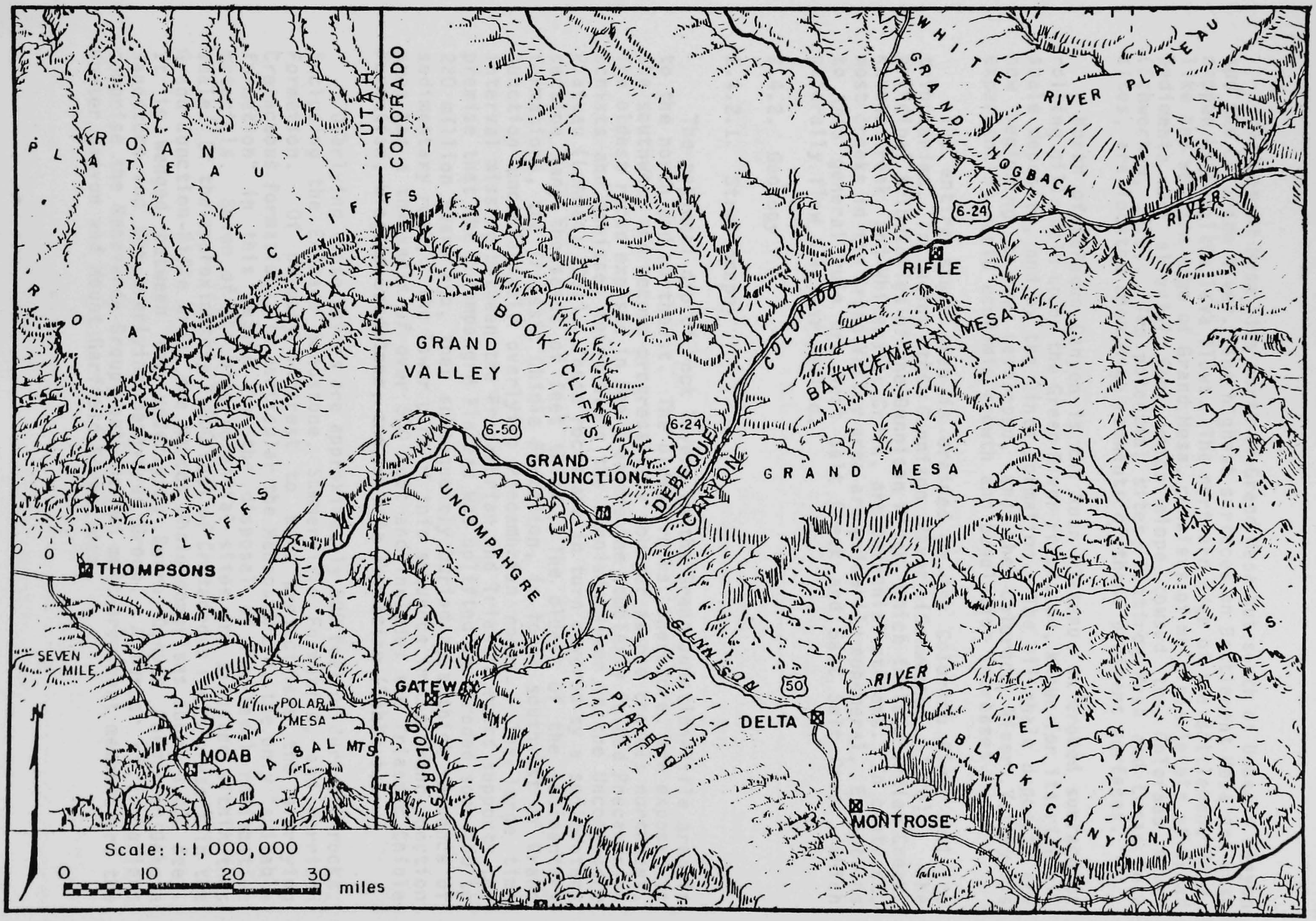


Figure 1. Physiographic diagram of the Grand Junction-Rifle area.

Battlement Mesa lies north of Grand Mesa but south of DeBeque Canyon and the Colorado River. The highest surfaces on Battlement Mesa are also capped by basaltic lava flows. The northern edge of the Battlement Mesa, like the western edge of Grand Mesa, consists of multiple levels of broad pediments and alluvial fans which slope toward the Colorado River (Schwochow, 1978). Two potential sites, Flatiron Mesa and Lucas Mesa sites, are located upon high remnants of these pediment surfaces.

North of DeBeque Canyon is the Roan Plateau, an eroded surface of rolling hills held up by the Green River Formation, known for its rich oil shale deposits, and by the Uinta Formation. The oil shale deposits are now beginning to be developed, and the Colorado River Valley is experiencing rapid economic growth and population increases.

The entire study area is drained by the Colorado River and its tributaries, including the Gunnison River (Schwochow, 1978). The principal tributaries of the Gunnison River, which include Indian Creek, Kannah Creek, and Whitewater Creek, are perennial streams. In contrast, most creeks in the Grand Valley area are primarily ephemeral. Exceptions to this general rule are West Salt Creek and East Salt Creek, which generally flow all year around.

2.4.2. Geology

2.4.2.1. Stratigraphy

The regional dip of rock layers in the Grand Junction-Rifle area is to the north and northeast. The oldest rocks, therefore, are exposed to the southwest and become progressively younger as one travels northeast. The oldest rocks exposed in the area are the complexly folded Precambrian schists and gneisses found along the Gunnison River in the Uncomphagre Plateau (Lohman, 1981). These rocks are in turn covered by a sedimentary section many thousands of feet thick. The oldest of the sedimentary formations, the Triassic Chinle Formation, is found southwest of Grand Junction unconformably overlying Precambrian rocks. The large time interval missing between the Precambrian and Triassic rocks supports the premise that the Uncompahgre Plateau was uplifted and eroded some 250 to 220 million years ago, then subsequently buried by a thick sequence of sedimentary rocks. The lower part of this sequence in the Grand Junction area has a thickness of over 500 feet and includes the Triassic Chinle Formation, Wingate Sandstone, and Kayenta Formation (Table 1).

Overlying these layers are approximately 800 feet of Jurassic rocks, including the Entrada Sandstone, Summerville Formation, and Morrison Formation. Of primary interest to this project are the overlying Cretaceous formations, in particular the Mancos Shale, the only "suitable formation" in this region for the disposal of low-level radioactive materials. Seven of the nine potential sites are situated within this shale. Of the approximately 7,000 feet of Cretaceous rocks present in the Grand Junction-Rifle area, the Mancos Shale comprises about 4,000 feet. It is wedged between the underlying Burro Canyon Formation/Dakota Sandstone and the overlying Mesaverde Group. A number of formations comprise the Mesaverde Group, but the two most prominent members are the Hunter Canyon and Mount Garfield Formations.

Table 1. Generalized stratigraphic section of the Grand Junction-Rifle area.

GEOLOGIC AGE	STRATIGRAPHIC UNIT	ROCK DESCRIPTION	APPROXIMATE THICKNESS IN FEET
Late Tertiary	Unnamed Basalt	Numerous dark gray, black, and dark red-brown basalt lava flows on Grand and Battlement Mesas. Forms cliffs.	~ 800
		unconformity	
Early Tertiary	Uinta Formation	Tan, gray, and buff siltstone, sandstone, and marlstone.	800-1000
	Green River Formation	Tan to gray calcareous siltstone with dark brownish gray kerogen-rich beds (oil shale). Forms steep slopes and cliffs.	1000-3000
	Wasatch Formation and Ohio Creek Conglomerate	Varigated sandstone, siltstone, shale, mudstone, conglomerate. Forms benches and slopes.	300-5000
		unconformity	
Late Cretaceous	Mesaverde Group	Buff colored sandstones and siltstones with coal beds. Forms cliffs.	1000-5000
	Mancos Shale	Gray and black shale with thin beds of sandstone and limestone. Forms slopes and valley floors.	3000-6000
	Dakota Sandstone	Sandstone, coaly shale, conglomerate. Forms benches and slopes.	100-225
		unconformity	
Early Cretaceous	Burro Canyon Formation	Green siltstone, shale, sandstone, conglomerate. Forms benches and slopes.	10-225
Late Jurassic	Morrison Formation	Varicolored claystone, sandstone, siltstone with thin limestone beds. Forms slopes and badlands.	300-600
Middle Jurassic	Summerville Formation	Red and green colored siltstone, mudstone and thin sandstones. Forms slopes.	40-60
	Entrada Sandstone	White and salmon-red quartz sandstone. Slick Rock member forms cliffs.	75-300
		unconformity	
Late Triassic(?)	Kayenta Formation	Red and purple siltstone, shale, sandstone, and conglomerate. Forms bench between cliffs.	0-200
Late Triassic	Wingate Sandstone	Buff and light red sandstone, cross-bedded. Forms steep cliffs.	300-400
	Chinle Formation	Red siltstone, shale, limestone, and conglomerate. Forms steep slopes at foot of cliffs.	80-120
		unconformity	
Precambrian Proterozoic Y and X	Unnamed	Gneiss, schist, granite and pegmatite dikes. Forms floors of canyons in Uncompahgre Plateau.	unknown

Modified from Lohman, 1981; Cashion, 1973; and Tweto and others, 1976.

The two remaining potential sites are located in the Wasatch Formation, an interbedded sequence of shale, siltstone, and sandstone of early Tertiary age which overlies the Mesaverde Group. In some areas the basal part of the Wasatch Formation is mapped as a separate formation, the Ohio Creek Conglomerate. The Wasatch Formation has been divided into three members by Donnell (1961b). Shale and claystone dominate the lower and upper members, whereas the middle member is primarily sandstone. The two potential sites are in the upper member of the Wasatch Formation. Overlying the Wasatch Formation is the Tertiary Green River Formation, store house of the world's richest oil shale deposits (Lohman, 1981). This formation forms much of the impressive Roan Cliffs, exposed along the Colorado River near Rifle. Recently, the upper sandstone and siltstone member of the Green River Formation, the Evacuation Creek member, has been named the Uinta Formation (Tweto and others, 1978).

Grand Mesa to the south and east of the study area is capped by a sequence of basaltic lavas approximately 10 million year old that attain a maximum thickness of 800 feet in places. These lavas are thought to have filled the valleys and lowlands that existed during Miocene time. The basalt now forms the resistant cap on Grand Mesa. Isolated remnants of these lava flows are also present on Battlement Mesa (Schwochow, 1978).

2.4.2.2. Structure

Regional structure in the Grand Junction-Rifle area consists of broad uplifts and deep structural basins (Schwochow, 1978). The Uncompahgre Uplift, which trends northwest-southeast, is the most obvious structural feature. On the southwest it is bounded by the Paradox Basin and on the northeast by the Piceance Basin. All nine potential sites are within the Piceance Basin. The area southeast of Grand Junction has been influenced by the Gunnison Uplift.

These uplifts and basins have smaller-scale folds and faults associated with them. For example, the northeast margin of the Uncompahgre Uplift is bounded by normal faulting and monoclinal folding. To the northeast and east of Rifle, the Grand Hogback Monocline marks the boundary between the Colorado Plateau and White River Uplift. In some areas this major folded structure has been locally faulted. In Grand Valley the Mancos Shale generally dips 2^{o} to 9^{o} to the north and northeast into the Piceance Basin, but many small folds and a few faults locally complex the structure.

None of the potential sites are known to be underlain by faults or steeply dipping beds. Several sites, including Two Road, McDonald Creek, Camp Gulch, and East Salt Creek sites, are in regions with minor structural folding and faulting. These particular sites will need to be carefully evaluated with respect to these structures.

2.4.2.3. Mineral Resources

An abundance of mineral resources occurs within the Grand Junction-Rifle area. The Piceance Basin contains oil, natural gas, coal, uranium, sand, gravel, and a high percentage of the world's oil shale. General outline of the oil and gas fields in the study area are shown on

Figure 2. The principal petroleum-bearing formations include, in order of increasing age, the Wasatch Formation, Mesaverde Group, Dakota/Burro Canyon Formations, Morrison Formation, and Entrada Sandstone. Because at least one of these formations underlies the entire study area, there is a possibility that oil or gas occurs beneath the sites.

Major coal fields in the study area are also shown on Figure 2. Economically significant coal deposits are known to occur in only one formation in the area, the Mesaverde Group. The Mesaverde Group is found north and northeast of the Book Cliffs, and east of the western base of Grand Mesa. Two sites, the Lucas Mesa and Flatiron Mesa sites are underlain by the Mesaverde Group, and therefore may have coal in the deep subsurface beneath them. The Dakota Sandstone locally contains thin coal beds, but nowhere in the study area are there known Dakota coal beds of commercial interest. None of the sites are underlain by important, shallow coal deposits.

Thick oil shale deposits occur in the Parachute Creek member of the Green River Formation. Extent of the oil shale deposits in the study area is shown on Figure 2. A significant part of the known oil shale reserves in the United States occurs in this formation in the Piceance Basin. None of the potential sites are underlain by important oil shale deposits.

Uranium and vanadium deposits are known to occur in the Burro Canyon Formation, Dakota Sandstone, Morrison Formation, Entrada Sandstone, and Wingate (or Navajo?) Sandstone (Schwochow, 1978; Fischer, 1960). These formations occur throughout most of the study area, hence there is a possibility that any or all of the nine potential sites may be underlain by uranium-vanadium deposits. However, no uranium or vanadium deposits have been recognized beneath any of the sites.

Sand and gravel resources are relatively abundant in the study area. Such resources occur in terraces and modern alluvium along the Colorado and Gunnison Rivers, and in pediment deposits along the Book Cliffs, Grand Mesa, and Battlement Mesas. In general the most sound sources of riprap are pediment deposits shed from Battlement and Grand Mesas. These deposits contain well-indurated clasts of basalt that have excellent engineering characteristics. Pediment gravels from the Book Cliffs, river terraces, and modern alluvium often contain an abundance of shale and sandstone clasts, and these types of clasts may not be suitable for construction or riprap purposes. High-quality aggregate could also be obtained by quarrying the basalt cap on Grand Mesa or the small basalt-cap remnants on top of Battlement Mesa. In some areas, acceptable materials may also be obtained by quarrying various sandstone formations.

2.4.2.4. Ground Water

Several formations carry significant amounts of ground water in the study area (Repplier and others, 1981; Wright Water Engineers, 1979; Boettcher, 1972; Coffin and others, 1968; Lohman, 1965). They include, in order of increasing age, the Green River Formation, Mesaverde Group, Dakota Sandstone, Burro Canyon Formation, Entrada Sandstone, and Wingate Sandstone. The middle part (Molina member) of the Wasatch Formation includes many sandstones capable of producing large volumes of water. The

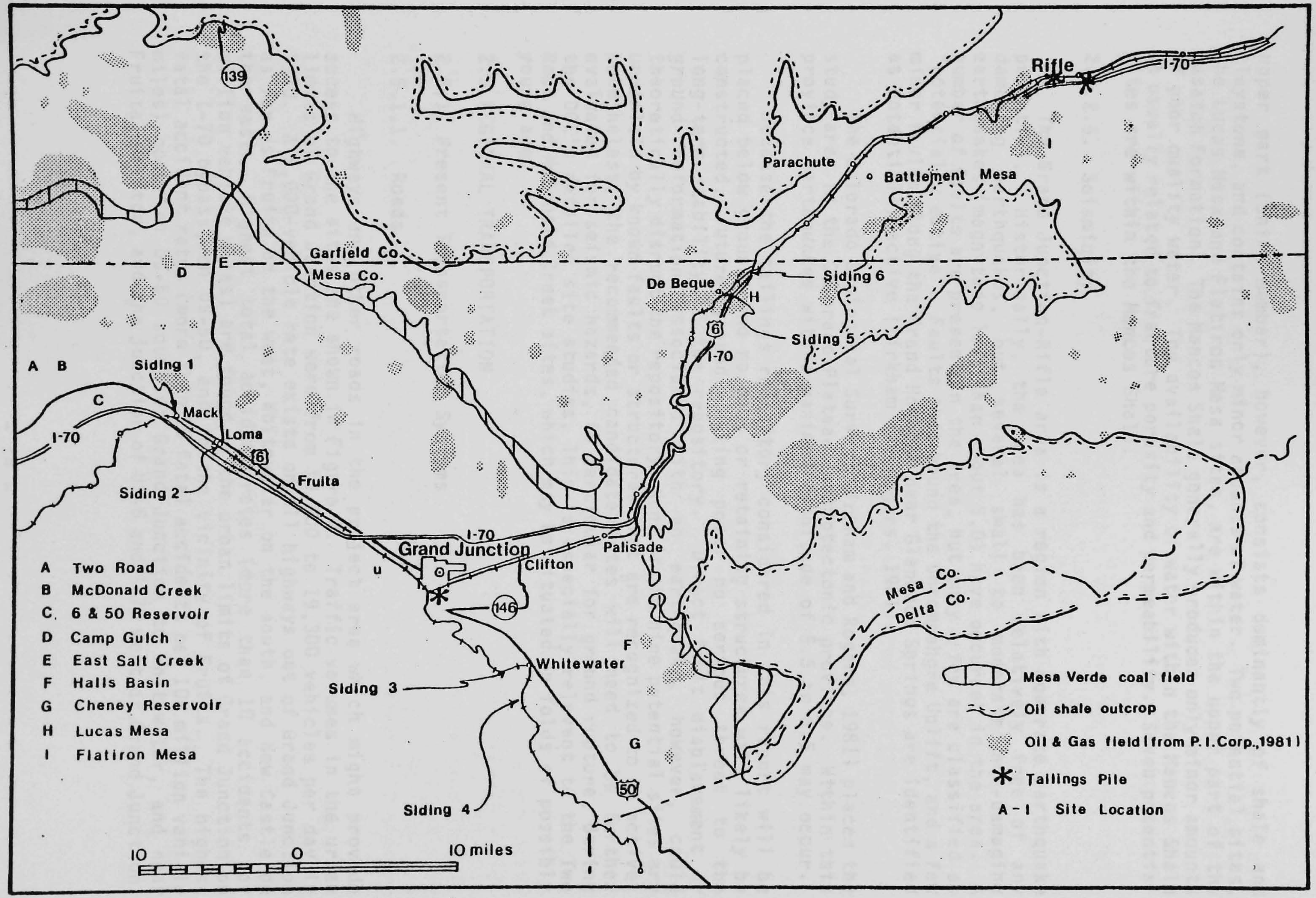


Figure 2. Regional transportation systems and mineral resources of the Grand Junction-Rifle area.

upper part (Shire member), however, consists dominantly of shale and claystone, and contains only minor amounts of water. Two potential sites, the Lucas Mesa and Flatiron Mesa sites, are within the upper part of the Wasatch Formation. The Mancos Shale generally produces only minor amounts of poor quality water. The availability of water within the Mancos Shale is usually related to fracture porosity and permeability. Seven potential sites are within the Mancos Shale.

2.4.2.5. Seismicity

The Grand Junction-Rifle area is a region with moderate earthquake potential. Historically, the area has been relatively free of any damaging earthquakes, but several small to moderate non-damaging earthquakes (magnitude less than about 5.0) have occurred in the area. A number of faults are present in the area, but only a few are classified as "potentially active". Faults that bound the Uncompahgre Uplift, and a few minor faults along the Grand Hogback near Glenwood Springs are identified as potentially active (Kirkham and Rogers, 1981).

The Colorado Geological Survey (Kirkham and Rogers, 1981) places the study area in the Colorado Plateau seismotectonic province. Within this province earthquakes with a maximum magnitude of 5.5 to 6.5 may occur.

Because the tailings repository considered in this report will be placed below ground, and no dams or retaining structures will likely be constructed, future ground shaking poses no serious threat to the long-term stability of the repository. Direct fault displacement or ground deformation associated with an earthquake, however, could theoretically disrupt the repository. None of the nine potential sites are underlain by known faults or structures that are recognized to be active. Nonetheless, the recommended candidate sites will need to be further evaluated for seismic hazards, in particular for ground rupture, during the DOE's detailed site studies. This is especially relevant to the Two Road and McDonald Creek sites, which may be situated on folds of possibly young age.

2.5 REGIONAL TRANSPORTATION

2.5.1. Present Transportation Systems

2.5.1.1. Roads

Highways and other roads in the project area which might provide access to the sites are shown in Figure 2. Traffic volumes in the urban limits of Grand Junction were from 10,000 to 19,300 vehicles per day in 1980. A 5,000-vehicle rate exists on all highways out of Grand Junction as far as Fruita on the west, Whitewater on the south, and New Castle on the east. Highest total accident rates (more than 10 accidents per million vehicle miles) are found in the urban limits of Grand Junction on the I-70 bypass, on US-50, and in the vicinity of Fruita. The highest fatal accident rates (more than 10 fatal accidents per 100 million vehicle miles) occur on US-50 south of Grand Junction to Whitewater, and near Fruita, Clifton, and the junction of US-6 and I-70 west of Grand Junction.

2.5.1.2. Railroad

Railroad routes are shown in Figure 2. The Rio Grande Railroad main line follows the Colorado River through the center of the study area from east to west, and a spur line extends to the south from Grand Junction through Whitewater and beyond.

2.5.2. Possible Project Transportation Systems

Feasible tranportation of tailings could involve truck, rail, conveyor, slurry, or some combination of these.

2.5.2.1. Truck Haulage

Trucks at the highway load limit, 40 tons, will be able to carry 24 tons of tailings per load. The weight of tailings to be moved and the resultant number of truckloads is given in Table 2.

Table 2. Approximate weight of tailings and related material, and resulting truckloads or rail carloads.

Tailings Location	Total Weight, with Field Moisture (tons)	Number of Truckloads1/ (loads)	Number of Rail Carloads2/ (loads)
Grand Junction	3,490,000	145,417	34,900
New Rifle	2,700,000	112,500	27,000
Old Rifle	360,000	15,000	3,600
Total	6,550,000	272,917	65,500

1/ 16-ton trucks carrying 24 tons per load
2/ 100-ton hopper cars

Elements which make up the cost of truck transportation and other methods are given in Table 3. The actual cost of a transportation system to each site varies with the combination of factors indicated in this table. The cost of transportation via a possible system for each site is presented in Table 6. Cost estimates are only approximations, but they are believed to be comparable among the transportation methods and disposal sites. It is assumed that truck boxes will be covered to prevent blowing of the tailings.

Truck hauling costs may be greater than estimated in this report, if considerable maintenance is required for the old paved highway to the three extreme western sites. A new overlay of asphalt would cost $100,000 per mile, or $0.6 to $1.2 million, depending on the site. It has been estimated by the Colorado Department of Highways and a highway users association that the ton mile tax pays 20% of the highway construction and maintenance costs, but that heavy trucks cause 70% of the deterioration. If so, then about half, or $0.3 to $0.6 million of the maintenance, should be charged as a cost of truck haulage. As stated on page 9-5 of the July 1981 Ford, Bacon, and Davis Report, "no costs are included for repair and maintenance of public roads, based on the assumption that legal load limits will not be exceeded and the state gasoline taxes provide the needed revenues for such repair and maintenance." Winter maintenance (plowing) of haul roads may be necessary. This was not included in the cost figures.

Safety of transportation by truck is related to highway traffic volumes and highway accident rates. These volumes and rates are given for highway routes to each site in Table 4. Traffic volume is high throughout the area. Accident rates are greatest on US-50 south of Grand Junction, on the I-70 bypass through Grand Junction, and on I-70 east of Grand Junction to DeBeque. These factors make truck transportation of the tailings out of the Grand Junction area quite dangerous.

Transport by truck only, at the rate of a truck every five minutes working continuously 24 hours per day, seven days per week, would require 505 days to move the Grand Junction pile and 443 days for the Rifle piles.

Table 3. Estimated minimum transportation costs.

Truck:	
Variable with Distance	
Road Construction (Two-lane, graveled)	
Primitive or No Road, Mountain	$763,000/mile
Primitive or No Road, Rolling	378,000/mile
Gravel Surfacing only, Rolling	96,000/mile
Variable with Weight	
Loading (6-yd. or 9-yd. front-end loader)	$ 0.33/ton
Variable with Distance and Weight	
0 to 10 miles (winding, mountainous, paved)	$ 0.194/ton mile
0 to 10 miles (mostly level, paved)	0.128/ton mile
10 to 30 miles (mostly paved)	0.110/ton mile
30 to 50 miles (mostly paved)	0.091/ton mile
Rail:	
Fixed	
Siding Construction (one mile)	$462,400/siding
Bin for loading unit train	$2,000,000/bin?
Variable with Weight	
Loading	$ 0.33/ton
Variable with Distance and Weight	
Hauling only	$ 0.15/ton mile
Conveyor:	
Variable with Distance	
Conveyor System	$1,010,000/mile
Variable with Weight	
Loading	$ 0.33/ton
Variable with Distance and Weight	
Maintenance and Operation	$ 0.14/ton mile

Data are derived from the Colorado Department of Highways, Burnett Construction Company, the Rio Grande Railroad, and PEMCO (mfg. of conveyors). Methods of arriving at costs are given in Appendix B.

2.5.2.2. Rail Haulage

Several types of equipment might be used, but the most economical would probably be 100-ton open-top hopper cars, covered with canvas if necessary to prevent blowing of tailings. Two principal modes of operation would be feasible, (a) a unit train, or (b) multiple car loading. In either case, 50-car units would be a suitable maximum length, because the train would be only one-half mile long and would require no more than a one-mile siding for loading and unloading. The unit train would require a huge steel hopper for continuous loading, at a cost of about $2 million for the hopper alone, plus usual loading costs. Continuous unloading facilities would also be needed, but this might be a 1,000 tons per hour conveyor belt, either to stockpile the tailings or transport them to the final disposal site. A unit train could make two round trips per day. In continuous operation this would move the Grand Junction pile in 349 days and the Rifle piles in 306 days.

Table 4. Distances, traffic rates, and accident rates for highway routes to proposed disposal sites.

Site	Road Haul Distances, Miles						1978 Highway Traffic Volume, Million Vehicle Miles per Year	1978 Highway Accident Rates	
	Total	Highway	Other Paved	Gravel	Dirt	None[1/]		Total/Million Vehicle Miles	Fatal/100 Million VM
Grand Junction Pile									
Two Road	33.1	29.7	1.0		2.4		41	2.5	7.3
McDonald Creek	34.7	29.7	1.0		1.1	2.9	41	2.5	7.3
6 and 50 Reservoir	28.1	26.6	1.0			0.5	41	2.5	7.3
Camp Gulch	32.7	27.7	1.0			4.0	40	2.6	7.5
East Salt Creek	30.1	29.1	1.0				40	2.6	7.5
Halls Basin	15.0	6.0	0.7			8.3	23	6.1	4.3
Cheney Reservoir	17.9	16.5	0.3			1.1	38	4.6	7.0
Lucas Mesa	41.1	33.6	0.7	2.3		4.5	80	6.1	2.5
Flatiron Mesa	71.7	63.3	3.1	0.7		4.6	134		
New Rifle Pile									
Two Road	89.3	86.9		2.4			133	1.6	4.5
McDonald Creek	90.9	86.9		1.1	2.7	1.1	133	1.6	4.5
6 and 50 Reservoir	84.3	83.8				0.5	133	1.6	4.5
Camp Gulch	88.9	84.9				4.0	132	1.6	4.5
East Salt Creek	86.3	86.3					133	1.6	4.5
Halls Basin	65.3	57.0			5.3	3.0	120	1.8	3.3
Cheney Reservoir	68.6	67.5				1.1	134	1.9	4.3
Lucas Mesa	33.3	26.5		2.3		4.5	52	2.1	0
Flatiron Mesa	9.9	2.2	2.4	0.7		4.6	4	-	-
Old Rifle Pile									
Two Road	91.8	89.4	2.4				138	1.8	4.4
McDonald Creek	93.4	89.4	1.1	2.7	0.2		138	1.8	4.4
6 and 50 Reservoir	85.3	84.8			0.5		138	1.8	4.4
Camp Gulch	91.4	87.4			4.0		136	1.7	4.4
East Salt Creek	88.8	88.8					137	1.7	4.4
Halls Basin	67.8	59.5		5.3	3.0		124	2.0	3.2
Cheney Reservoir	81.1	70.0			1.1		139	2.0	4.1
Lucas Mesa	35.8	29.0		2.3		4.5	54	2.2	0
Flatiron Mesa	8.4	0.7	2.4	0.7		4.6	1	-	-

[1/] No road or a primitive road

In a preliminary review, Rio Grande Railroad officials did not think a unit train was feasible, but suggested multiple car loading. This would mean leaving the 50 cars at the pile to be loaded, without the engine, and then returning the engine to pick the cars up, perhaps as a part of a longer train. This could mean delays of up to a day in travel. Three front-end loaders for loading, a 1,000-tons-per-hour conveyor belt for unloading, and perfect timing would permit removal of the Grand Junction pile in the same time as by truck, 505 days. But two or three times as much time could be required because of hauling delays.

Costs of rail transportation are 15 cents per ton mile plus loading and unloading (see Table 3). These costs are variable depending upon the speed desired and the unloading system at each proposed site. A possible transportation system will be described for each site in the transportation section of individual site descriptions, and an estimated cost will be given there. Possible distances of rail transportation are given in Table 5. The sidings, numbers one through six, which might be used for each site, are shown in Figure 2 and in the transportation map for each site. Estimated minimum costs are given in Table 6.

Railroad lines could be constructed to one of the five westernmost sites (Two Road, MacDonald Creek, 6 & 50 Reservoir, Camp Gulch, or East Salt Creek) at a cost of $2.4 million to $5.1 million more than for truck, since a good highway already exists almost to each site. These additional costs could be reduced somewhat by salvage of the rails, ties, and ballast. The amount of this savings has been estimated at $0.3 to $0.6 million by Rio Grande Railroad engineers. Use of abandoned railroad grades in the area might provide a slight additional savings, although these grades are much deterioriated with many washouts, and the area is already quite level and amenable to railroad construction.

Safety is a very important advantage of rail transportation. Rail provides a way to move the tailings out of the congested Grand Junction area and to avoid heavy highway traffic segments such as a DeBeque Canyon without increasing highway traffic or hazard.

2.5.2.3. Conveyor Haulage

A 36-inch conveyor belt could move 750 tons per hour. Belts can be covered where necessary. Slopes of up to 20 to 25 degrees (36 to 47 percent slope) are traversable. Spans of as much as 1,000 feet across rivers or gullies would be reasonable. Highway crossings are usually passed underneath by boring for a 48-inch steel pipe. Lengths of up to 15 miles or longer are feasible, in increments of 1,000 feet to 5,000 feet for each segment length.

Loading must be an even feed, by front-end loader or bulldozer. Unloading by a short, movable conveyor is a logical method of distribution within the site.

Costs are about one million dollars per mile for equipment and installation. Maintenance and operation might cost 14 to 24 cents per ton mile. Under ideal conditions the Grand Junction pile could be moved by conveyor in 226 days, in the conveyor segment, by continuous operation (18 to 20 hours per day) of the conveyor alone. Rifle piles would require 200 days. These time estimates do not include the time involved in setting the system up. The conveyor could be moved to other sites in this project (if separate sites are used for the Rifle and Grand Junction piles) and to other UMTRAP sites as well. This would spread the capital construction cost over more tons of tailings material and reduce the per ton cost. Use of conveyors would avoid highway travel and eliminate the highway accident risk.

Table 5. Possible rail transportation distances to proposed disposal sites.

	Haul Distance, Miles				
		Road[1]			
Site	Rail	Total	Existing	Proposed[2]	Conveyor[1]
Grand Junction Pile					
Two Road	21.3	11.1	8.7	2.4	
McDonald Creek	21.3	12.7	8.7	4.0	
6 and 50 Reservoir	21.3	6.1	5.6	0.5	
Camp Gulch	17.3	14.6	10.6	4.0	
East Salt Creek	17.3	12.0	12.0		
Halls Basin	11.4	11.1	0.1	11.0	
Cheney Reservoir	13.4	9.2	8.1	1.1	
Lucas Mesa	34.4	7.6	3.1	4.5	
Lucas Mesa	37.5				2.1
Flatiron Mesa	47.5	9.9	5.3	4.6	
Flatiron Mesa	47.5				3.3
New Rifle Pile					
Two Road	82.5	11.1	8.7	2.4	
McDonald Creek	82.5	12.7	8.7	4.0	
6 and 50 Reservoir	82.5	6.1	5.6	0.5	
Camp Gulch	78.5	14.6	10.6	4.0	
East Salt Creek	78.5	12.0	12.0		
Halls Basin	72.6	11.1	0.1	11.0	
Cheney Reservoir	74.6	9.2	8.1	1.1	
Lucas Mesa	26.8	7.6	3.1	4.5	
Lucas Mesa	23.7				2.1
Flatiron Mesa	0 (not feasible)				3.3
Old Rifle Pile					
Two Road	85.1	11.1	8.7	2.4	
McDonald Creek	85.1	12.7	8.7	4.0	
6 and 50 Reservoir	85.1	6.1	5.6	0.5	
Camp Gulch	81.1	14.6	10.6	4.0	
East Salt Creek	81.1	12.0	12.0		
Halls Basin	75.2	11.1	0.1	11.0	
Cheney Reservoir	77.2	9.2	8.1	1.1	
Lucas Mesa	29.4	7.6	3.1	4.5	
Lucas Mesa	26.3				2.1
Flatiron Mesa	0 (not feasible)				4.5

[1] Additional road or conveyor (one or the other, but not both) distances needed to complete the transportation begun by rail.

[2] Proposed road construction which would be needed, at the cost of this project.

Table 6. Minimum cost of transportation of tailings via possible routes to each proposed site.

Proposed Disposal Site	Transportation System from Grand Junction	Transportation System from Rifle	Distance, miles, from Grand Junction	Distance, miles, from Rifle	Cost, million dollars,[1] Transportation from Grand Junction	Cost, million dollars,[1] Transportation from Rifle	Cost, million dollars,[1] Transportation to Joint Disposal Site
Flatiron Mesa	RC[2]	TC	50.8	5.8	33.0	6.0	35.7[3]
	RC	C	50.8	4.5	33.0	7.4	37.1
	RT	T	57.4	9.9	38.3	10.3	45.1
Lucas Mesa	RC	RC	39.6	28.4	24.4	17.4	41.4
	RT	T	42.0	35.8	29.8	15.8	42.1
	RT	RT	42.0	37.0	29.8	23.8	49.7
Halls Basin	T	RT	15.0	86.3	11.0	45.4	50.7
	RT	RT	22.5	86.3	18.3	45.4	59.1
Cheney Reservoir	T	RT	17.9	96.1	8.4	41.8	49.4
	RT	RT	22.6	86.4	14.8	41.8	55.7
East Salt Creek	RT	RT	29.3	93.1	17.6	44.3	61.5
6 and 50 Reservoir	RT	RT	27.4	91.2	18.7	45.2	63.3
Camp Gulch	RT	RT	31.9	95.7	20.3	46.8	65.2
Two Road	RT	RT	32.4	96.2	19.6	46.0	64.9
McDonald Creek	RT	RT	34.0	97.8	21.3	47.6	67.2

[1] Methods of calculating costs, and cost components are given in Appendix A.

[2] R-rail, T-truck, C-conveyor

[3] Cost of joint disposal is less than the sum of individual disposal costs because of savings in joint use of railroad sidings, newly-constructed roads, and conveyors. Cost estimates are approximations which are believed comparable among the methods and among the sites.

2.5.2.4. Slurry Pipeline

Use of a slurry pipeline was not investigated. Many of the factors in a conveyor system would also apply to slurry. An additional factor for slurry would be the need for water to produce the slurry, and then de-watering of tailings at the disposal site. Purchase of water might be a difficult and lengthy process in the over-appropriated Colorado River drainage. Tailings de-watering at the disposal site would increase the cost of a slurry system.

2.5.2.5. Combinations of Systems

A combination of transportation methods may be the best choice. Rail plus either road or conveyor would seem most feasible in many cases. One possible combination transportation system for each site is presented in section 4, together with route maps. Minimum cost estimates are given in Table 6.

The relative safety of the various transportation systems, in their production of radioactive dust, is probably quite similar. Containment by covering of trucks, railcars, or conveyors will assure satisfactory and similar safety standards. Roadside measurements along the haul route for disposal of the Naturita uranium tailings pile showed no increase in radioactivity, even though the trucks were not covered. Decontamination of trucks, rail cars, or conveyors at the end of the project will be a simple washing process.

Industrial accidents associated with loading, unloading, and distributing the tailings are similar for all transportation systems and for all sites, because the handling methods will be similar. Enroute accidents will be more numerous for truck transport because of the highway accident hazard previously mentioned.

2.5.2.6. Cost of Site Development

In addition to costs of transportation, the costs of disposal may vary among the proposed sites because of differences in the cost of site development. These differences are probably minor, but there may be differences in the cost of independent disposal as compared to joint disposal of the Grand Junction and Rifle piles. The Environmental Impact Statement (EIS) is being written to cover both the independent-disposal and the joint-disposal alternatives. Therefore, no difference in cost of the EIS will result from the choice of separate or joint disposal sites. The environmental impact statement is expected to cost \$0.7 to \$1.0 million.

Acquisition of title to the sites is assumed to be without cost, because all of the proposed sites are on BLM land. Therefore, acquisition costs are nearly identical for all sites, regardless of whether independent or joint disposal is chosen.

Costs of on-site manipulation (excavation, distribution of tailings, and covering) are approximately proportional to the volume of tailings, because additional tailings would require either deeper excavation or a greater area of excavation. The deeper excavation would be proportionally more costly, but this would be somewhat equalized by the less volume of cover material required. Thus, the cost of site manipulation would be approximately the same, whether indepedent or joint disposal is selected. In either case, below-grade disposal would require excavations of 183 acres (for the Grand Junction pile) and 156 acres (for the Rifle piles) to a depth of 18 feet (5.54 meters). Subsequent covering with 10 feet (3 meters) of fill would be the same for all sites, assuming a nearby source of fill is available. Some differences in cost among sites may result from differing haul distances for rip-rap, as discussed in the Geology section for some sites.

2.6. Regional Land Ownership and Land Use

All of the potential sites are on public domain lands. These lands are administered by the U.S. Bureau of Land Management (BLM) which maintains a District Office in Grand Junction and Area Offices in Grand Junction and Glenwood Springs.

The primary land use of all nine potential sites is presently for cattle grazing and wildlife habitat. Present uses of many of these lands, however, may be modified in the near future as a result of development pressures. All sites on BLM lands can be assumed to be subject to grazing permits, and some sites or adjacent lands could be traded or sold for development.

The entire Grand Junction-Rifle-Glenwood Springs corridor is undergoing an explosion of population and growth related to energy development. Oil shale development will probably be the major factor in both the near and long range development of this area, particularly so for the DeBeque-Parachute-Rifle area. Coal development and generation of electricity from coal-fired power plants may also cause significant changes in the present use patterns of not only the private lands but also of adjoining public lands. Colorado-Ute Electric Association has applied for the use of Bureau of Land Management land north of Loma for a coal-fired power plant. The Camp Gulch site is within this permit area.

A proposal presently under study by the Bureau of Reclamation to divert saline waters from the Glenwood and Dotsero Springs areas may result in the utilization of several thousand acres in the Mack area for brine evaporation and salt disposal purposes. Some of the potential tailings disposal sites (Two Road and McDonald Creek) coincide with areas that are being considered for this salinity control project.

A proposal by the Bureau of Reclamation to construct the Dominguez Dam 1-1/4 miles upstream from the town of Whitewater on the Gunnison River is presently in the study and evaluation stage. The highwater elevation for the reservoir would be 4,800 ft for a plan based on an 18-megawatt generation plant, or 4,860 ft for a plan based on a 36-megawatt plant. Domestic usage of Gunnison River waters would probably be vastly increased by such a project, so the possibilities of contamination of the proposed reservoir by tailings placed at the Cheney Reservoir site could become a vocal public issue.

All of the sites are under oil and gas lease and subject to development of their potential oil and gas resources. The primary resource target is natural gas within the Dakota, Wasatch, Mesaverde, Morrison, and Entrada formations. At least three of these formations underlie all of the nine potential sites. Hence, all sites have some possibilities for future gas and/or oil production. Although the use of a site for tailings disposal purposes is not necessarily incompatible with exploration and development of its oil and gas resources, the existing rights of the lessees and the possibility of mitigation of inconveniences caused by modification of drill hole and pipeline locations should be considered. The locations and serial numbers of the oil and gas leases are shown on the land-use plats in the section on individual site descriptions to facilitate possible contacts with the lessees.

The potential for development of the sites for other mineral resources is remote. The gravels and shales that comprise the surface of all of the sites are not sufficiently unique to be considered a highly valuable resource.

Energy-related developments may result in the encroachment of housing areas toward presently remote sites. Other current uses of the proposed sites include recreation activities such as hunting and off-road vehicle driving. Such uses will undoubtedly increase in proportion to population growth.

Key personnel with the Mesa and Garfield County Planning Offices, and the Grand Junction offices of the BLM and the Bureau of Reclamation are as follows:

Daryl Shrum, Director, Mesa County Planning Office
Ray Gronwall, Land Planner, Mesa County Planning Office
Davis Farrar, Director, Garfield County Planning Office
Kenneth Ouellette, Civil Engineer, U.S. Bureau of Reclamation, Grand Junction Projects Office
Mac Berta, Area Manager, Grand Junction Resource Area, Bureau of Land Management
Dave Jones, District Manager, Grand Junction District Office, Bureau of Land Management
Alfred Wright, Area Manager, Glenwood Springs Resource Area, Bureau of Land Management

2.7. Regional Wildlife

Impacts of uranium tailings disposal on wildlife relate primarily to indirect effects of habitat change, direct effects of highway accidents, and special effects on endangered species.

2.7.1. Habitat

Major habitat types include desert grassland (East Salt Creek, Camp Gulch, Two Road, and McDonald Creek sites), saltbush (6 & 50 Reservoir, Halls Basin, and Cheney Reservoir sites), and sagebrush (Lucas Mesa and Flatiron Mesa sites). Much of the desert grassland has resulted from clearing of saltbush and reseeding with crested wheatgrass or smooth brome. Habitat components and wildlife of these habitat types are as follows:

2.7.1.1. Desert Grassland

Dominant plant species are galleta grass, needlegrass, crested wheatgrass, wildrye, smooth brome, Indian ricegrass, and cheatgrass. Occasional shadscale and other saltbush shrubs and sagebrush may be scattered throughout the area. Pinyon-juniper (or only juniper) stands occur on steeper slopes, and greasewood is found in moist drainages.

Typical wildlife includes pronghorn antelope (which were introduced in 1968 and are declining in population), desert cottontail, black-tailed jack-rabbit, white-tailed prairie dog, rock squirrel, deermouse, Burrowing Owl, Kestrel, Raven, Red-tailed Hawk, Rough-legged Hawk, Golden Eagle (winter), gray fox, coyote, bobcat, kit fox, badger, and long-tailed weasel.

2.7.1.2. Saltbush

Dominant plant species are shadscale, Nuttall's saltbush, and mat saltbush. Other species include rubber rabbitbrush, broom snakeweed, galleta grass, bottlebrush squirreltail, and cheatgrass. Pinyon-juniper stands occur on steeper slopes, and greasewood is found in moist drainages.

Characteristic wildlife are similar to the desert grassland type. Pronghorn antelope are more abundant, especially on the Cheney Reservoir site, where antelope hunting is permitted by the Colorado Division of Wildlife.

2.7.1.3. Sagebrush

The dominant plant is big sagebrush, while the understory is composed of needle and thread grass, western wheatgrass, Indian ricegrass galleta grass, junegrass, bottlebrush squirreltail, three awn, and cheatgrass. Pinyon-juniper stands occur on surrounding slopes.

Typical wildlife includes mule deer, elk, white-tailed prairie dog, golden-mantled ground squirrel, deermouse, a variety of other small rodents, coyote, gray fox, bobcat, Ferruginous Hawk, Sharp-shinned Hawk, Swainson's Hawk, and a variety of smaller birds. In agricultural areas the Mourning Dove is common in summer.

If we assume gradual restoration of the disposal area with a covering of top soil, and gradual succession of the disposal area to climax vegetation, the end effect on wildlife would be nil because the ultimate vegetation would be the same as the present natural vegetation. However, if a planted grassland is maintained, wildlife which are favored by grassland (such as antelope, elk, prairie dogs, ground squirrels and hawks) would benefit while those which prefer shrub types (such as mule deer and golden-mantled ground squirrel) would decrease. If the disposal area is enclosed with a four-strand barbed wire fence it will be of more use to wildlife than if surrounded with a high woven wire fence.

2.7.2. Highway Accidents

Wildlife most susceptible to highway accidents are deer and to some extent elk. Roads which intercept travel routes of deer from feeding and cover areas to water, and those in or close to wide strips of stream or river bottom vegetation, are most hazardous. Greatest deer losses, 0.365 deer per year per mile, occur along highway I-70 between Palisade and Rifle. These losses would likely increase significantly if the tailings are moved by truck along this highway segment. Garfield County Road 317, south of Rifle enroute to the Flatiron Mesa site, would probably also show increased deer casualties from increased truck traffic.

2.7.3. Threatened and Endangered Species

Threatened or endangered animals which might be affected by the UMTRAP Project, especially by disturbance of the proposed disposal site, include Peregrine Falcon, black-footed ferret, and Bald Eagle. Most of the sites are within potential Peregrine Falcon habitat (primarily hunting grounds, not nesting areas), as identified in a recent raptor survey. However, revegetation of the disposal site, either with natural vegetation or grassland, would likely improve the areas as hunting grounds for the falcon. The protected vegetation would probably produce small mammals and birds, the food of the falcon.

Black-footed ferrets have not been seen in the area, although it is classified as within historical ferret range. Many prairie dog towns, the essential habitat of the black-footed ferret, are found in some of the sites, especially those in desert grassland and saltbush communities.

Bald Eagles winter in the region and may occasionally hunt in the area of any of the disposal sites. The major river and stream bottomlands are the center of Bald Eagle activity, so the disposal sites are not primary hunting grounds.

Little effect on aquatic animals would be expected. However, within the region two fish species are listed as endangered by the U.S. Fish and Wildlife Service: the Colorado River squawfish and the humpback chub. Additionally, the Colorado Wildlife Commission lists bonytail chub and humpback sucker as endangered.

Three plants which are proposed for endangered or threatened status on the Federal Register may be present near proposed disposal sites. The endangered hedgehog/barrel cactus (Sclerocactus glaucus) has been found in Coon Hollow near DeBeque in grassy areas near large old junipers. This type of habitat exists in the nearby Lucas Mesa site. The U.S. Bureau of Land Management, however, has proposed treatment for the Lucas Mesa site to remove the sagebrush and replant grass. The BLM apparently does not consider Lucas Mesa critical habitat for the cactus.

An endangered phacelia (Phacelia submutica) has been found at the east edge of DeBeque in its habitat of "seleniferous knolls". None of the sites appear to have this type of habitat. The threatened Cliffdweller's candlestick (Cryptantha elate) is found east of the Whitewater Speedway. It might also be found on the Halls Basin site, which has a similar habitat.

2.7.4. Food Chain Effects

Possible entry of radioactive substances from the uranium tailings piles into the food chain would depend on uptake by plant roots or ingestion by animals at the disposal site. This in turn would depend on the depth of burial of the tailings and the penetrability of the cover material. Since these would be approximately the same for all sites, there would be no significant difference in food chain effects among the proposed sites.

The three-meter burial depth is beyond that penetrated by most native plant roots, except sagebrush and oakbrush. Burrowing animals such as prairie dogs and pocket gophers rarely, if ever, dig much deeper than one meter. The rock rip-rap would interfere with animal burrowing even to the one meter depth.

Uptake by plant roots of the principal radioactive substances, notably the uranium isotopes, radium, and radon gas, is probably very slow or non-existent in any case. These substances do not readily enter a water-solution, as required for absorption by plant roots. Radon is a noble gas which does not combine chemically with other elements or compounds, and thus it would not be changed to a more absorbable form. These radioactive substances do not readily enter plants in nature. This is demonstrated by geobotanical prospecting, which does not depend on detecting radioactivity, and thus uranium, in the plants, but instead depends on detection of associated elements such as selenium.

2.8 Regional Meteorology

2.8.1. Precipitation

Annual precipitation varies from 8.29 inches at Grand Junction to 10.93 inches at Rifle. Usually it is evenly distributed throughout the year. The maximum observed clock-hour rainfall in the study area during the period 1940-1972 (May through September) has been 0.64 inches. Rainfall models have predicted rates of 1.3 inches in 30 minutes and 3.3 inches in 24 hours, with a mean recurrence interval of 100 years. Maximum 24-hour rainfall is most likely to occur in August. Drought conditions may develop when the area receives less than 75 percent of average precipitation. One-year droughts are probable every seven years, two-year droughts every 44 years, and three-year droughts every 313 years.

Snow is normally expected between October and April, with the greatest amount in January. Mean annual snowfall at Grand Junction is 26.8 inches.

2.8.2. Air Temperature

Mean annual air temperature varies from 47.8^{0}F at Rifle to 52.5^{0}F at Grand Junction. Monthly mean temperatures are lowest in January at Rifle (23.2^{0}F), and highest in July at Grand Junction (78.2^{0}F). For the period of 1951 to 1970, the lowest temperature (-38^{0}F) occured in Rifle, and the highest (105^{0}F) at Palisade. However, readings higher than 100^{0}F are infrequent, as are prolonged subzero temperatures. Frost-free periods vary from 109 days at Rifle to 188 days at Palisade.

2.8.3. Wind

Prevailing winds are from the east-southeast at an average of 8.2 miles per hour at Grand Junction. The next most frequent wind direction is west-northwest. This distribution of wind direction is quite constant throughout the year because of the dominance of valley-induced upslope and downslope flows. Monthly average wind speeds range from 5.6 mph for January to 9.9 mph for June. At Grand Junction the highest sustained wind in the period from 1899 to 1976 was 66 mph with direction from the south.

2.8.4. Evaporation

Evaporation data are scarce and fragmentary. Grand Junction experienced the following evaporation rate in 1980: 7.9 inches in May, 13.9 inches in June, 12.3 inches in July, and 7.6 inches in September. Low precipitation and high evaporation (i.e., a very low, less than 0.5, P:E ratio) results in very difficult revegetation.

3. DESCRIPTION OF THE SITE SELECTION PROCESS

To insure the safe, long-term containment of uranium tailings material, a number of general placement objectives have been established for tailings disposal in Colorado. These placement objectives, which are compatible with the preferred method of tailings disposal (below-grade and dewatered), are as follows:

1. Tailings or waste disposal areas should be located at a relatively remote site so as to reduce potential population exposures and the likelihood of human intrusions to the maxiumum extent reasonably achievable.

2. Tailings or waste disposal areas should be located at a site where disruption and dispersion by natural forces are eliminated or reduced to the maximum extent reasonably achievable.

3. Tailings and waste should be placed below grade, in trenches or pits excavated into relatively impervious shale.

4. Tailings and waste should be covered with a minimum of three meters of earth materials that is designed to reduce surface exhalation of radon from the tailings or waste to less than two picocuries per square meter per second above background levels, is designed to reduce root or animal penetration and salt migration, and is constructed to minimize erosion.

5. Reclamation of the tailings or waste areas should include a full, self-sustaining vegetative cover or riprap to minimize wind and water erosion. The final contour slopes should be as close as possible to the natural surface, but not steeper than a ratio of 5 horizontal to 1 vertical.

6. Seepage of toxic materials to the ground or surface waters should be minimized to the maximum extent reasonably achievable so that ground water and other natural systems will not be degraded. Seepage control measures should include consideration of both physical and geochemical methods.

7. Tailings and waste should not adversely affect important mineral resources or unique historic, archaeologic, wildlife, or ecologic areas.

8. Tailings or waste should be confined to a single area to preclude the proliferation of numerous, small disposal areas.

9. The final disposition of the tailings and waste should be such that ongoing active maintenance is not necessary to preserve isolation and that monitoring will be minimized to the maximum extent reasonably achievable.

These objectives can be achieved and candidate sites can be determined and compared through a two-phase selection process. Phase I of this process consists of a series of elimination or filtering steps in which "potential sites" are delineated within a specific area around a particular tailings pile of interest. For this investigation an area with a 15-mile radius around each tailings pile, and a 20-mile wide corridor along the railroad from the Utah-Colorado line to Glenwood Springs and from Grand Junction south to the Mesa-Delta County line was inventoried. Phase II involves review and evaluation of these potential sites by an appropriate committee that selects three to five "candidate sites" for further detailed study by the DOE.

PHASE I: The first step in Phase I is to determine the geologic formations that possess acceptable permeability, thickness, and lateral lithologic continuity. The formation should have beds of low or very low permeability that are at least 150 feet thick and are laterally persistent for many square miles. Formations with these characteristics are herein called "suitable formations". Certain other geologic formations in Colorado may in part meet this criterion, but they generally are not as thick, as laterally persistent, or may contain aquifers. These formations are not obvious host formations, but are herein called "possibly suitable formations". In areas where there is insufficent area underlain by "suitable formations", the "possibly suitable formations" may become important and in such cases should receive thorough evaluation. Detailed studies may eventually prove that some areas underlain by "possibly suitable formations" do meet the specified siting requirements.

Distribution of suitable and possibly suitable formations in the Grand Junction-Rifle area are shown on Plate 1. In the study area only one formation, the Mancos Shale, meets the criteria for suitable formations. The Mancos Shale, a thick, laterally persistant, Cretaceous marine shale, is generally acceptable as a host formation for a tailings repository. The uppermost part of the formation, however, complexly interfingers with several sandstone beds. Similarly, the lower part of the Mancos contains limy beds and transitional silty and sandy zones. No sites were selected in either of these parts of the Mancos Shale.

One formation in the area, the Wasatch Formation, is classified as a possibly suitable formation. The Wasatch Formation consists of continental deposits of claystone with occasional sandstone and limestone beds. The middle part of the Wasatch Formation in the vicinity of DeBeque is particularly sandy (Donnell, 1961b). No sites were selected in the middle part of the Wasatch Formation.

The Green River Formation was initially considered as a likely candidate for designation as a possibly suitable formation because it contains thick sequences of shale, much of which is oil-rich. Additional evaluation, however, convinced us that the formation should not be so designated. Our rationale for excluding this formation involves several factors, including 1) a site within the Green River Formation could inhibit future oil shale mining and 2) the formation crops out only in steep cliff areas that are unacceptable for a tailings repository.

The second step of Phase I consists of delineating areas of favorable slope that are underlain by suitable formations or, where necessary, by possibly suitable formations. The most favorable slopes range from two to five percent, but slopes of five to ten percent or less than two percent may also be acceptable. Areas that are underlain by suitable formations or potentially suitable formations and that have acceptable slopes and size are considered to be "target areas". A target area may contain more than one potential site.

Thirty target areas were selected for the Grand Junction-Rifle study area. They are the State Line, West Salt Creek, Dry Canyon, Camp Gulch, East Salt Creek, Coyote Wash, Dry Gulch, Lipan Wash, Mack East, Persigo Wash, Leach Creek, Indian Wash, Halls Basin, Whitewater Creek, Indian Creek, Windger Flats, Black Mountain, Place Mesa, Pyramid Rock, Roan Creek, Mesa, Monument Gulch, Parachute, North Rifle, Flatiron Mesa, Mamm-Divide Creek, Cactus Valley, Grass Valley, New Castle, and Garfield Creek target areas. Locations of these target areas are shown on Plate 1.

The third step of Phase I involves the evaluation of target areas with regard to the following criteria and selection of potential sites by excluding areas that do not meet the criteria. All of the following areas are automatically disqualified as potential sites:

1) areas of insufficent size,
2) areas subject to extensive river flooding,
3) areas of critical ground-water resources or recharge,
4) areas of complex geologic structure (e.g. abundant faulting, folding, and jointing),
5) areas susceptible to geologic hazards that could disrupt the repository (e.g. active faulting, subsidence, unstable slopes, etc.),
6) areas with severe erosion potential or unstable landforms,
7) areas of Quaternary glacial or igneous activity,
8) areas with critical mineral, geothermal, archaeologic, cultural, historic, wildlife, or ecologic resources,
9) areas of critical surface water, springs, and present or planned large bodies of water,
10) areas of concentrated human habitation or future growth areas--towns, subdivisions, and densely populated rural areas,
11) National Parks, National Monuments, Wildlife Refuges, wildnerness areas, and wild and scenic river areas,
12) areas of prime, irrigated agricultural lands,
13) areas with severe transportation safety aspects.

Consideration of these criteria in regards to the target areas results in the selection of "potential sites". General locations of the recommended potential sites are illustrated on Plate 2, along with regional land ownership. Detailed site maps and site descriptions are contained in section 4 of this report. Site boundaries assigned in this report should not be considered permanently fixed. It may be necessary to somewhat revise site boundaries because of ownership, land use, environmental, geotechnical, or other considerations.

A number of sites within target areas received further consideration during this study, but were not recommended as potential sites. These are discussed in Appendix A and are shown on Plate 2.

The potential sites recommended to the Candidate Site Review Committee for the relocation and/or reprocessing of the Grand Junction and

Rifle uranium mill tailings piles from west to east, are as follows:

A. Two Road site
B. McDonald Creek site
C. 6 & 50 Reservoir site
D. Camp Gulch site
E. East Salt Creek site
F. Halls Basin site
G. Cheney Reservoir site
H. Lucas Mesa site
I. Flatiron Mesa site

The fourth and final step of Phase I is the geotechnical evaluation and ranking of the potential sites by use of a grading matrix. To use the grading matrix, shown in Figure 3, scores are assigned to a number of geologic, hydrologic, and meteorologic factors for each site. Each factor is assigned a rank value from zero to four in the matrix based on the characteristics of the particular site being evaluated. Some factors are more important than others, and they are weighted accordingly. The total site score is calculated by adding all factor scores. A maximum score of 152 is possible. The result of Phase I is this preliminary report which describes all potential sites, presents data relative to the sites, and assigns geotechnical ranks to the sites.

PHASE II: Potential sites are reviewed and further evaluated during Phase II by the Candidate Site Review Committee. Members of the Committee include:

Rahe Junge--Colorado Geological Survey
Richard Gamewell--Colorado Dept. of Health, Radiation Control Div.
Betsy Moen--University of Colorado, Inst. of Behavioral Sciences
James E. Morris - Colorado Division of Wildlife
Richard Lessner - City Manager, Rifle
George Van Slyke - Colorado Division of Water Resources, State Engineer's Office
Pat Gormley - Remedial Action Lay Advisory Committee, Grand Junction
Ned Noack - Colorado Department of Health, Waste Management Div.
Jim Pendleton - Colorado Mined Land Reclamation Division
Tom Douville - Mesa County Health Department
John Blair - Colorado Dept. of Health, Water Quality Control Div.
Barbara Chocol - Colorado Department of Highways
Darrell Lowder - City of Grand Junction
David Ouimette - Colorado Dept. of Health - Epidemiology Div.
James Drinkhouse - Garfield County Commissioner

The Committee will recommend three to five potential sites to be candidate sites for further detailed analysis by the U.S. Department of Energy. Recommendations by the Committee should be based not only on the currently available geotechnical data, but also on other important additional factors that must be considered for an acceptable disposal site. These factors, which are generally described in this report, include, but are not limited to, transportation elements, land use, land ownership, wildlife, archaeologic, cultural, and ecologic impacts, local

SITE DESIGNATION: ______________________ SITE LOCATION: ______________________

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		2% to 5%	1	
2. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	silty clay	clay	1	
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	>20 ft.	10 to 20 ft.	5 to 10 ft.	2 to 5 ft.	0 to 2 ft.	2	
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	shale or claystone	2	
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	>200 ft.	2	
6. Presence of fracturing (joints & shear zones)	very high	high	moderate	low	very low	1	
7. Seismic risk	very high	high	moderate	low	very low	1	
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low		very low	4	
9. Present erosional/depositional setting	intense gullying	moderate gullying	minor gullying	sheet or rill wash	no erosion or undergoing deposition	4	
10. Long-term geomorphic stability	very poor	poor	moderate	good	excellent	4	
11. Conflict with mineral resources	serious conflicts		moderate conflicts		no or minor conflicts	1	
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	produces minor-mod. amounts of poor quality water	produces little or no water	4	
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	produces minor-mod. amounts of poor quality water	produces little or no water	4	
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	>200 ft.	2	
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	1/2 to 1 mile	1 to 2 miles	>2 miles	2	
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	0 to 1/2 sq. miles	at head of drainage	2	
17. Evaporation to precipitation ratio	<1		1 to 2		>2	1	

Total Site Score ________

Figure 3. An example of the geotechnical rating matrix used to comparatively rate potential sites: Rank x weight = Factor Score; 0 = low rank; 4 = highest rank; Highest possible score = 152.

attitudes toward particular sites, reclamation potential, economics, and site remoteness. The Committee should incorporate such important factors into the final selection of candidate sites. The findings and recommendations of the Committee are then submitted to the State of Colorado, specifically the Colorado Department of Health, for review and submittal to the U.S. Department of Energy. The candidate sites will be studied in greater detail by the U.S. Department of Energy, and the results of this study will be used as the basis for an environmental impact statement on the proposed relocation project.

It must be emphasized that this report is a reconnaissance evaluation of the potential sites. The type of information needed to thoroughly examine all the relevant geotechnical, environmental, economic, political, and social parameters can only be obtained by detailed studies. The reconnaissance data presented in section 4 of this report, however, should provide a suitable foundation so that the committee members can satisfactorily select three to five candidate sites.

4. DESCRIPTION OF POTENTIAL SITES

Each potential site was evaluated in regards to the limiting criteria and the geotechnical rating matrix. Additionally, general and site-specific data were collected on transportation, land ownership and use, and environmental and economic factors. Published information and data from Federal, State, and local agencies were used in the preparation of this report. Additionally, a number of valuable reports and maps were used extensively to compile the data necessary for the site evaluation. These references are listed in Section 5.

Land use and ownership maps were compiled from Bureau of Land Management (BLM) and County records. Federal oil and gas lease numbers and BLM file numbers for improvements are included on these maps.

Mine records held by the Colorado Division of Mines and the Colorado Geological Survey indicate that none of the potential sites are undermined. Information on existing registered water wells and decreed springs was collected from the Colorado Division of Water Resources. Locations and status of oil and gas wells on or near the sites were provided by the Colorado Oil and Gas Conservation Commission and Petroleum Information, Inc. Drillers' logs from water wells and geophysical logs from oil and gas wells aided stratigraphic and hydrologic interpretations. The Colorado State Historical Society, Colorado State Archaeologist, Colorado Division of Wildlife, and Colorado Natural Areas Program contributed valuable comments on historic sites and landmarks, archaeologic sites, and wildlife and ecologic areas.

A preliminary search of recorded cultural resources was conducted by the Colorado Historical Society. This search, which included both archaeological and historical records, identified documented resources near some of the proposed sites. Archaeological resources are located in Mesa County near the Cheney Reservoir and Two Road Sites. Details regarding these resources are further described on a site by site basis in this report. The Colorado Historical Society notes that the specific site areas have not been inventoried and that the data in these areas are incomplete. There is a possibility that unidentified cultural resources exist within the sites. A detailed, professional survey of the sites should be conducted during later investigations, and the results submitted to the Colorado Historical Society.

Personnel with the Colorado Natural Areas Program indicated that the proposed sites were not within an inventoried natural area. However, additional data and studies are currently being compiled. The Colorado Natural Areas Program within the Colorado Department of Natural Resources should be contacted when detailed, site-specific studies are being conducted.

Important considerations in regards to the economic feasibility of sites include availability of riprap and clay for liner and cap material, excavatibility of the host rock, and transportation elements. Since all potential sites are in shale or claystone host rocks, there is a readily available potential source of clay on and adjacent to each site. Possible riprap sources are mentioned in the site descriptions, and nearby gravel sources are indicated on the mineral resource map of each site. Some sites are capped by gravel deposits that may yield acceptable riprap. Detailed durability studies of these materials were not conducted during this investigation. Host rock excavatibility is an important factor, but because it is highly dependent on site specific subsurface conditions, it was not evaluated during this phase of the project. Although absence of ground water and distance from surface water are desirable environmental factors, a certain amount of water may be needed if reprocessing is to be carried out. Haul routes, road conditions, haul distances, and transportation costs are discussed in each site description.

A short explanation regarding the methodology related to determination of erosion potential and long-term geomorphic stability may clarify some possibly confusing issues. All land areas are susceptible to some type of erosion, with the exception of areas that are experiencing active deposition. Currently, depositional areas are relatively rare in western Colorado. Areas with low or moderate erosion potential generally are protected by a cap of erosion-resistant rock or gravel and do not have through-going drainage systems. These areas are often suitable for tailings disposal, although some specially engineered structures or construction techniques may be needed to assure long-term resistance to erosion.

High erosion potential areas generally have easily eroded material at the surface and may be within through-going, but small drainages. Certain areas with high erosion potential may be acceptable for tailings disposal if specially designed protective structures are constructed. A severe erosion potential exists along creeks, streams, and rivers that drain sizeable areas and are subject to flash flooding or mainstream river flooding. It is difficult, if not impossible, to design and construct a safe tailings repository in a severe erosion potential area.

The long-term geomorphic stability of an area relates not only to erosion potential, but also to other types of geologic hazards that may disrupt or disturb the area. Because the site selection techniques used in this study eliminate areas subject to most geologic hazards, variance in erosion potential is a key element used in comparing the long-term stability of the nine potential sites. In general, sites undergoing active deposition or with low erosion potential have good to excellent long-term stability. Areas with moderate erosion potential are believed to have good long-term stability. Moderate or acceptable long-term stability is associated with sites having a high erosion potential that appears to be controllable through state-of-the-art engineering techniques. Other high erosion areas have only poor long-term geomorphic stability, and sites with a severe erosion potential have very poor stability characteristics. In all cases, further detailed studies are necessary to accurately define a specific area's potential for long-term stability.

It should be re-emphasized that the site boundaries herein designated are not permanently fixed. Boundaries may be somewhat revised to allow for conflicts related to land ownership, land use, geotechnical aspects, or other factors.

4.1 Two Road Site

4.1.1. General Site Description

4.1.1.1. Location

The Two Road site is in Grand Valley about 28 miles northwest of Grand Junction in Mesa County. It is adjacent to the Utah-Colorado border and is about five miles north of Interstate 70. This site is a north-south elongate area almost three miles long by 1/2 mile wide falling in Sections 7, 8, 17, 18, 19, and 30 of T9S, R104W (Figure 4). The area is bisected by a northwest-southeast trending dirt road called Two Road.

4.1.1.2. Transportation Aspects

Only one feasible transportation route exists if we assume that rail transportation out of the Grand Junction area is necessary to avoid the accident hazards of highway transportation of tailings. This route would include rail transport from the piles to Siding One (see Figures 2 and 4) near Mack. Truck transport from there to the Two Road site would traverse 8.7 miles of paved highway (US-6 & 50) and 2.4 miles of dirt road which would require gravel surfacing but little other construction.

The minimum cost of transportation would be $19.6 million from Grand Junction and $46 million from Rifle, not including costs of manipulating and covering the tailings on the disposal site. Some additional maintenance cost might be needed for the paved highway.

Little traffic now uses the paved highway, which has been replaced by I-70. Presently some trucks use the dirt road for access to natural gas wells and drilling sites.

4.1.1.3. Topographic Setting

The Two Road site is situated on a gently south-sloping, elongate pediment surface. East of the pediment surface lies a broad shallow drainage basin with slopes less than five percent (Figure 5). West of the Two Road site is an ephemeral stream which has dissected the underlying sediments to form slopes steeper than five percent and in places greater than ten percent. Total relief in the site area is less than 160 feet over a three mile distance.

4.1.1.4. Land Use and Ownership

The Two Road site is wholly on public lands administered by the Bureau of Land Management that are subject to existing oil and gas leases (Figure 6). Primary use of the site is for grazing purposes. Two Road, a secondary County road, crosses the site.

The Bureau of Reclamation has identified a preferred site for a large salt evaporation area that completely envelops the Two Road site. This proposed project is in connection with the Glenwood-Dotsero Springs unit of the Colorado River Water Quality Improvement Program. Saline waters would be transported by ditch and/or pipeline from a collection point near

Dotsero to the evaporation pond site. A map showing the location of the proposed pond is shown in Figure 6.

4.1.2. Geotechnical Evaluation

The geotechnical rating matrix for the Two Road site is given in Figure 10. The site received a score of 128 and ranks first based on the evaluated geotechnical parameters.

4.1.2.1. Geology

Approximately 500 to 1,100 ft of Mancos Shale underlies the Two Road site, based on structure contour mapping by Cashion (1973) and nearby petroleum drill holes. Shale thickness increases from south to north, primarily as a result of structural tilting. The site lies almost directly on and slightly west of the axis of a large, regional anticline that is related to the Uncompahgre Uplift. Bedrock in the site area is thought to generally dip northward or northwestward at slopes of 2^o to 5^o. No bedrock exposures occur on site; therefore, it was necessary to calculate the dips from the structure contour map of Cashion (1973).

Two Road site lies on a pediment surface or old channel deposit of unknown age (Figure 7). The surface is 40 to 60 ft above adjacent ephemeral creeks and 50 to 80 ft above Bitter Creek, the primary creek in the area. There are no good exposures of the deposit which caps this surface. Shallow test pits and poor exposures along the periphery of the site suggest the unit is dominantly clayey, silty small pebble gravel that is an estimated 3 to 6 ft thick along the perimeter of the site. If the unit represents an old channel deposit, the gravels may be thicker in the middle part of the channel. The gravel clasts consist of reworked sedimentary rocks from the Book Cliffs and Roan Cliffs and are primarily sandstone, chert, and shale, with minor amounts of other types of sedimentary clasts. A thin veneer of red-brown wind blown silt commonly overlies the pediment gravel on parts of the site.

The surface configuration of the site area is that of an elongate, gently arched ridge. It is uncertain if the modern topographic surface coincides with the older depositional surface. The old surface may have been eroded on its edges and thus lowered by erosion. It is also remotely possible that the old pediment deposit has been structurally arched since deposition. This possibility needs further evaluation if Two Road site is recommended for the final repository site. This question can be answered by detailed mapping and drilling or trenching to expose the base of the gravel unit across the site. If the base of the unit is folded, Quaternary deformation would be suspected and additional work would be required to fully understand the problem.

Soils on the Two Road Site are loamy Ustollic Haplargids in the order Aridosols.

Presently, sheet and rill wash occur on the site. The gravel cap has effectively prevented any severe erosion on site. Because the site lies on a drainage divide, there is little potential for flash flooding on site. The major known geologic factor that affects the long-term stability of the site relates to the areas of severe erosion potential along the ephemeral creeks adjacent to the site (Figure 8). These erosional areas must be considered when designing the repository and protective riprap cover.

There are moderate potential conflicts between the Two Road site and mineral resource recovery. As with most sedimentary basins, there is some potential for oil and/or gas beneath the site. Primary underlying potential reservoir rocks include the Dakota, Morrison, and Entrada Formations. Several tests wells have been drilled within a mile of the site, but all were plugged and abandoned (Figure 9). A small amount of gas was reported in the #1 Gov't Krey well in SE/4 NW/4 sec. 10, but the volume was far to little to make a gas well. The topographic base map indicates the well in the NW/4 sec. 18 is a gas well, but the records of the Colorado Oil and Gas Conservation Commission indicates the well was dry and plugged. The Dakota Formation contains thin coal beds in some areas, but it is highly unlikely that this would ever become an economically recoverable resource.

The lithologic and size characteristics of the gravel deposit that underlies Two Road site are not favorable for an economic source of sand or gravel. Likewise, it is improbable that the unit will contain any significant amount of useable riprap for a repository. The nearest potential sources of riprap include quarried sandstone from the Dakota or Entrada Formations a few miles southeast of the site, quarried sandstone from the Mesaverde Formation exposed in the Book Cliffs several miles north, river gravel along the Colorado River several miles to the southeast, or basaltic pediment gravels from the west flank of Grand Mesa.

4.1.2.2. Hydrology

There are no major streams, lakes, springs, or irrigation ditches on or within two miles of the Two Road site. Several creeks occur in the area, but according to U.S. Geological Survey topographic maps all are ephemeral. The site lies on a drainage divide between two unnamed ephemeral creeks. These creeks join Bitter Creek about one-half to one mile below the site. Bitter Creek flows into the Colorado River over 10 miles from the site.

The surficial materials on the Two Road site probably carry little or no water. It is possible that the surficial unit may temporarily hold small amounts of water following periods of heavy precipitation, but any such water would rapidly dissipate because of evaporation or seepage around the flanks of the site.

Examination of the Colorado Division of Water Resources' records indicates there are no registered water wells or decreed springs in the township that includes Two Road site. In general the Mancos Shale produces only minor amounts of poor quality water (Lohman, 1965; Boettcher, 1972). Any water present within the Mancos Shale is usually found in fractured zones. The first underlying potential aquifer is the Dakota Formation, 500 to 1,100 ft below the ground surface, but this aquifer is often of poor quality and may be contaminated by hydrocarbons.

4.1.3. Environmental Factors

Vegetation on the Two Road site is desert grassland. Some range improvement has been completed in the area. Many of the natural shrubs (especially shadscale) are dead, but cheatgrass and snakeweed are abundant. Some galleta grass and needle grass occurs, but the site is poor grazing land. The site includes part of Brewster Ridge, which is a well-known food-hunting area for Golden Eagles, and raptors such as Red-tailed and Rough-legged Hawks. Small mammals, birds, and small predators typical of southwestern desert would be found here. The desert cottontail is the most common game species.

The Colorado Historical Society indicates there is lithic scatter located within the boundaries of Two Road site (index numbers 5ME00274A, 5ME00289A, 5ME00396A, 5ME00397A). However, the Colorado Historical Society requires more information to evaluate the historical or cultural eligibility status of this area.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

——→	Existing Surfaced Road
— →	Gravel Surfacing Required
– – → –	Road Construction & Gravel Surfacing Required
++++++	Railroad Siding
⋯⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▨	Area Underlain by Unsuitable Formation
☐	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

⊢—⊢—⊢ C 029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•—•—•—	Transmission Line (with BLM Ref. No.)
–•–•–•–	Telephone Line
→—→	Irrigation Ditch (with BLM Ref. No.)
—⊃	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium,Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⌀	Abandoned Location (never drilled, permit expired)
●	Oil Well
—●—	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
☼	Plugged Gas Well
—○—	Plugged Dry Hole
⁘	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
⚒	Gravel Pit (may be abandoned)
▨	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

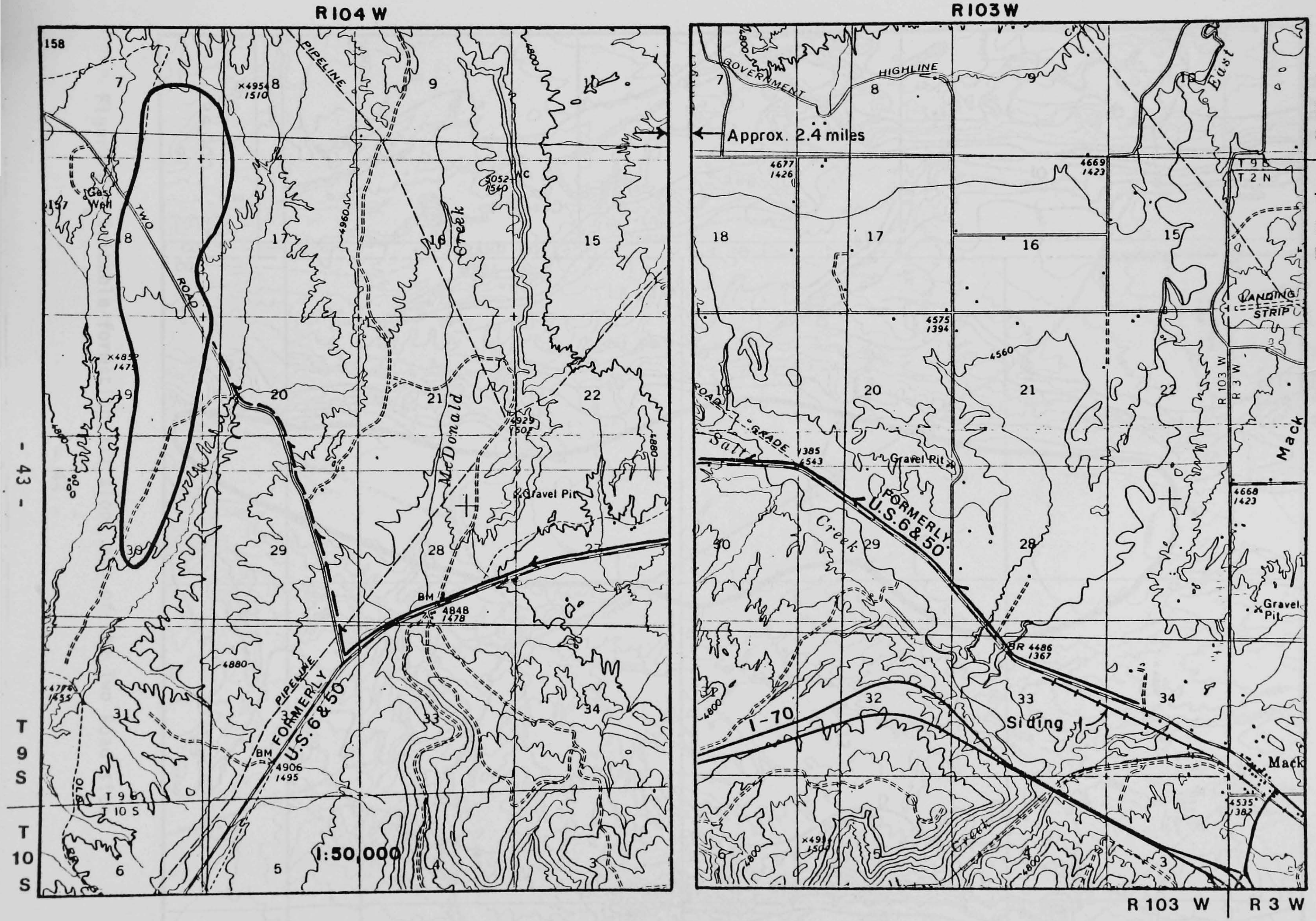


Figure 4. Possible transportation route to the Two Road site.

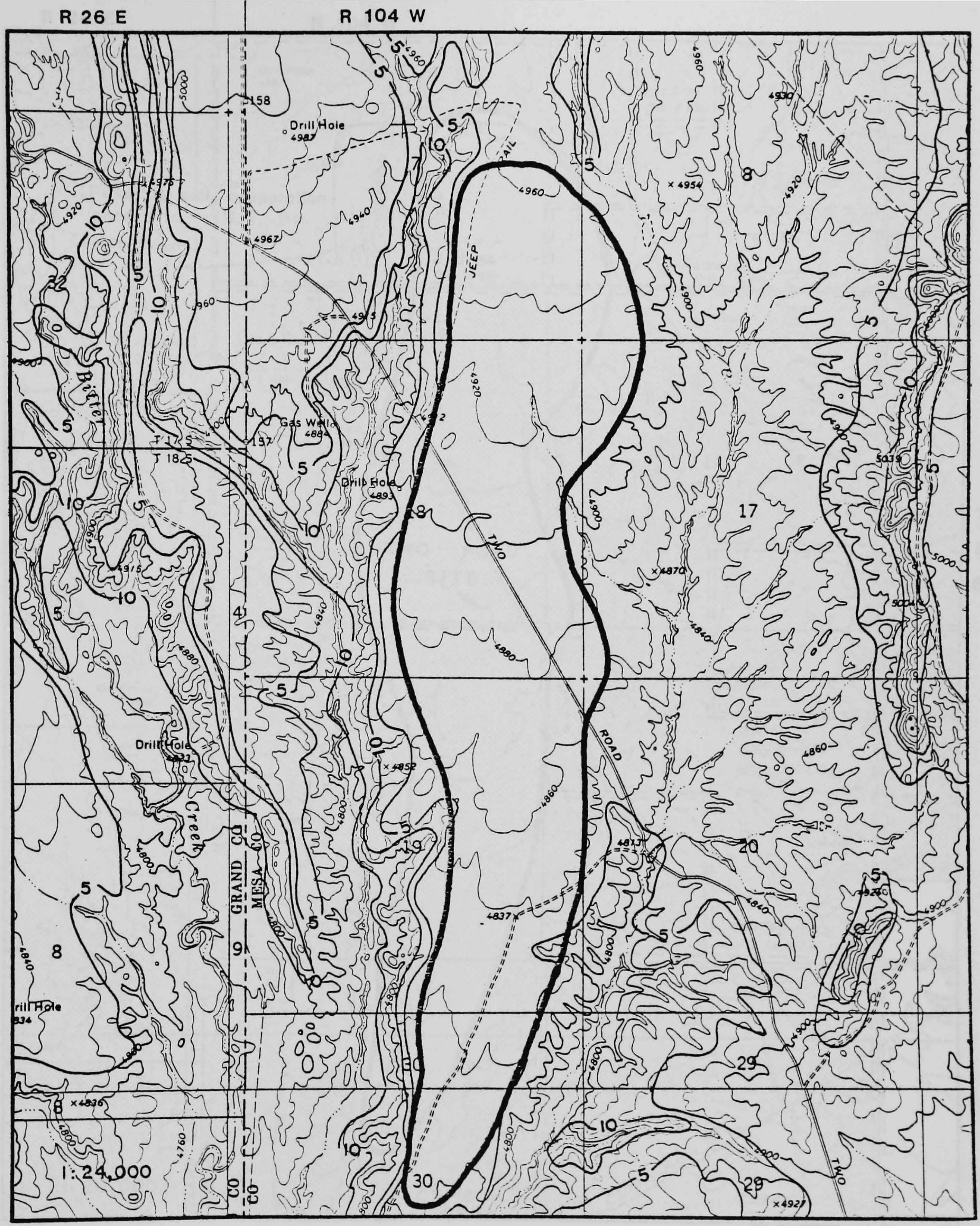


Figure 5. Suitable formation and slope map of the Two Road site.

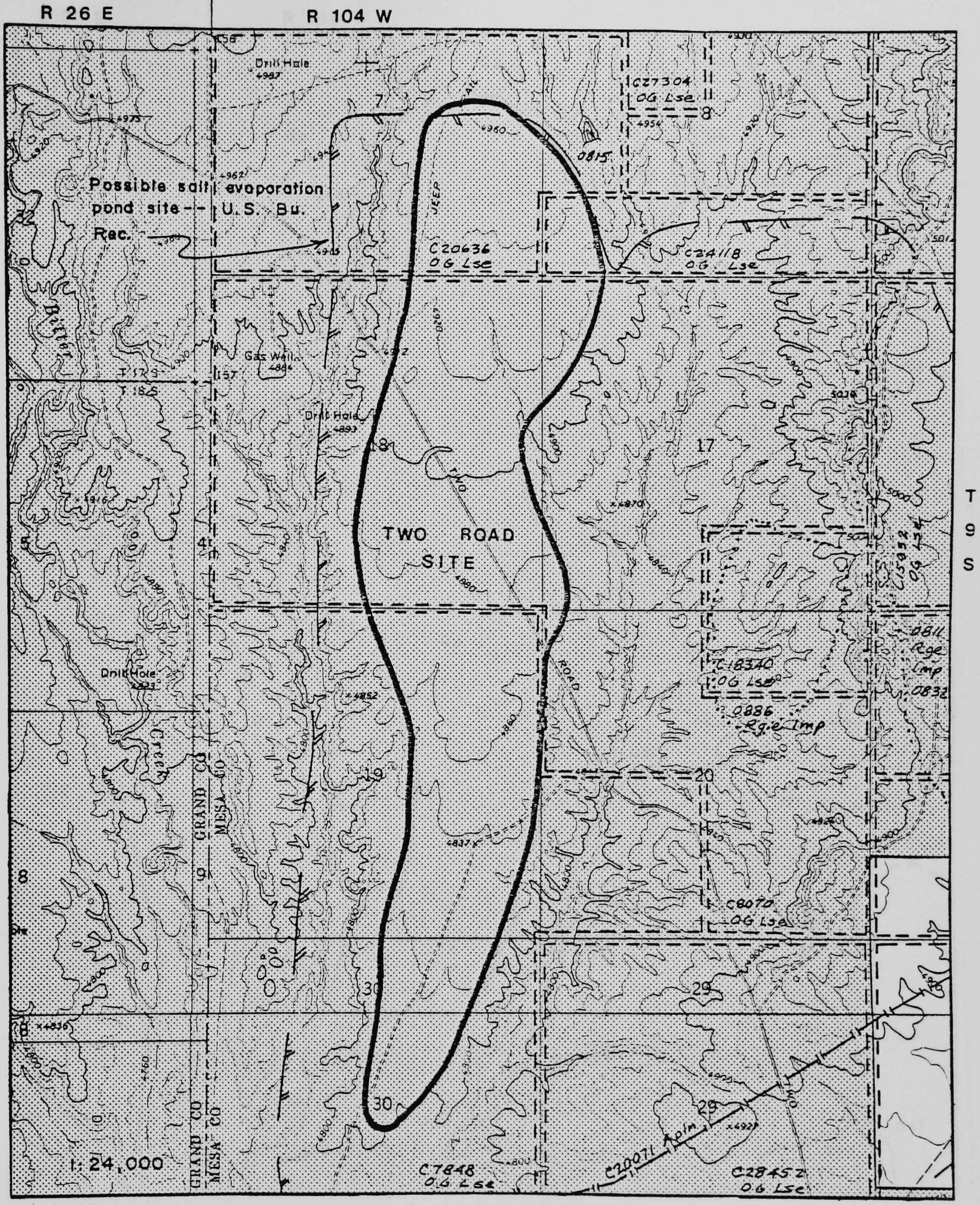


Figure 6. Land use and ownership map of the Two Road site.

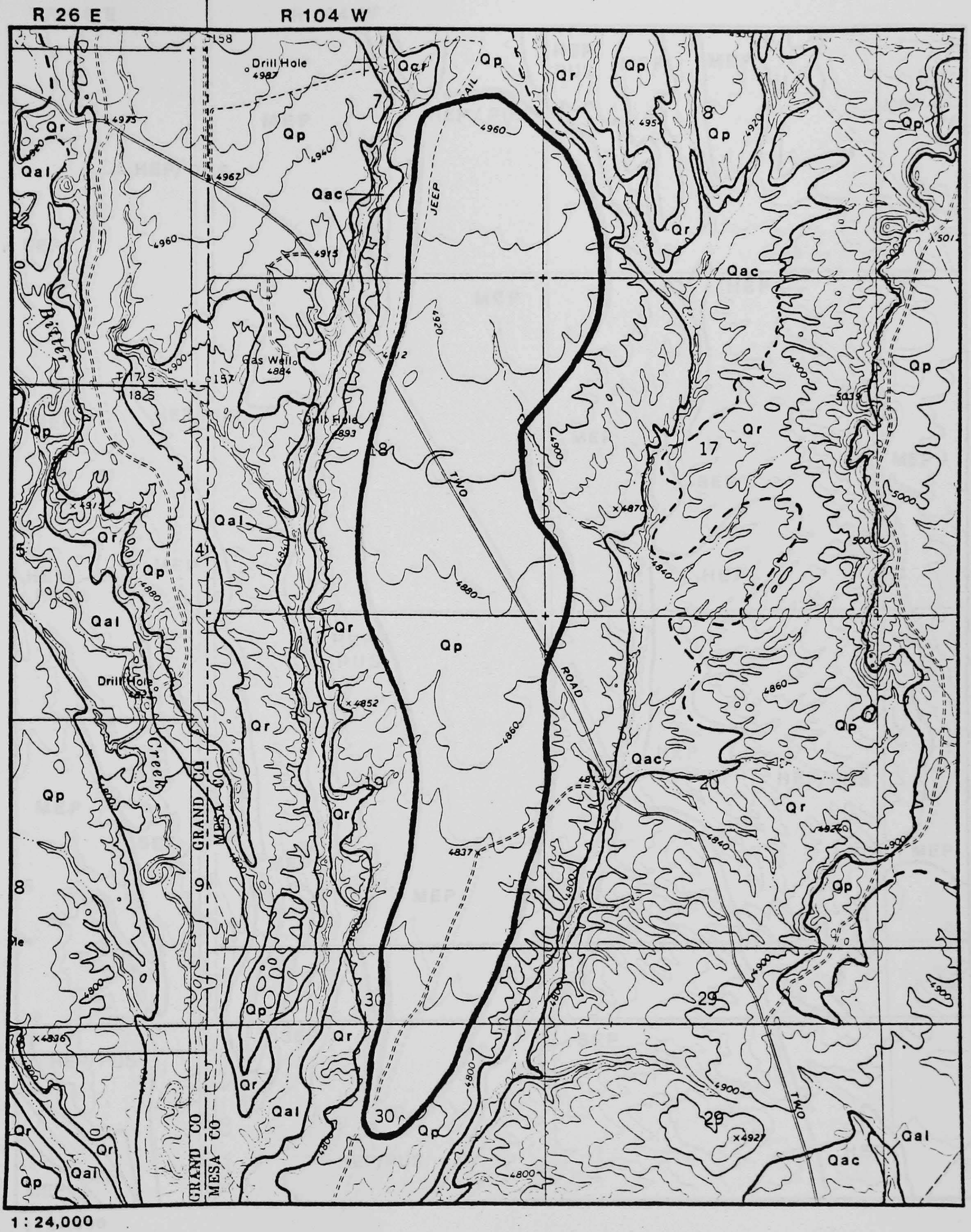


Figure 7. Surficial geologic map of the Two Road Site.

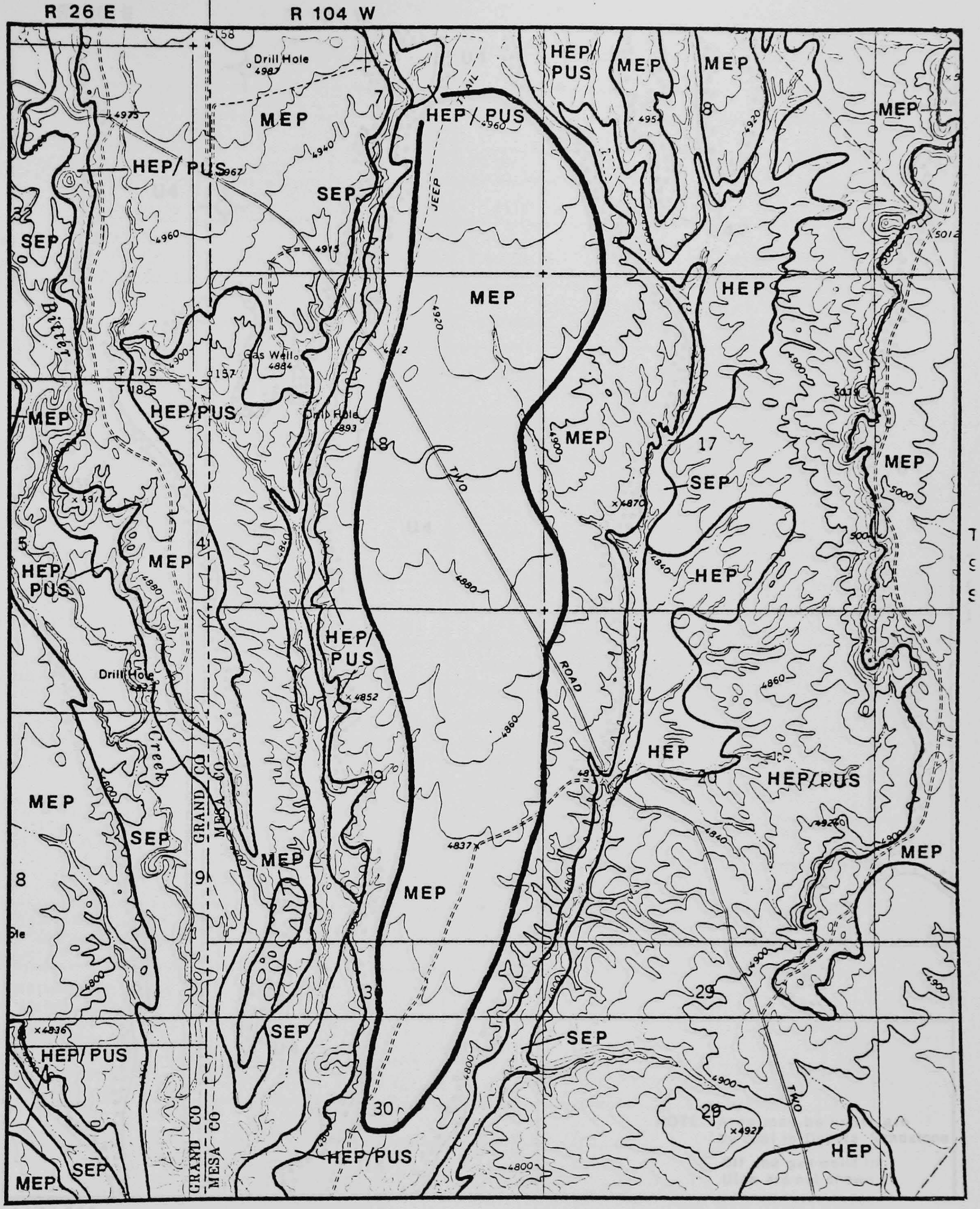


Figure 8. Geologic hazards map of the Two Road site.

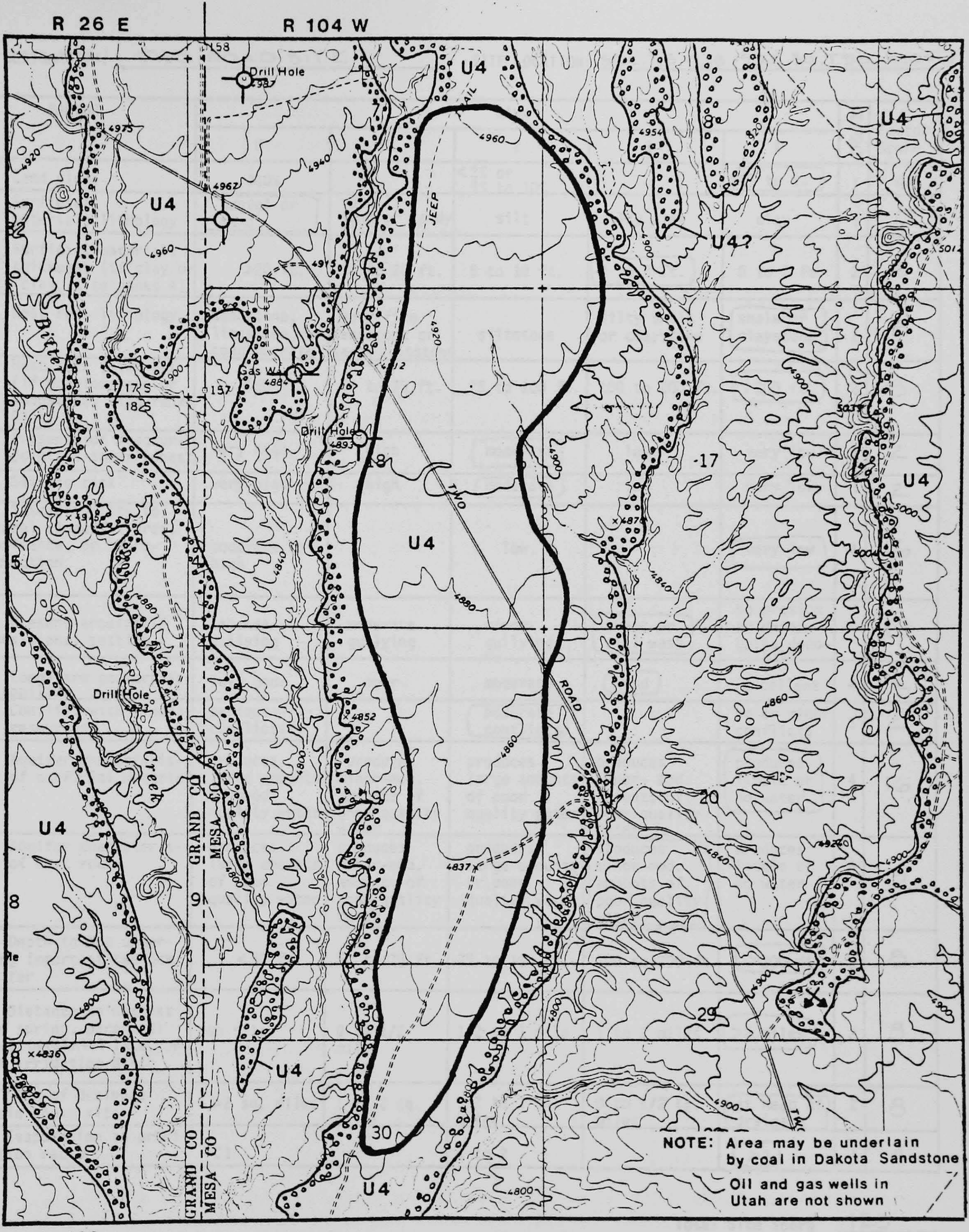


Figure 9. Mineral resources map of the Two Road site.

SITE DESIGNATION: TWO ROAD SITE SITE LOCATION: SEC.7,8,17,18,19,20,30,T9S,R104W

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	[✓ gravel or sand]	very fine sand or sandy silt	silt	silty clay	clay	1	0
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	>20 ft.	10 to 20 ft.	5 to 10 ft.	[✓ 2 to 5 ft.]	0 to 2 ft.	2	6
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	[✓ shale or claystone]	2	8
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	high	[✓ moderate]	low	very low	1	2
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low.		[✓ very low]	4	16
9. Present erosional/depositional setting	intense gullying	moderate gullying	minor gullying	[✓ sheet or rill wash]	no erosion or undergoing deposition	4	12
10. Long-term geomorphic stability	very poor	poor	moderate	[✓ good]	excellent	4	12
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	produces minor- mod. amounts of poor quality water	[✓ produces little or no water]	4	16
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts or poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	1/2 to 1 mile	1 to 2 miles	[✓ >2 miles]	2	8
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	0 to 1/2 sq. miles	[✓ at head of drainage]	2	8
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 128

Figure 10. Geotechnical rating matrix for the Two Road site.

4.2. McDONALD CREEK SITE

4.2.1. General Site Description

4.2.1.1. Location

McDonald Creek site is in Grand Valley about 26 miles northwest of Grand Junction in Mesa County. It is two miles east of the Two Road site (Plate 1). This site lies about five miles north of Interstate 70 in sections 9 and 16, T9S, R104W (Figure 11). It is approximately 1/2 mile wide and 1 and 3/4 miles long.

4.2.1.2. Transportation Aspects

If we assume that rail transportation out of the Grand Junction area is essential to avoid the accident hazards of highway travel, only one feasible transportation route exists. This route would include rail haulage from the tailings piles to Siding One near Mack (Figures 1 and 11). Truck transport from there to the McDonald Creek site would traverse 8.7 miles of paved highway, 1.1 miles of dirt road, and 2.9 miles of primitive road. The dirt road would require gravel surfacing and the primitive road would require complete construction and surfacing.

The minimum cost of transportation would be $21.3 million from Grand Junction and $47.6 million from Rifle, not including costs of manipulating and covering the tailings on the disposal site. Some maintenance cost might be needed for the 8.7 miles of paved highway.

Little traffic now uses the paved highway, which has been replaced by I-70. Presently some trucks use the dirt road for access to natural gas wells and drilling sites.

4.2.1.3. Topographic Setting

The McDonald Creek site is in a shallow drainage basin at the head of McDonald Creek, an ephemeral stream. The site sits on an eroded pediment surface which slopes generally southward at about one to three percent (Figure 12). One-fourth mile east of the site boundary lies a steep 150-foot escarpment which marks the eastern edge of an adjacent, but higher pediment surface. To the west is another shallow drainage basin similar to, but larger and lower than McDonald Creek. Total relief across the entire site does not exceed 90 feet.

4.2.1.4. Land Use and Ownership

Land use and ownership of the McDonald Creek site is shown in Figure 13. The site is wholly on public lands administered by the Bureau of Land Management, and it is subject to existing oil and gas leases. A buried gas pipeline extends along the southwest side of the site. Range improvements include shallow furrows for water dispersal purposes and a reseeding program. Primary use of the site is for grazing purposes.

The Bureau of Reclamation has identified a site which completely envelops the Two Road site and includes most of the McDonald Creek site for use as a large salt evaporation pond in connection with the Glenwood-Dotsero Springs unit of the Colorado River Water Quality Improvement Program. Saline waters would be transported by ditch and/or pipeline from a collection point near Dotsero and Glenwood Springs to the evaporation pond site. Location of the salt evaporation pond, shown in Figure 13, may be altered during later detailed studies of the Bureau of Reclamation.

4.2.2. Geotechnical Evaluation

The geotechnical rating matrix for the McDonald Creek site is shown in Figure 17. The site received a score of 121 and ranks second based on the evaluated geotechnical parameters.

4.2.2.1. Geology

The McDonald Creek site is underlain by approximately 600 to 1,600 ft of Mancos Shale, based on structure contour mapping by Cashion (1973) and nearby petroleum test holes. Shale thickness decreases from north to south across the site. Structurally, the site lies just east of the axis of a regional anticline mapped by Cashion (1973). Bedrock in the site area is thought to dip north-northeastward at approximately 4^{o} to 7^{o}. No bedrock exposures occur on site, therefore it was necessary to calculate these dips from Cashion (1973).

As shown in Figure 14, the majority of the McDonald Creek site is mapped as an old pediment surface. The surface could also be an old channel deposit associated with an ancient stream drainage that extended southward from the Book Cliffs towards the Colorado River. There are no exposures through this old surface on the site. Poor exposures to the north and west of the site of what is believed to be the same surface suggest the perimeter of the site may be underlain by 2 to 7 ft of silty, clayey pebble gravel with occasional large clasts in the cobble to boulder size range. If the deposit is part of an old channel, the gravel may be thicker in the middle part of the channel. The lithology of the gravel clasts is predominantly sandstone and chert with minor amounts of shale and other types of sedimentary clasts. Windblown silt is sometimes found overlying the pediment gravels on the site.

A thin finger of alluvium and colluvium is mapped as extending into the site. The boundary between this unit and the pediment gravel is not well defined, and some alluvial/colluvial material may occur outside of the mapped boundaries. There are no natural exposures of the alluvium and colluvium on site. The unit is probably no more than a few feet thick, and may be comprised of clayey, occasionally slightly gravelly silt. A small part of the southeast corner of the site is underlain by colluvium and residuum. Likewise, there are no exposures of this material on site. It is suspected to be no more than several feet thick and may consist mainly of clay and silt with minor amounts of gravel and weathered shale.

The surface on which McDonald Creek lies is an elongate, north-south trending basinal form that drains southward. The west side of this surface is bounded by a moderately prominent cliff some 60 to 80 ft high. A higher and older pediment or channel deposit lies directly east of and adjoins the surface that underlies the site. This higher surface is held up in part by a well indurated gravel deposit that forms a very prominent 100 to 180 ft high cliff on its east side. The lower part of this gravel deposit appears to be more indurated than the upper part.

No known faults underlie the McDonald Creek site. Several mapped faults and suspicious lineaments, however, occur northeast of the site and trend towards it (Cashion, 1973; Schwochow, 1978). The basinal form of this drainage may be the result of erosion, but it is remotely possible that recent folding has created the basin. These features should be carefully evaluated to ascertain their seismogenic and hydrologic importance.

Soils on the McDonald Creek site are classified as loamy Ustollic Haplargids in the Aridosols order.

Most of the McDonald Creek site is currently undergoing only sheet wash or rill wash. In the upper part of the site it is difficult to even locate any main drainage on the ground. A slight amount of creek incision, but not gullying, is present along McDonald Creek on the lower part of the site. Positioning the site at the drainage head, and the presence of a gravel cap combine to give the site a good potential for long-term stability. The potential for future erosion on most of the site is classified as moderate (Figure 15). A narrow area along McDonald Creek in the south end of the site is mapped as having a high erosion potential. Headward erosion in this part of the site can be prevented by appropriate engineering. Erosion rates of the pediment flank on the northeast and northwest sides of the site will need to be considered for selection of the repository boundaries.

As with any area in a sedimentary basin in the Rocky Mountain region, there is some potential for oil and/or gas beneath the site. No wells have been drilled within the boundaries of the McDonald Creek site, and therefore, the presence of any significant hydrocarbons is unknown. The nearest successful well lies just over one-half mile northeast of the site (Figure 16). Two other holes have been drilled in the area, but both were dry and have been plugged.

Some coal in the Dakota Sandstone may underlie the site, but there is no evidence to suggest it is economically significant. The pediment gravel that forms the site surface consists primarily of sandstone, shale, and chert clasts. The deposit has not been fully evaluated as a potential source of construction materials, but the nature of the deposit suggests it probably is not of any great value. Some riprap may be obtained from the on-site pediment gravel on the higher and somewhat older, well-indurated pediment deposit directly east of the site. It is possible that these potential riprap sources may not be adequate for protecting the repository. Better quality riprap may need to be trucked to location from gravel deposits along the Colorado River or the west flank of Grand Mesa. Other possible riprap sources include quarried sandstone from the Uncompahgre Plateau or the Book Cliffs.

4.2.2.2. Hydrology

McDonald Creek is an ephemeral creek which joins the Colorado River about 10 miles downstream from the site. The site lies at the head of

McDonald Creek, hence the likelihood of any creek flooding on site is very remote. The nearest important surface water to the site is West Salt Creek, about one and one-quarter mile to the northeast.

The surficial deposits on McDonald Creek site may carry minor amounts of water seasonally. Precipitation in the basin may infiltrate into the soil and move towards the creek, depending on climatic conditions. The first underlying potentially important aquifer is the Dakota Sandstone, some 600 to 1,600 ft deep. Any water present in this formation will probably be of poor quality, being brackish or contaminated with hydrocarbons. The Mancos Shale, host rock for this site, generally contains very minor amounts of poor quality water (Boettcher, 1972; Lohman, 1965). Localized perched water zones may occur beneath the site at the bedrock-surficial contact or in fractured zones in the Mancos Shale.

According to the Colorado Division of Water Resources' records, there are no registered wells or decreed springs on or near the McDonald Creek site.

4.2.3. Environmental Factors

Vegetation on the McDonald Creek site is desert grassland. It is mostly cheatgrass and galleta grass with scattered shadscale saltbushes, many of which are dead. Most of the site has undergone range improvement, and crested wheatgrass has been introduced. A few scattered junipers are found at the edges of the site. Small mammals, birds, and small predators typical of this type of desert would be found here. The site is a food-hunting area for Golden Eagles and raptors such as the Red-tailed and Rough-legged Hawks. The desert cottontail is the most common game species.

There are no documented archaeologic or historic resources within the McDonald Creek site according to the records of the Colorado Historical Society.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

⟶	Existing Surfaced Road
— →	Gravel Surfacing Required
– – → –	Road Construction & Gravel Surfacing Required
┼┼┼┼┼┼	Railroad Siding
⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▧	Area Underlain by Unsuitable Formation
▭	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

├─┼─┼─┤ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 06 LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•——•———	Transmission Line (with BLM Ref. No.)
·-·-·-	Telephone Line
→ →	Irrigation Ditch (with BLM Ref. No.)
→⊃	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium,Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⌀	Abandoned Location (never drilled, permit expired)
●	Oil Well
-●-	Plugged Oil Well
☼	Gas Well
✳	Suspended (Shut-in) Gas Well
⊕	Plugged Gas Well
-○-	Plugged Dry Hole
▩	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
⚒	Gravel Pit (may be abandoned)
▨	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

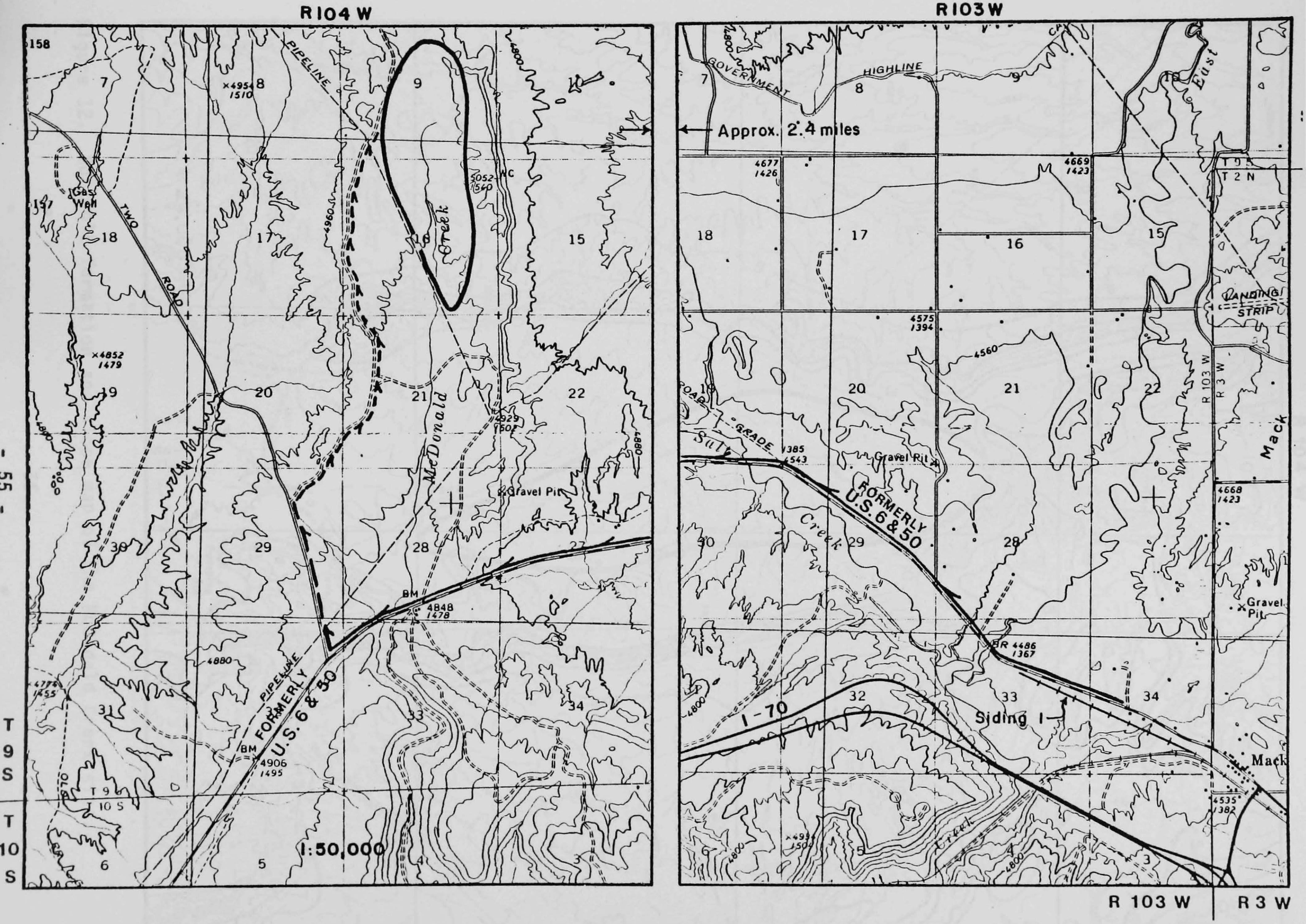


Figure 11. Possible transportation route to the McDonald Creek site.

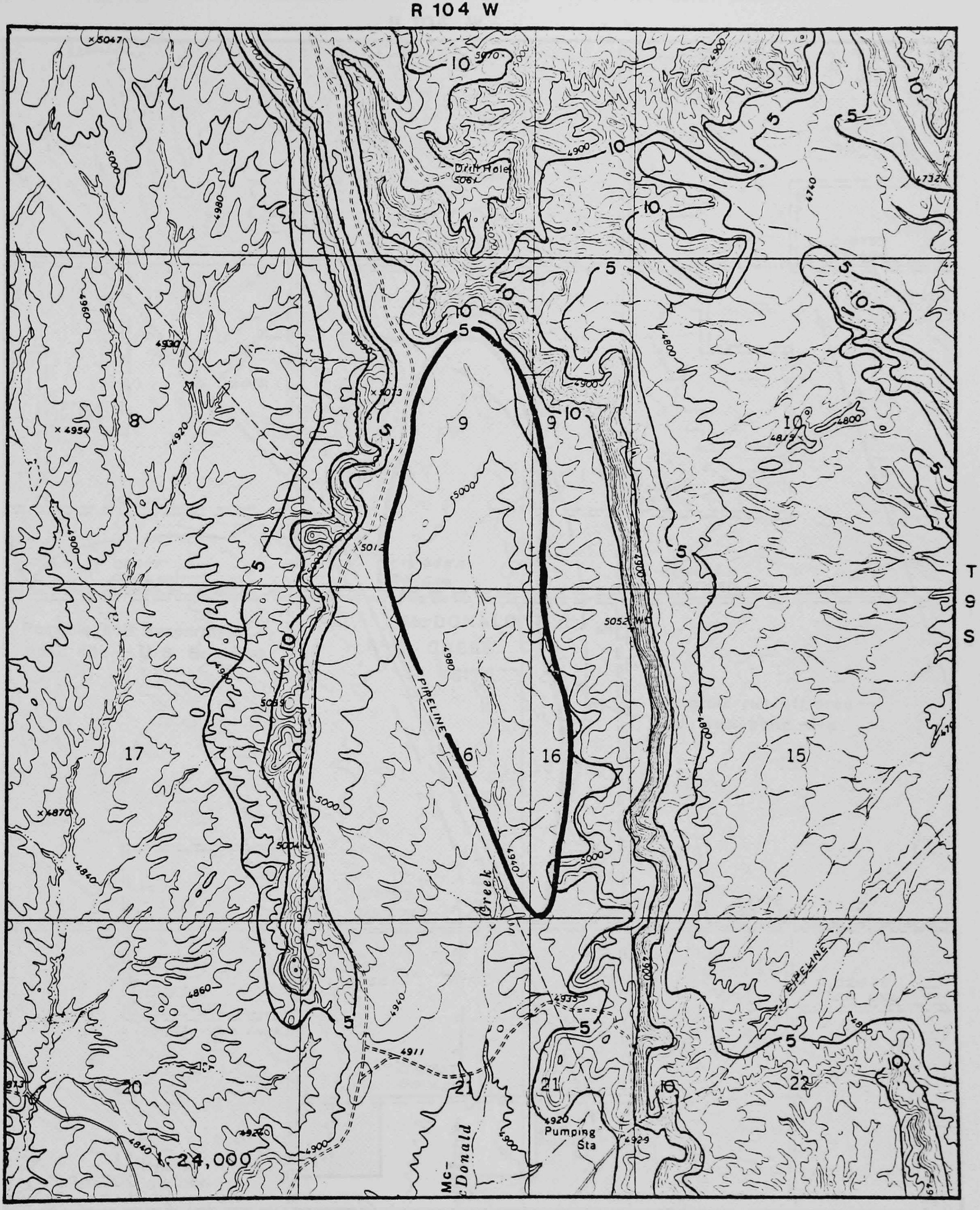


Figure 12. Suitable formation and slope map of the McDonald Creek site.

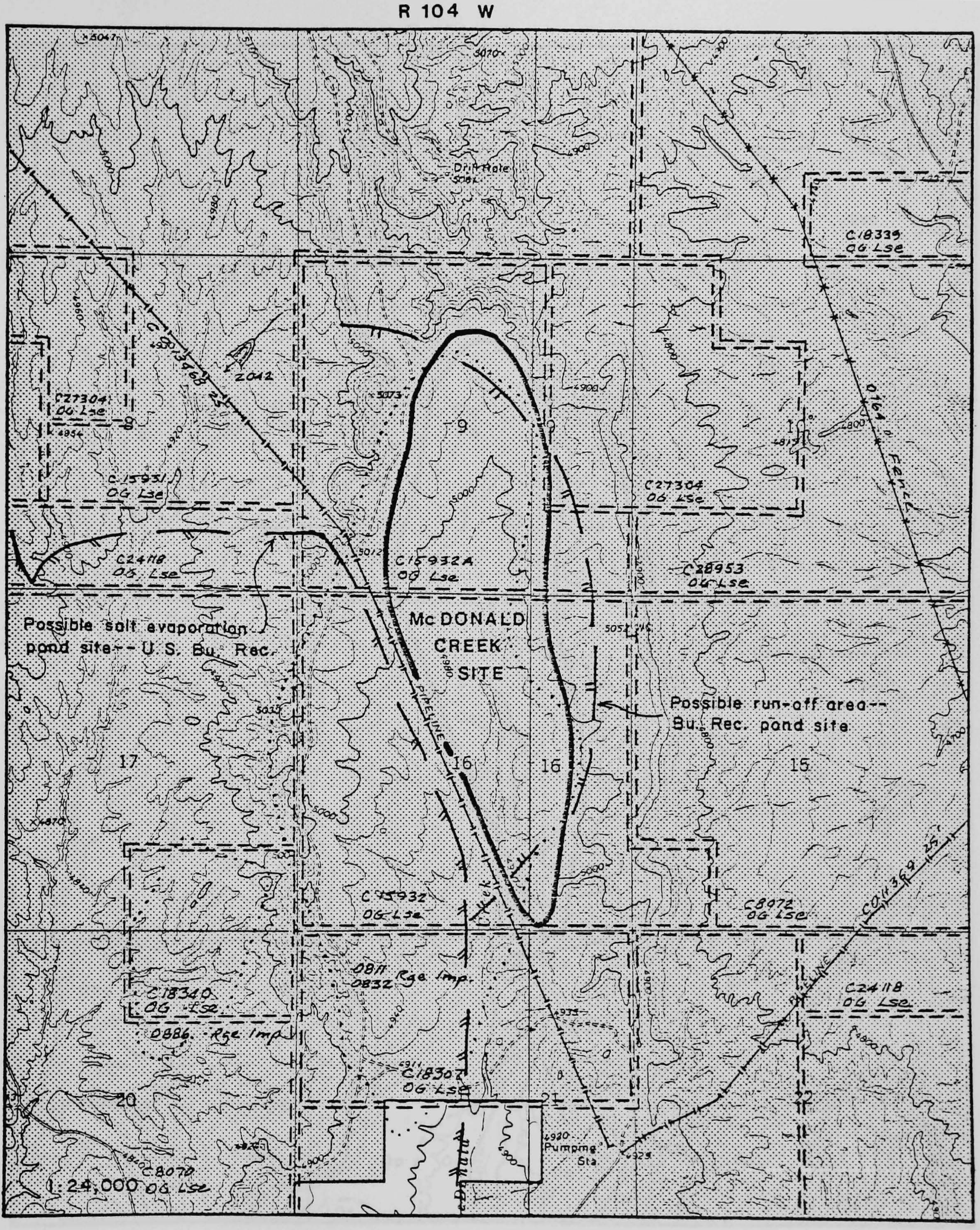


Figure 13. Land use and ownership map of the McDonald Creek site.

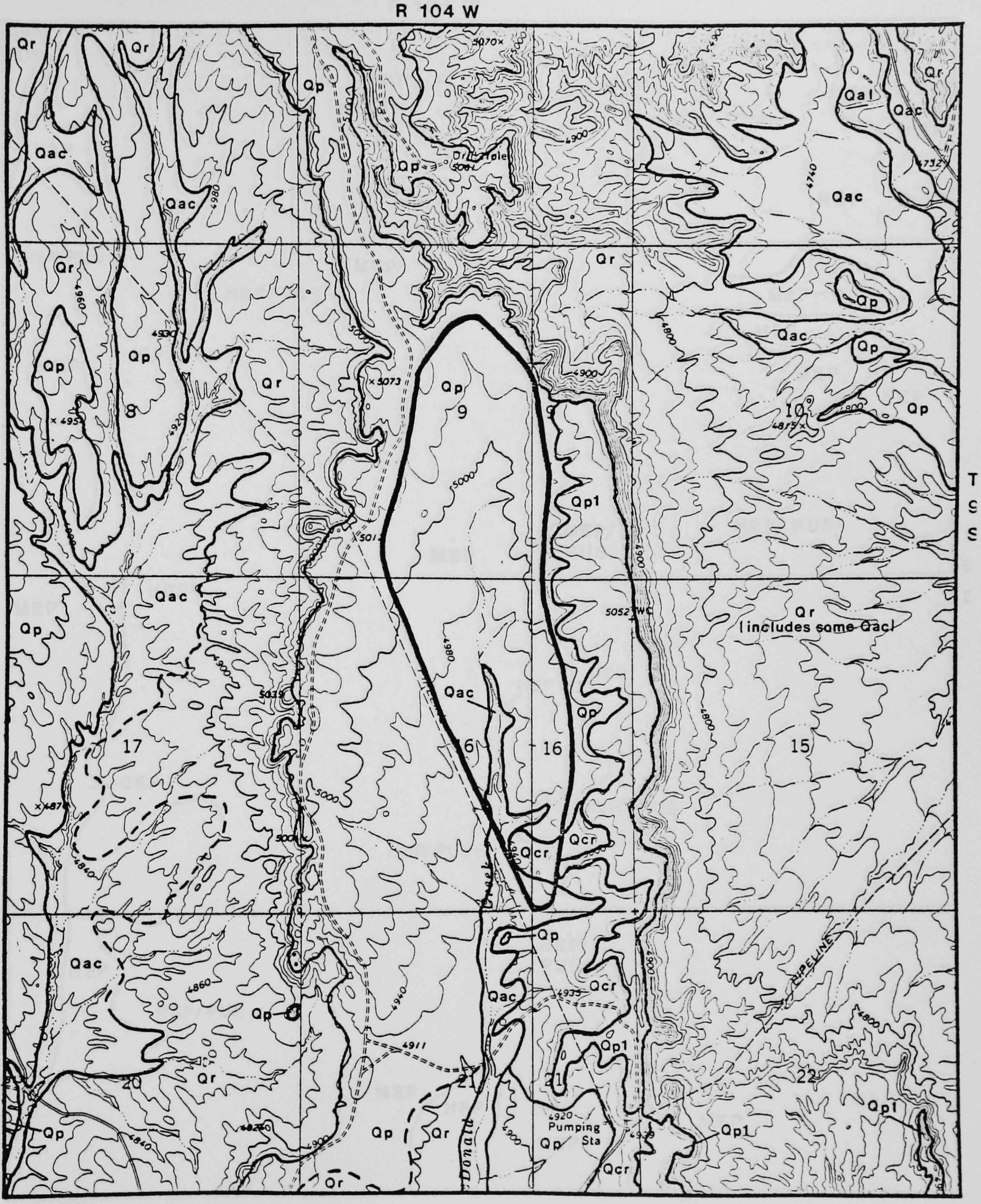


Figure 14. Surficial geologic map of the McDonald Creek site.

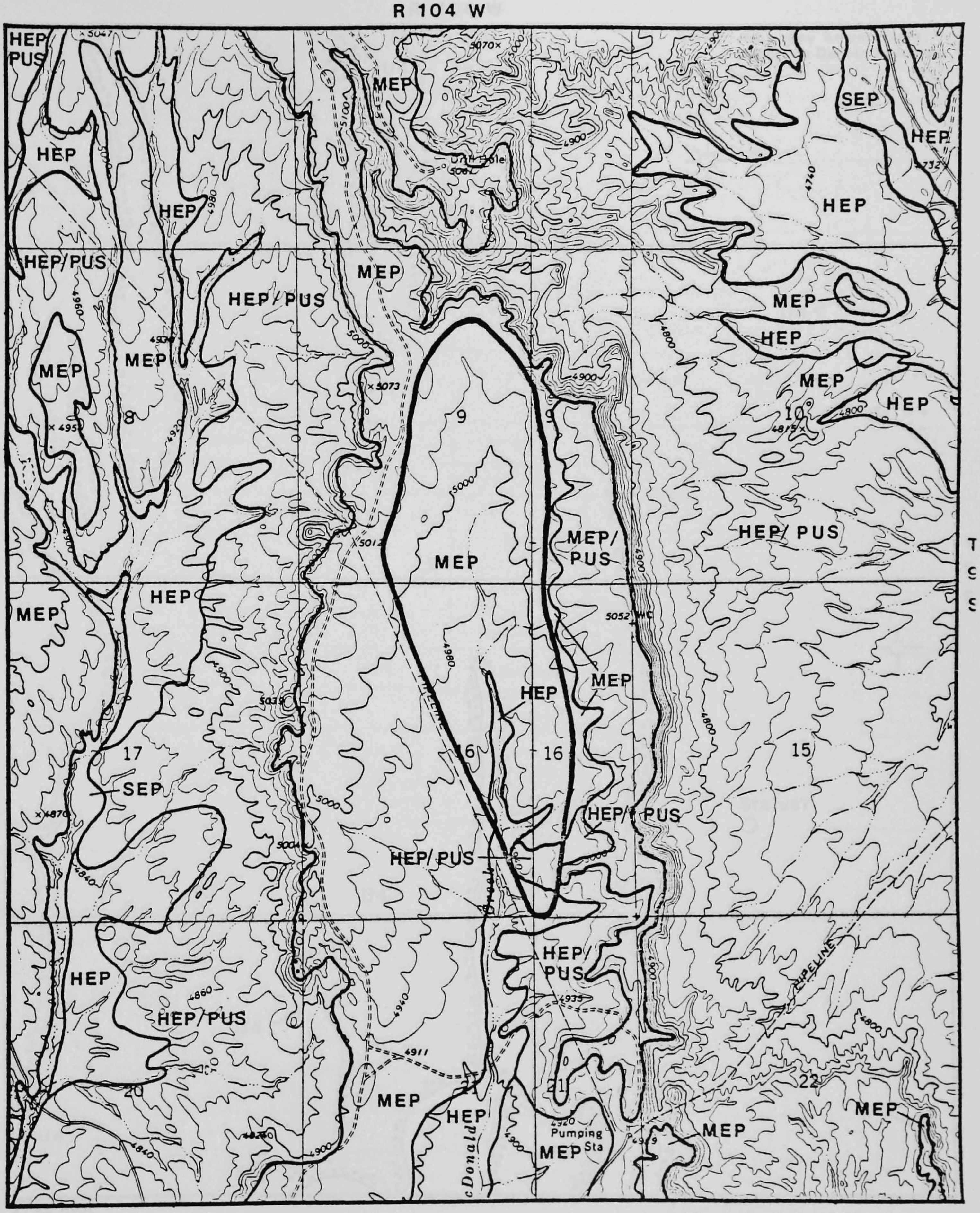


Figure 15. Geologic hazards map of the McDonald Creek site.

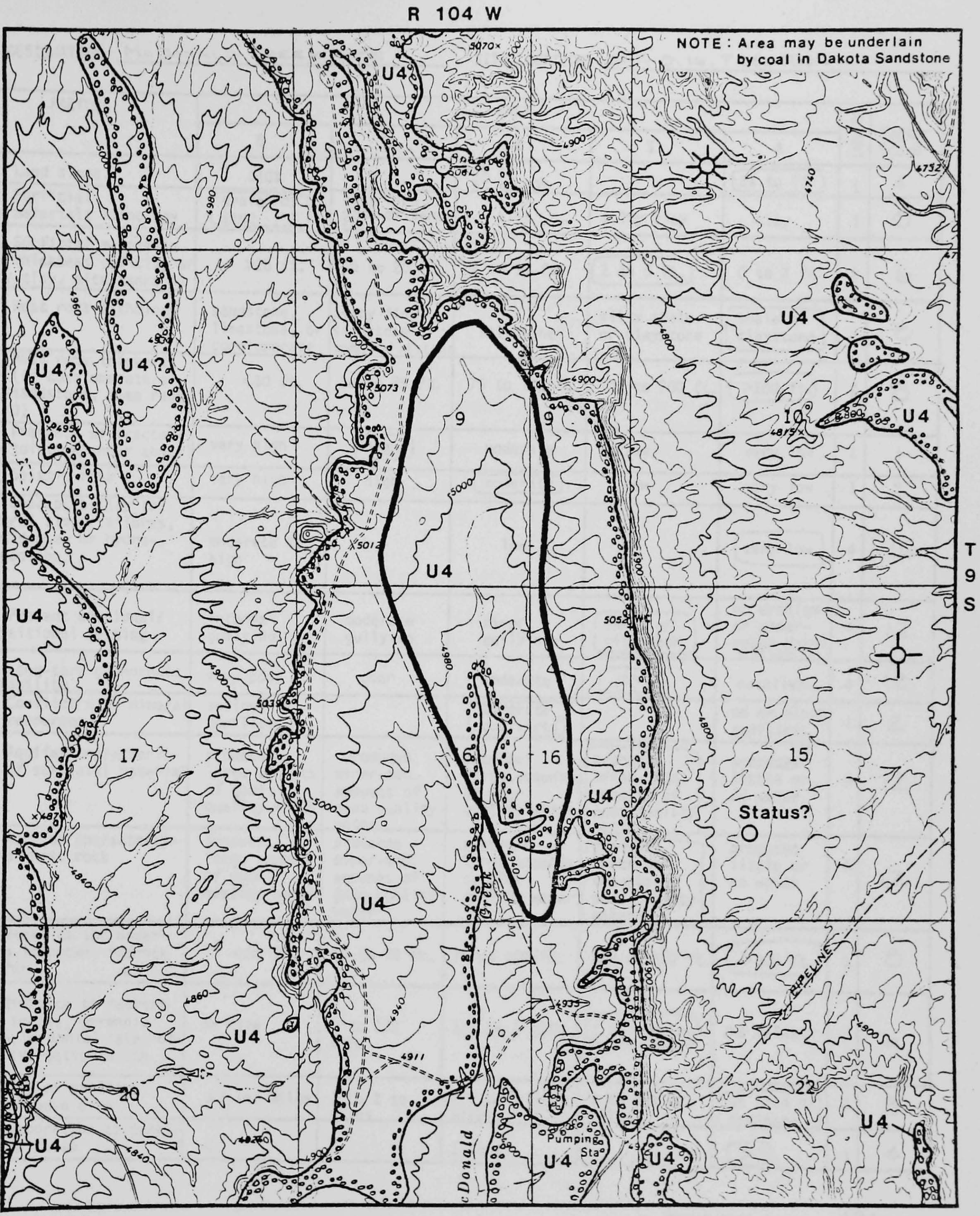


Figure 16. Mineral resources map of the McDonald Creek site.

SITE DESIGNATION: McDONALD CREEK SITE SITE LOCATION: SEC. 9, 16, T9S, R104W

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	[✓ gravel or sand]	very fine sand or sandy silt	silt	silty clay	clay	1	0
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	>20 ft.	10 to 20 ft.	5 to 10 ft.	[✓ 2 to 5 ft.]	0 to 2 ft.	2	6
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	[✓ shale or claystone]	2	8
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	[✓ high]	moderate	low	very low	1	1
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydro-compaction	moderate to high		low		[✓ very low]	4	16
9. Present erosional/ depositional setting	intense gullying	moderate gullying	minor gullying	[✓ sheet or rill wash]	no erosion or undergoing deposition	4	12
10. Long-term geomorphic stability	very poor	poor	moderate	[✓ good]	excellent	4	12
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	1/2 to 1 mile	[✓ 1 to 2 miles]	>2 miles	2	6
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	0 to 1/2 sq. miles	[✓ at head of drainage]	2	8
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 121

Figure 17. Geotechnical rating matrix for the McDonald Creek site.

4.3 6 & 50 RESERVOIR SITE

4.3.1. General Site Description

4.3.1.1. Location

The 6 & 50 Reservoir site is located in Grand Valley about 24 miles northwest of Grand Junction in Mesa County (Plate 1). It lies between former U.S. Highway 6 and 50 and Interstate 70 in sections 26, 34 and 35, T9S, R104W on the north flank of the Uncompahgre Plateau. The site is a little larger than 1/4 of a square mile in area (Figure 18).

4.3.1.2. Transportation Aspects

One feasible transportation route exists to the 6 & 50 Reservoir site, if we avoid the accident hazards of highway transportation in the Grand Junction area, and use rail transportation instead. The route would include rail transport from the piles to Siding One (see Figures 1 and 18) near Mack. Truck transport from there to the 6 & 50 Reservoir site would traverse 5.6 miles of paved highway and 0.5 miles of newly constructed road to the site.

The minimum cost of transportation would be $18.7 million from Grand Junction and $45.2 million from Rifle, not including costs of manipulating and covering the tailings on the disposal site. Additional maintenance cost might be incurred for the 5.6 miles of paved highway. Little traffic now uses this highway, which has been replaced by I-70.

4.3.1.3. Topographic Setting

The site is situated in a small basin on a southern side of a broad shallow topographic basin which drains toward 6 & 50 Reservoir about one mile to the northeast. Slopes do not exceed five percent anywhere within the site; however, immediately south of the site there are surfaces which exceed five percent slope (Figure 19). Total relief over the site area is about 120 feet.

4.3.1.4. Land Use and Ownership

Land use and ownership of the 6 & 50 Reservoir site is shown in Figure 20. The site is wholly on public lands administered by the Bureau of Land Management and is subject to existing oil and gas leases. The 6 & 50 Reservoir, which covers about 40 acres, is about one mile northeast of the site. Primary uses of the site are for grazing purposes and for small game and waterfowl hunting. Private land adjacent to the 6 & 50 Reservoir site in the S/2 of section 34 is owned by (018) Chris Jouflas, 319 Belaire, Grand Junction, CO 81501.

4.3.2. Geotechnical Evaluation

The geotechnical rating matrix for the 6 & 50 Reservoir site is shown in Figure 24. The site received a score of 109 and ranks 7th based on the evaluated geotechnical parameters.

4.3.2.1. Geology

Approximately 100 to 400 ft of shale in the Mancos Shale underlies the 6 & 50 Reservoir site, based on nearby hydrocarbon test holes and regional structure. Shale thickness increases from south to north across the site. A subtle hogback south of the site is formed by the Ferron Sandstone member of the Mancos Shale. Structurally, the site lies on the northeast flank of an anticline that extends northward into Grand Valley from the Uncompahgre Uplift. Good bedrock exposures are not present on the site, therefore the bedrock dip, thought to be between 4° and 10° was calculated from the structure contour map of Cashion (1973).

As shown in Figure 21, the 6 & 50 Reservoir site is in a shallow basin on the northeast side of the Uncompahgre Plateau. The basin is filled with mixed alluvium and colluvium interbedded with occasional thin debris flow deposits. Dominant lithologies of the basin fill, as are exposed in gully walls on site, are silty clays and clayey silts interbedded with silty, clayey, and sandy small pebble gravels and fine to very fine sands. The gravel clasts are principally composed of sandstone. Maximum thickness of the basin fill deposits on site is unknown because there are no bedrock exposures in the gullies on site. Maximum thickness is estimated at 10 to 20 ft, but is probably variable across the site. In exposed gully walls along the main creek just north of the site, fill thickness ranges from about 7 ft to over 14 ft. The southeast side of the site is underlain by residuum. This material consists of weathered Mancos Shale, is primarily silty clay, and is probably no more than a few feet thick.

No known faults underlie or are near the 6 & 50 Reservoir site. Minor faults do occur in a similar structural setting to the west along the State line, but none has been mapped in the site area by previous workers (Cashion, 1973), and none were identified during this investigation.

Soils on the 6 & 50 Reservoir site are Entisols of the subgroup Typic Torriorthents. These soils are shallow and clayey.

The 6 & 50 Reservoir site appears to primarily be an area of deposition, with sediments being carried by slope wash, gravity, and debris flows onto the site from the south. Several small gullies or washes are present on the 6 & 50 Reservoir site, but these appear to be the result of headward erosion. Most are very shallow, having depths of only 2 to 3 ft. Two gullies are up to 6 ft deep on the site and reach depths of 8 to 9 ft near their junction with the main creek just north of the site. This main creek has cut through up to 14 ft of the basin fill. Erosion potential in the alluvial-colluvial deposits and residuum on site is mapped as high (Figure 22). A severe erosion potential exists along the main creek just north of the site. Potentially unstable slopes may exist in the area of residuum on the east side of the site. Oversteepening of slopes in this area should be avoided during excavation work.

The long-term geomorphic stability of the site is rated as moderate. Future gullying may occur on site in the fine-grained alluvium and colluvium. The main creek could possibly migrate southward and threaten the north end of the site with severe erosion. A relatively small (about 7/8 sq. mile) drainage basin exists above the site. Intense rainstorms in this area may trigger small debris flows that would deposit sediments on the site in the future. This could be detrimental during placement of the tailings, but would probably be beneficial over the long-term by placing additional cover material over the repository.

Some potential for oil and/or gas exists beneath the site. The only petroleum test hole drilled in the vicinity of the 6 & 50 Reservoir site was the Tres Oil # 1 well located just southeast of the site (Figure 23). This hole was dry and later plugged and abandoned. Thin coal beds in the Dakota Sandstone may underlie the site, but because of their thinness and depth, they are probably not of any economic significance.

Potential sources of riprap are not present on site. Pediment gravels a mile or two to the west and northwest may be suitable riprap sources, but it may be necessary to quarry riprap from the sandstones that outcrop south of the site. Other potential sources of riprap include Colorado River gravels or basaltic pediment gravels along the west side of Grand Mesa, both of which would have to be trucked a considerable distance to the site.

4.3.2.2. Hydrology

Several small ephemeral streams flow across the 6 & 50 Reservoir site. These washes drain a combined total area of about 7/8 sq. mile above the site. Minor flooding or debris flow activity could occur on these washes during intense rainfalls. The small ephemeral washes on site drain into an unnamed, somewhat larger, but still ephemeral creek just north of the site. This slightly larger creek flows into 6 & 50 Reservoir about 0.7 miles downstream of the site. 6 & 50 Reservoir may occasionally dry up, but the adjoining area remains a wetland year around and is important to waterfowl and other wildlife. The unnamed creek joins West Salt Creek slightly over 2 miles below the site.

Surficial deposits on the 6 & 50 Reservoir site may carry minor amounts of water seasonally. Precipitation in the site area and in the small drainage basin above the site may infiltrate into the soil and move northward through the basin-filling alluvium and colluvium. Local perched water zones may occur beneath the site at the bedrock-surficial contact or within fractured zones in the bedrock. The Mancos Shale, host rock for the 6 & 50 Reservoir site, generally contains only minor amounts of poor quality water found in fractured zones (Boettcher, 1972; Lohman, 1965). The first underlying potentially significant aquifer is the Dakota Sandstone, some 200 to 500 ft below the surface. Water in this formation is often brackish or contaminated by hydrocarbons. There are no decreed springs or registered water wells on or near the 6 & 50 Reservoir site, according to the records of the Colorado Division of Water Resources.

4.3.3. Environmental Factors

Vegetation on the 6 & 50 Reservoir site is saltbush desert. A prostrate shadscale is the major shrub, with much bare ground between the bushes, and with greasewood in the draws. Annual herbaceous plants are quite abundant. Galleta grass, Indian grass, and broom snakeweed are found occasionally. The nearby 6 & 50 Reservoir and its surrounding marshland, 0.7 miles from the site, is used by waterfowl, Mourning Doves, and the common hawks of the area, the Red-tailed and Rough-legged Hawks. The adjacent area is a favorite cottontail hunting site.

There are no documented archaeologic or historic resources within the 6 & 50 Reservoir site according to the records of the Colorado Historical Society.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

──→	Existing Surfaced Road
— →	Gravel Surfacing Required
– – → –	Road Construction & Gravel Surfacing Required
┼┼┼┼┼┼┼	Railroad Siding
⋯⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▧	Area Underlain by Unsuitable Formation
▭	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

├─┼─┼─┤ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•—•—•— —	Transmission Line (with BLM Ref. No.)
·–·–·–	Telephone Line
→ →	Irrigation Ditch (with BLM Ref. No.)
→	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium,Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⌀	Abandoned Location (never drilled, permit expired)
●	Oil Well
⊕	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
☼	Plugged Gas Well
⊕	Plugged Dry Hole
⁘	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
⚒	Gravel Pit (may be abandoned)
▧	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

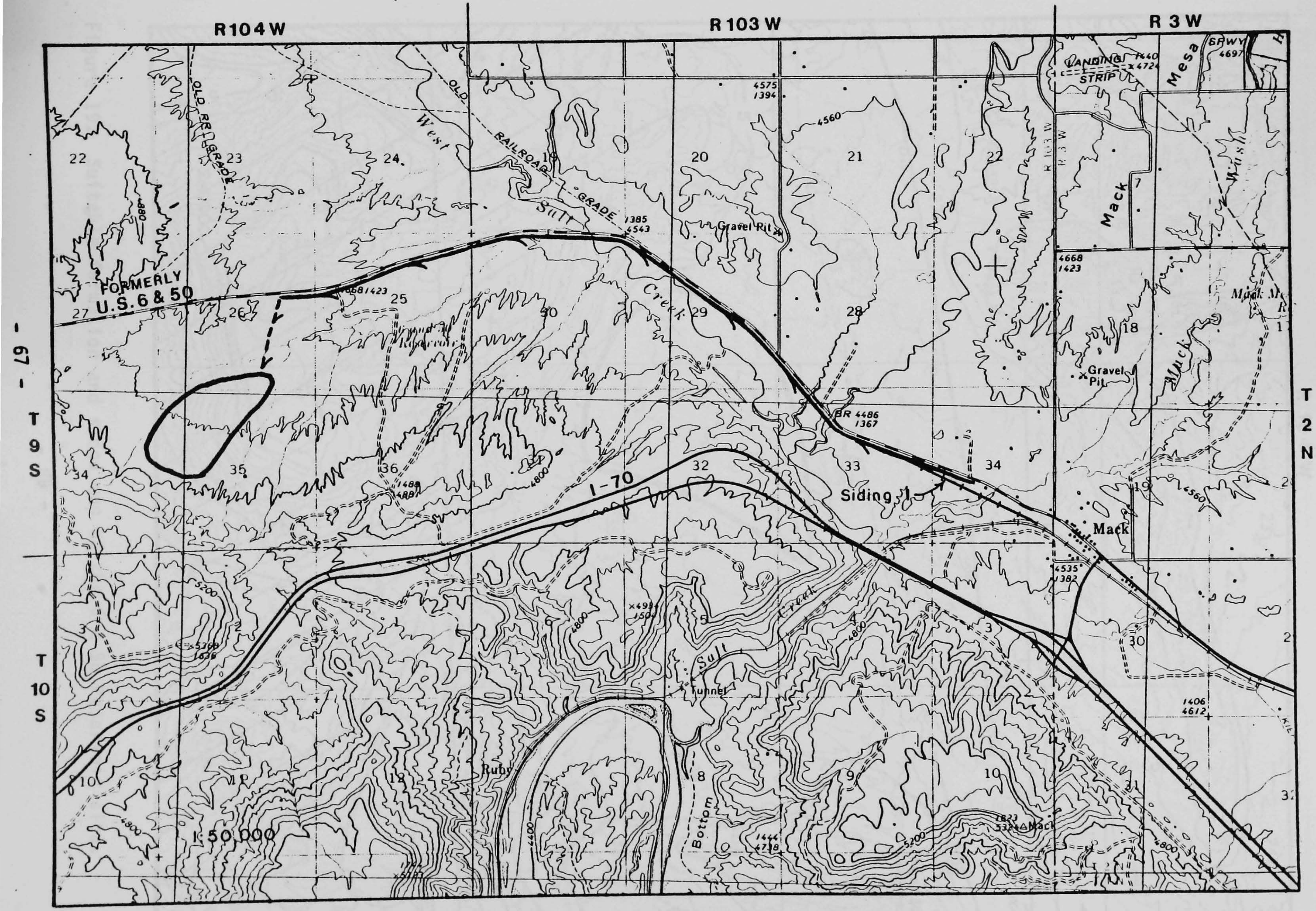


Figure 18. Possible transportation route to the 6 & 50 Reservoir site.

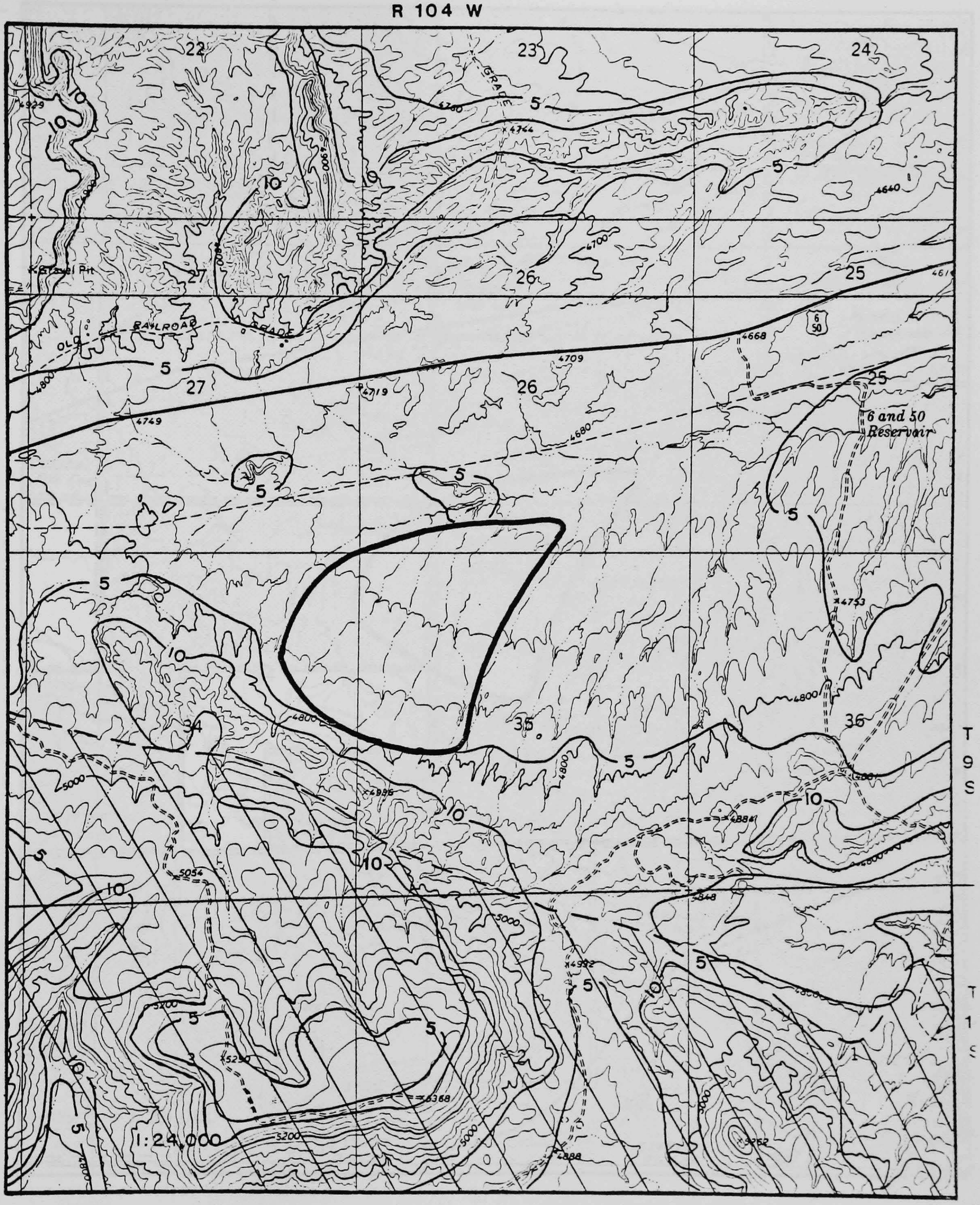


Figure 19. Suitable formation and slope map of the 6 & 50 Reservoir site.

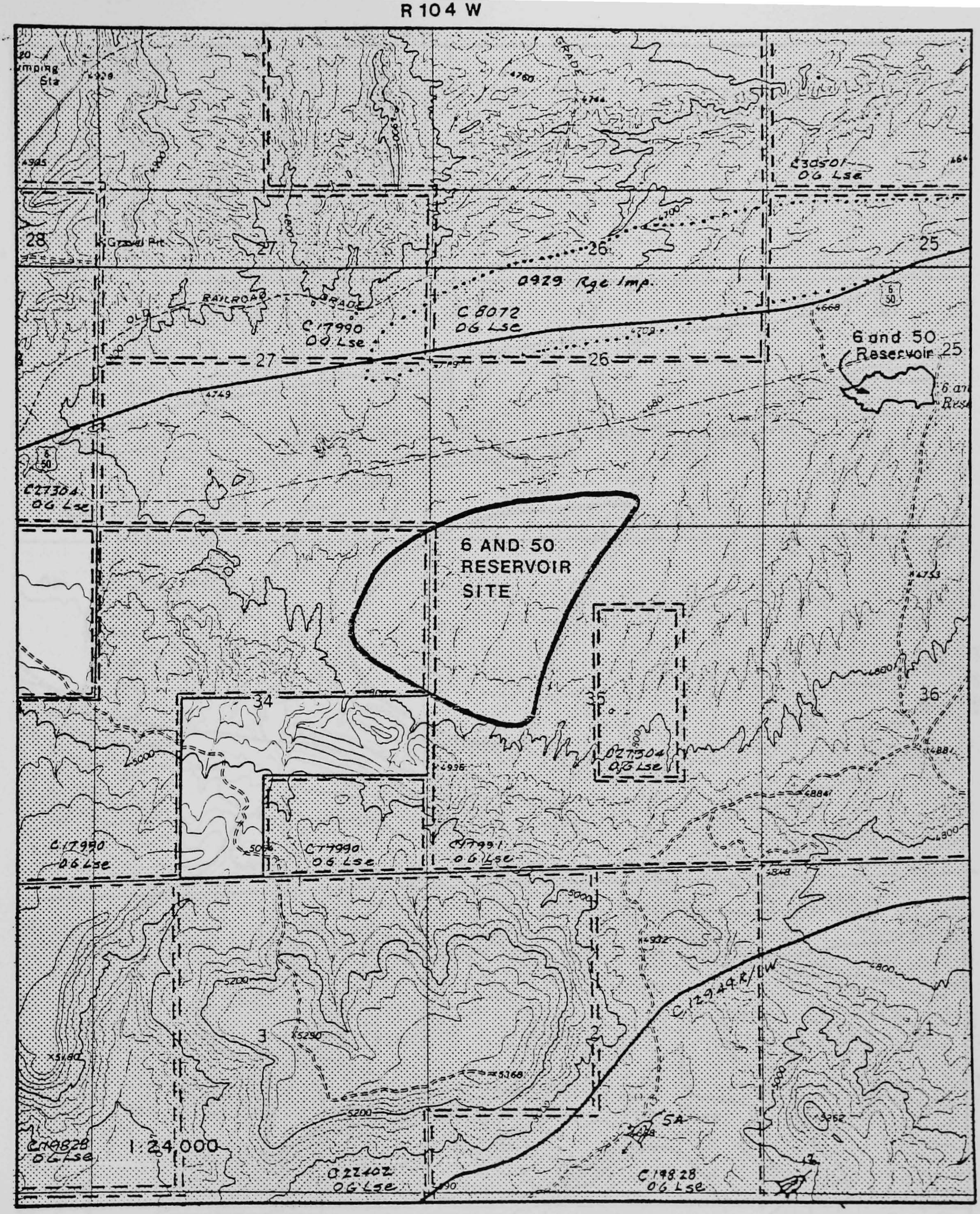


Figure 20. Land use and ownership map of the 6 & 50 Reservoir site.

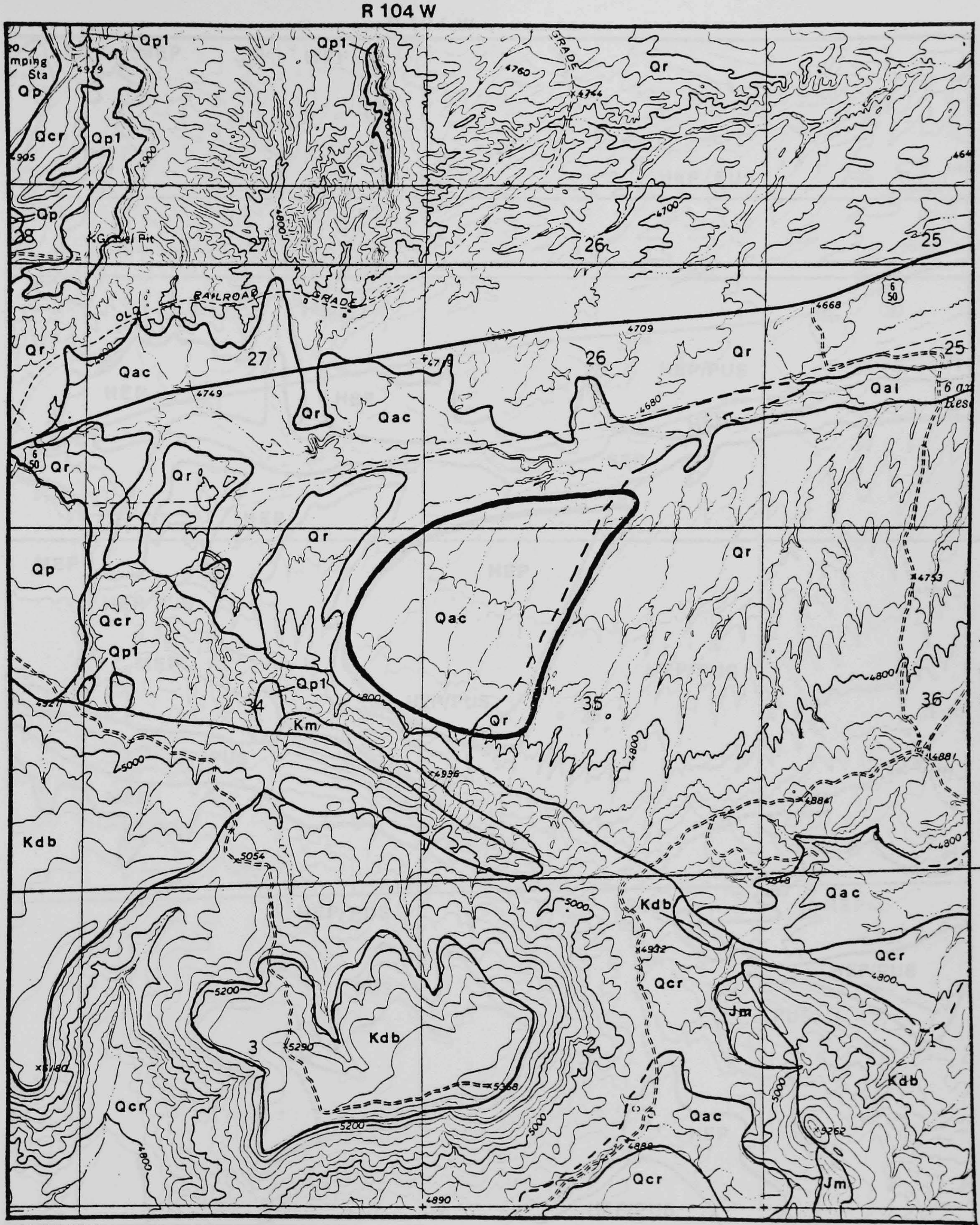


Figure 21. Surficial geologic map of the 6 & 50 Reservoir site.

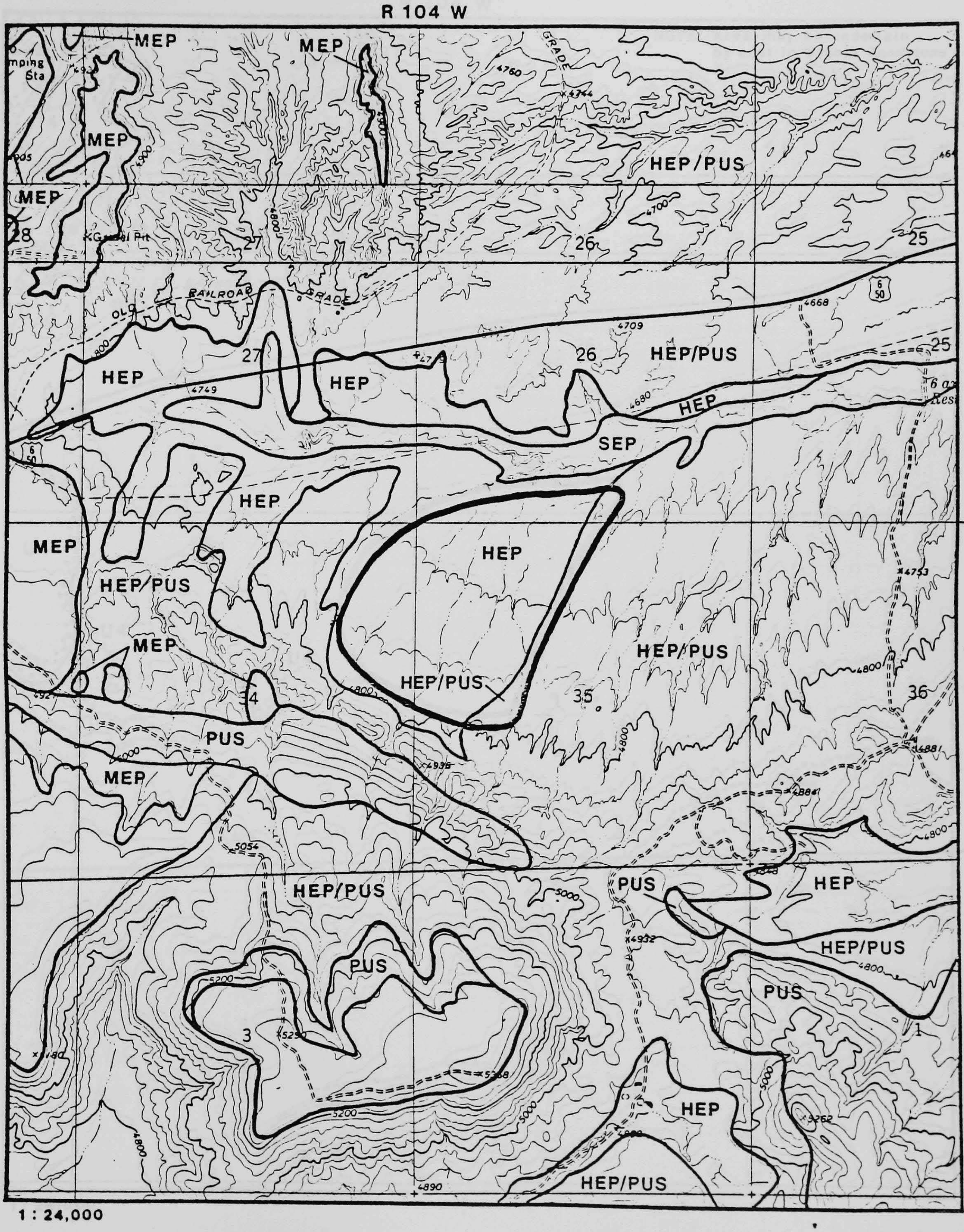


Figure 22. Geologic hazards map of the 6 & 50 Reservoir site.

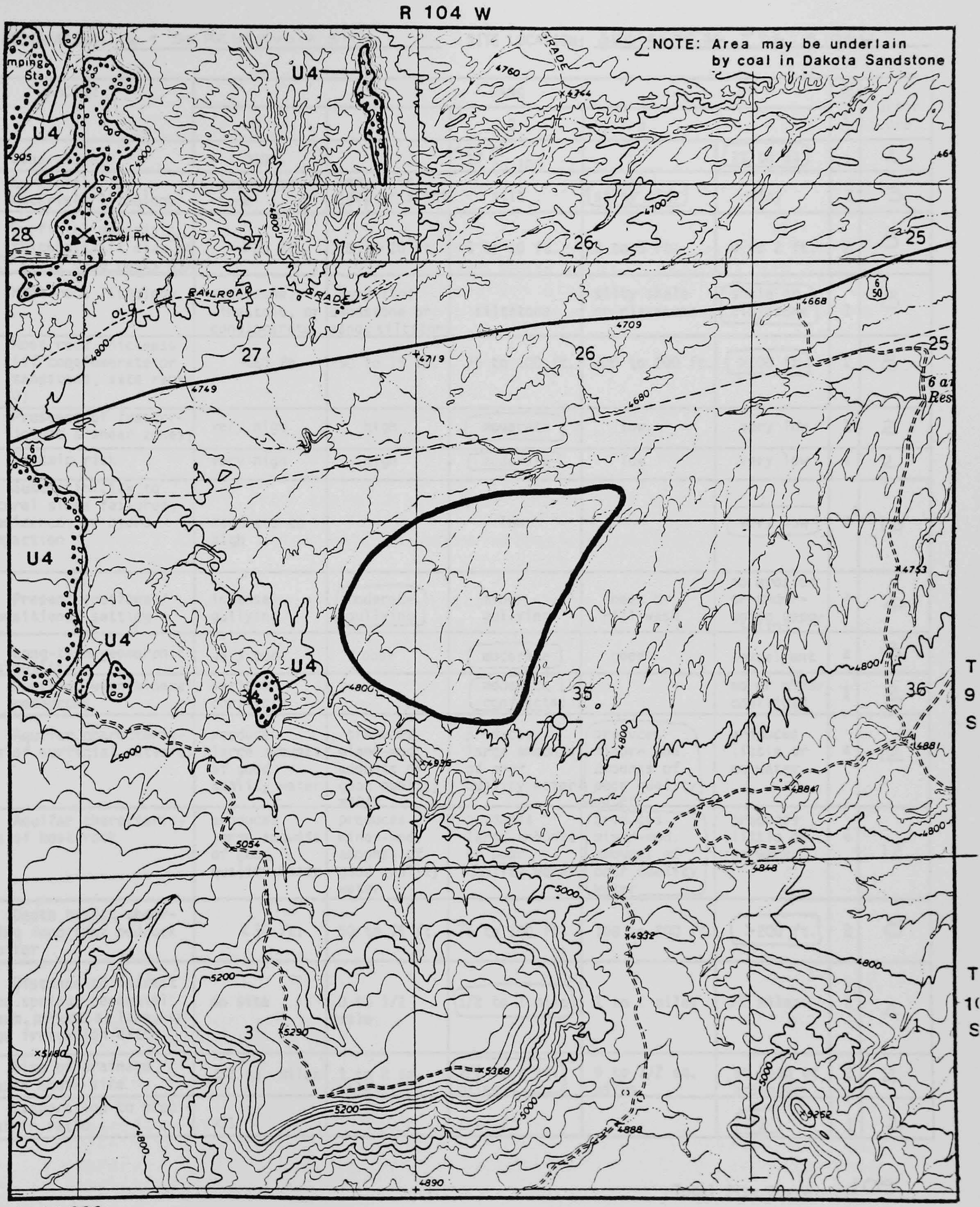


Figure 23. Mineral resources map of the 6 & 50 Reservoir site.

SITE DESIGNATION: 6 & 50 RESERVOIR SITE SITE LOCATION: SEC. 26,35,34, T9S, R104W

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	[✓ silty clay]	clay	1	3
3. Surficial materials thickness [✓ (if clay or silty clay, site ranks 4)]	>20 ft.	10 to 20 ft.	5 to 10 ft.	2 to 5 ft.	0 to 2 ft.	2	8
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	[✓ shale or claystone]	2	8
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	high	[✓ moderate]	low	very low	1	2
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low		[✓ very low]	4	16
9. Present erosional/depositional setting	intense gullying	[✓ moderate gullying]	minor gullying	sheet or rill wash	no erosion or undergoing deposition	4	4
10. Long-term geomorphic stability	very poor	poor	[✓ moderate]	good	excellent	4	8
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts or poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	[✓ 1/2 to 1 mile]	1 to 2 miles	>2 miles	2	4
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	[✓ 1/2 to 1 sq. miles]	0 to 1/2 sq. miles	at head of drainage	2	4
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 109

Figure 24. Geotechnical rating matrix for the 6 & 50 Reservoir site.

4.4 CAMP GULCH SITE

4.4.1. General Site Description

4.4.1.1. Location

The Camp Gulch site is located in Grand Valley about 25 miles northwest of Grand Junction, two miles south of the Mesa-Garfield county line, and 2 and 1/2 miles west of Colorado Highway 139 (Figure 25). The site covers almost 3/4 of a square mile in an elongate shape in sections 21, 22, 27 and 28, T8S, R103W.

4.4.1.2. Transportation Aspects

If we assume that rail transportation out of the Grand Junction area is essential to avoid the accident hazards of highway travel, only one feasible transportation route exists. This route would include rail haulage from the piles to Siding Two (See Figures 1 and 25) near Loma. Truck transport from there to the Camp Gulch site would traverse 10.6 miles of paved highway (Colo-139) and 4.0 miles of primitive road (Mitchell Road), which would require extensive construction and gravel surfacing.

The minimum cost of transportation would be $20.3 million from Grand Junction and $46.8 million from Rifle, not including costs of manipulating and covering the tailings on the disposal site.

The route would pass through the populated Loma area and along Colorado Highway 139, with a 1980 traffic volume of 789 vehicles per day.

4.4.1.3. Topographic Setting

The site lies in two small basins which drain to the southeast on slopes less than five percent (Figure 26). To the west and southwest is a disected drainage which has slopes greater than five percent. To the northeast small mesas rise above the site and represent remnants of an older pediment surface. Total relief in the area is about 180 feet.

4.4.1.4. Land Use and Ownership

Land use and ownership of the Camp Gulch site is shown in Figure 27. The site is wholly on public lands administered by the Bureau of Land Management. These lands are subject to existing oil and gas leases. A buried pipeline and secondary County roads border parts of the site. Primary use of the site is for grazing purposes.

The Bureau of Reclamation identified a site which is immediately north of the Camp Gulch site for possible long-term storage of salt in connection with the Glenwood-Dotsero Springs unit of the Colorado River Water Quality Improvement Program. This site is presently not the preferred alternative and, thus, probably will not be used in this desalinization program.

Colorado-Ute Electric Association has recently made application to the Bureau of Land Managment to purchase about 3,000 acres north of Mack and west of the Douglas Pass road (Colo. Highway 139). The proposed sale area covers almost all of the Camp Gulch site. The Colorado-Ute site would be used for the purpose of constructing a coal-fired electrical generation plant. Mr. Jerry Walker with Colorado-Ute stated that generating facilities are proposed for the Camp Gulch site. The Colorado-Ute plan includes eventual construction of a rail line from a coal mine in the Book Cliffs area to the plant site and eventually south to Mack to connect with the D&RGW line. Such a rail line might be utilized for transport of uranium tailings, if constructed at an appropriate time.

4.4.2. Geotechnical Evaluation

The geotechnical rating matrix for the Camp Gulch site is given in Figure 31. The site received a score of 120 and ranks third based on the evaluated geotechnical parameters.

4.4.2.1. Geology

Approximately 2,300 to 2,800 ft of Mancos Shale underlie the Camp Gulch site, based on nearby petroleum holes and structure contour mapping by Cashion (1973). Shale thickness increases from south to north across the site. Structurally, the site lies on the northwest flank of the Highline Canal anticline. Bedrock in the area probably dips generally northeast at 1^{o} to 3^{o}. Several northeast-trending faults lie west of and extend towards the site. These faults and associated folds may slightly increase the complexity of the structural setting of the Camp Gulch site.

As illustrated in Figure 28, the Camp Gulch site lies at the head of two small adjacent basins just off of Camp Gulch, and is underlain almost entirely by alluvium and colluvium. There are no exposures of the basin fill on the site, but based on other nearby similar basins, it is probably a silty clay that occasionally is slightly gravelly. Maximum thickness of the fill is unknown, but is estimated at 8 to 12 ft. A very small part of the site is underlain by residual weathered bedrock. This material is probably no more than a few feet thick and consists of silty clay.

Soils on the Camp Gulch site are mapped as loamy Aridisols of the subgroup Ustollic Haplargids.

Sheet wash and rill wash are the principal types of erosion presently occurring on the Camp Gulch site. No active gullies exist on site. Moderate gullying is associated with the unnamed ephemeral creek directly northeast of the site. Although current erosion on the site is low, the entire site is judged to have a high potential for future erosion because of the presence of the fine-grained, easily eroded deposits that blanket the area (Figure 29). Artificially oversteepened slopes in the area may be potentially unstable, particularly so for the mapped area of residuum. The long-term geomorphic stability of the Camp Gulch site is ranked only as moderate because of the high erosion potential. Properly engineered riprap structures, however, can reduce the likelihood of erosion breaching the repository.

Camp Gulch site lies just north of the Highline Canal gas field, which coincides with an anticline similarly named. A number of petroleum wells have been drilled near the Camp Gulch site, but none on it. Hence, the oil and gas potential beneath the site is unknown. Most wells in the immediate area were dry and plugged, but about one-half mile northeast of the site is a shut-in gas well (Figure 30). Coal in the Dakota Sandstone may underlie the site. This is not considered an economically important resource because it probably occurs in thin beds that are over 2,000 ft deep beneath the site.

Potential riprap sources do not exist on the Camp Gulch site. Nearby pediment gravels within one mile of the site may contain suitable riprap, but the gravel clasts found in these deposits are primarily sandstone and shale. Other potential sources of riprap may include quarried sandstone from the Book Cliffs a few miles north of the site, Colorado River gravel, or basaltic pediment gravel west of Grand Mesa. The latter two sources would require considerable truck haulage to reach the site.

4.4.2.2. Hydrology

The Camp Gulch site lies at the head of two small adjacent basins. The upper basin drains into the unnamed ephemeral creek just off site, and this unnamed creek joins Camp Gulch about one mile below this point. Camp Gulch flows into East Salt Creek about one mile from this junction. East Salt Creek is the nearest important surface water to the site. It is just under one mile from the site in a direct line. The lower basin that forms part of the Camp Gulch site drains directly into East Salt Creek about one and one-half miles downstream from the lower site boundary. In that the site is at the head of both small basins, there is almost no potential for flooding along drainages on the site. The unnamed creek which borders the northeast side of the site, however, drains a somewhat larger area. Flooding along this creek might affect the adjacent site area.

Surficial deposits on the Camp Gulch site probably carry minor amounts of water seasonally. Precipitation could infiltrate into the surficial deposits and move down gradient towards the unnamed creek and East Salt Creek. Local perched water zones may occur at the bedrock-surficial contact or in fractured zones in the bedrock beneath the site. Mancos Shale, host rock for the site, generally carries only minor amounts of poor quality water in fractures (Boettcher, 1972; Lohman, 1965). The first underlying potentially important aquifer is the Dakota Sandstone, some 2,300 to 2,800 ft below the surface. Water within this formation is probably saline and may be contaminated by hydrocarbons.

According to the Colorado Division of Water Resources' records there are no registered water wells or decreed springs near the Camp Gulch site.

4.4.3. Environmental Factors

Vegetation on the Camp Gulch site is desert grassland. The dominant species is cheatgrass, with galleta grass, some rabbitbrush and shadscale interspersed in patches. The surrounding rims, one-fourth mile north, contain pinyon-juniper stands. Salt cedar and cottonwood are found in nearby stream bottoms. The area is quite barren and is poor grazing land.

The site is a food-hunting area for Golden Eagles, Red-tailed Hawks, Rough-legged Hawks, and other raptors which feed on the typical small mammals and birds of desert grassland. The desert cottontail is the only commonly-hunted species present on the site. Pronghorn antelope have been introduced in the region, but have declined and are now uncommon.

There are no documented archaeologic or historic resources within the Camp Gulch site according to the records of the Colorado Historical Society.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

——→	Existing Surfaced Road
— →	Gravel Surfacing Required
– – → –	Road Construction & Gravel Surfacing Required
++++++	Railroad Siding
⋯⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▨	Area Underlain by Unsuitable Formation
▭	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

├─┼─┤ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•—•—•—	Transmission Line (with BLM Ref. No.)
·—·—·	Telephone Line
→→	Irrigation Ditch (with BLM Ref. No.)
→⊃	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium,Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⊘	Abandoned Location (never drilled, permit expired)
●	Oil Well
⊕	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
☼	Plugged Gas Well
⊕	Plugged Dry Hole
⁘	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
⚒	Gravel Pit (may be abandoned)
▨	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

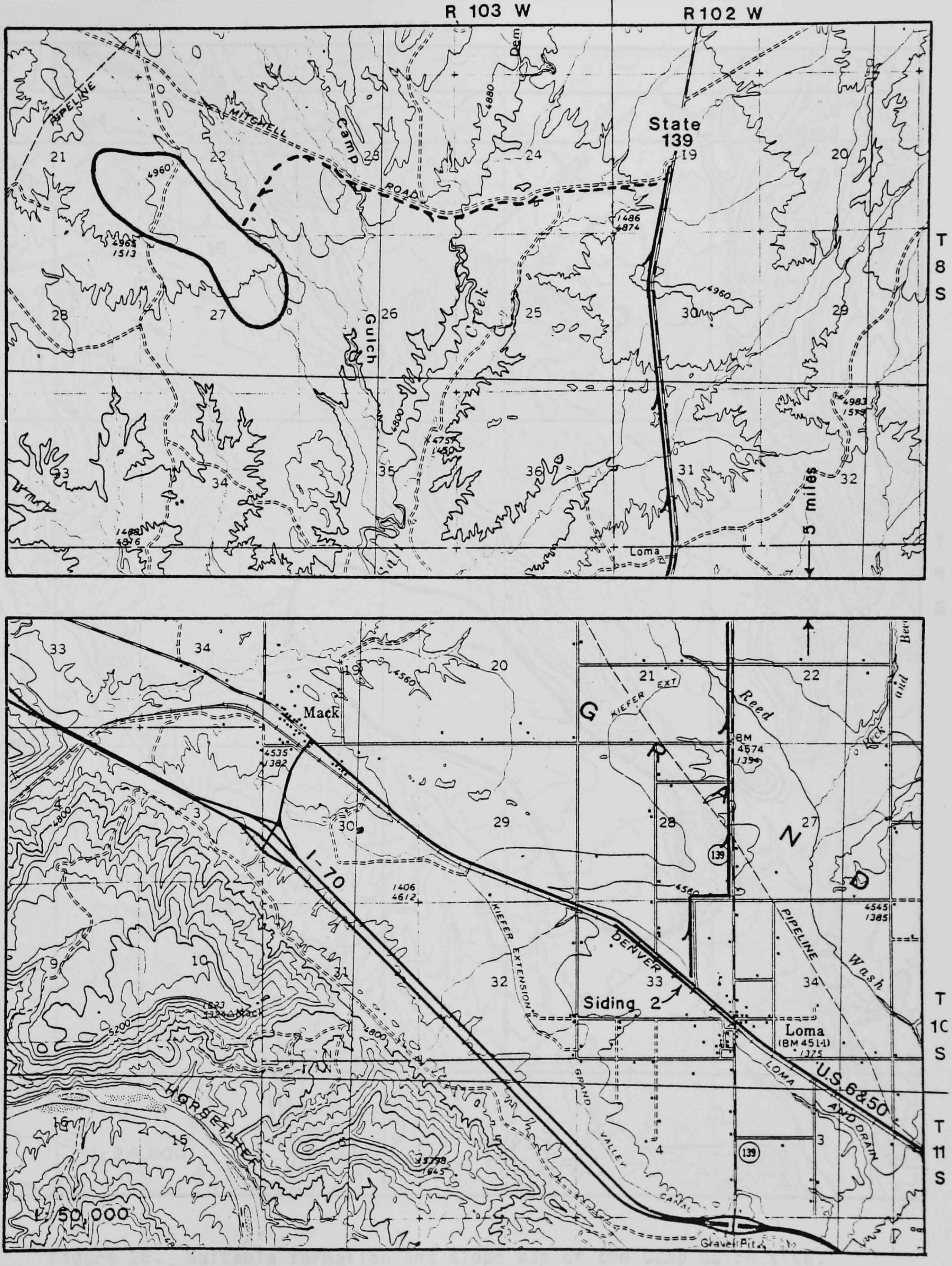


Figure 25. Possible transportation route to the Camp Gulch site.

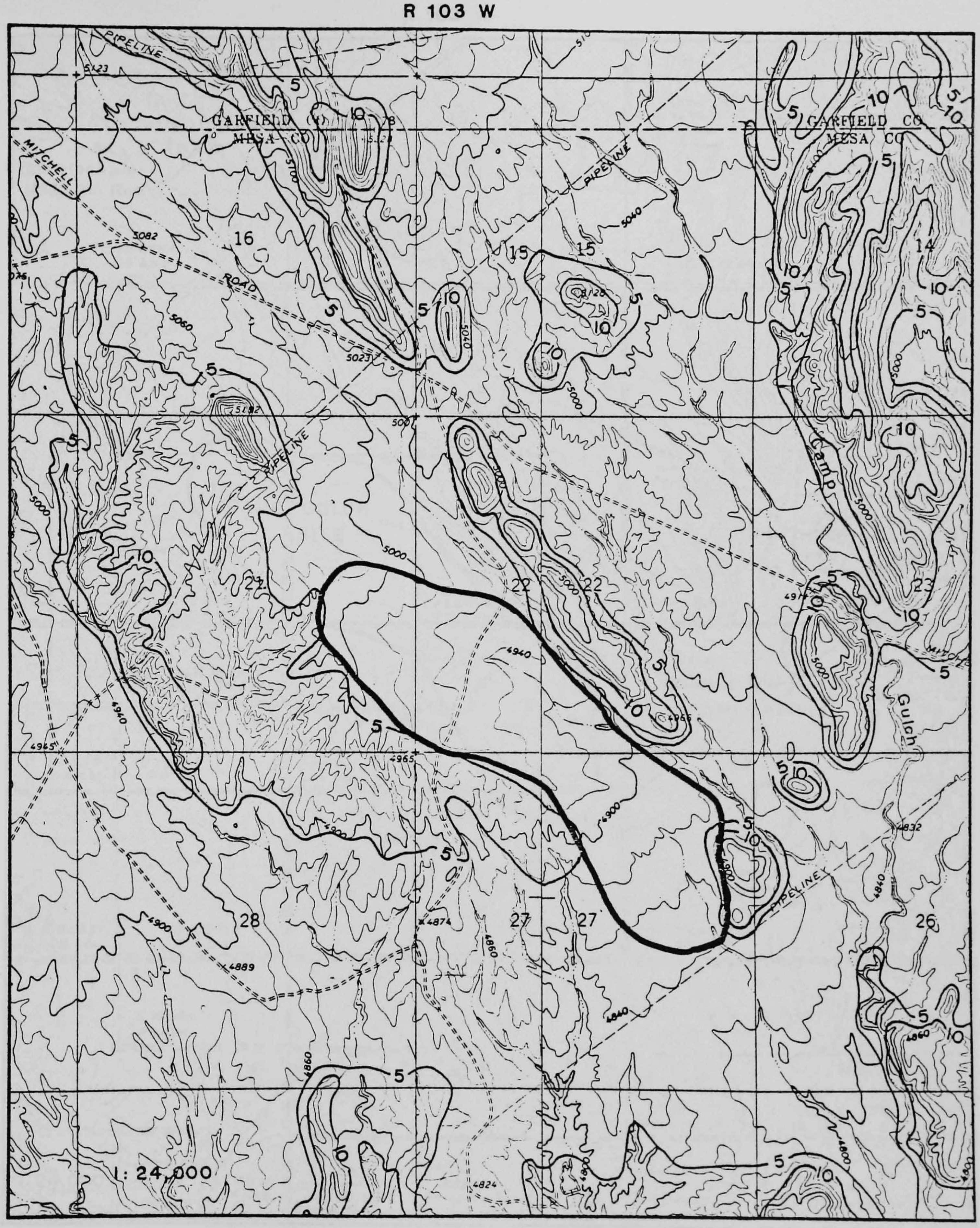


Figure 26. Suitable formation and slope map of the Camp Gulch site.

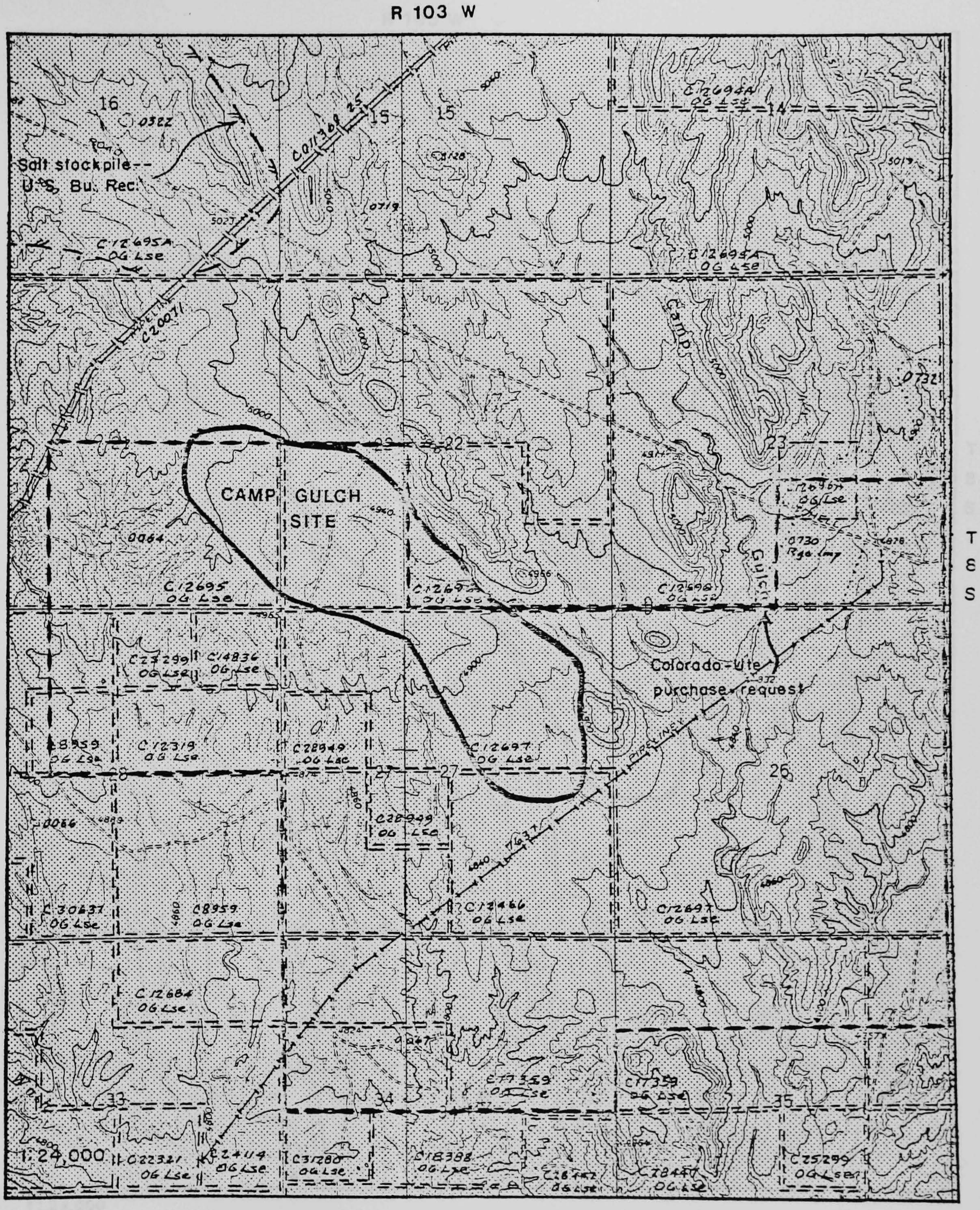


Figure 27. Land use and ownership map of the Camp Gulch site.

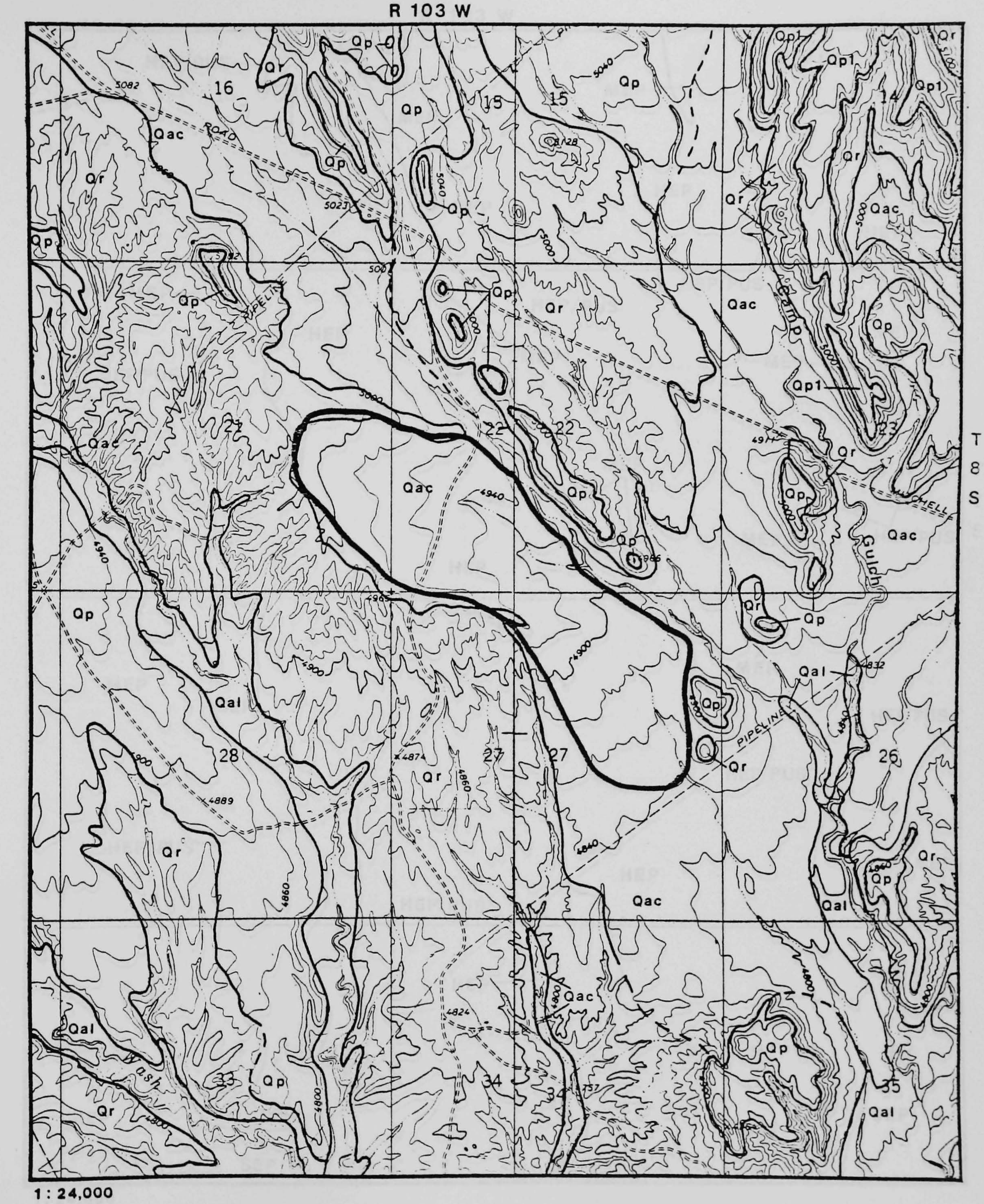


Figure 28. Surficial geologic map of the Camp Gulch site.

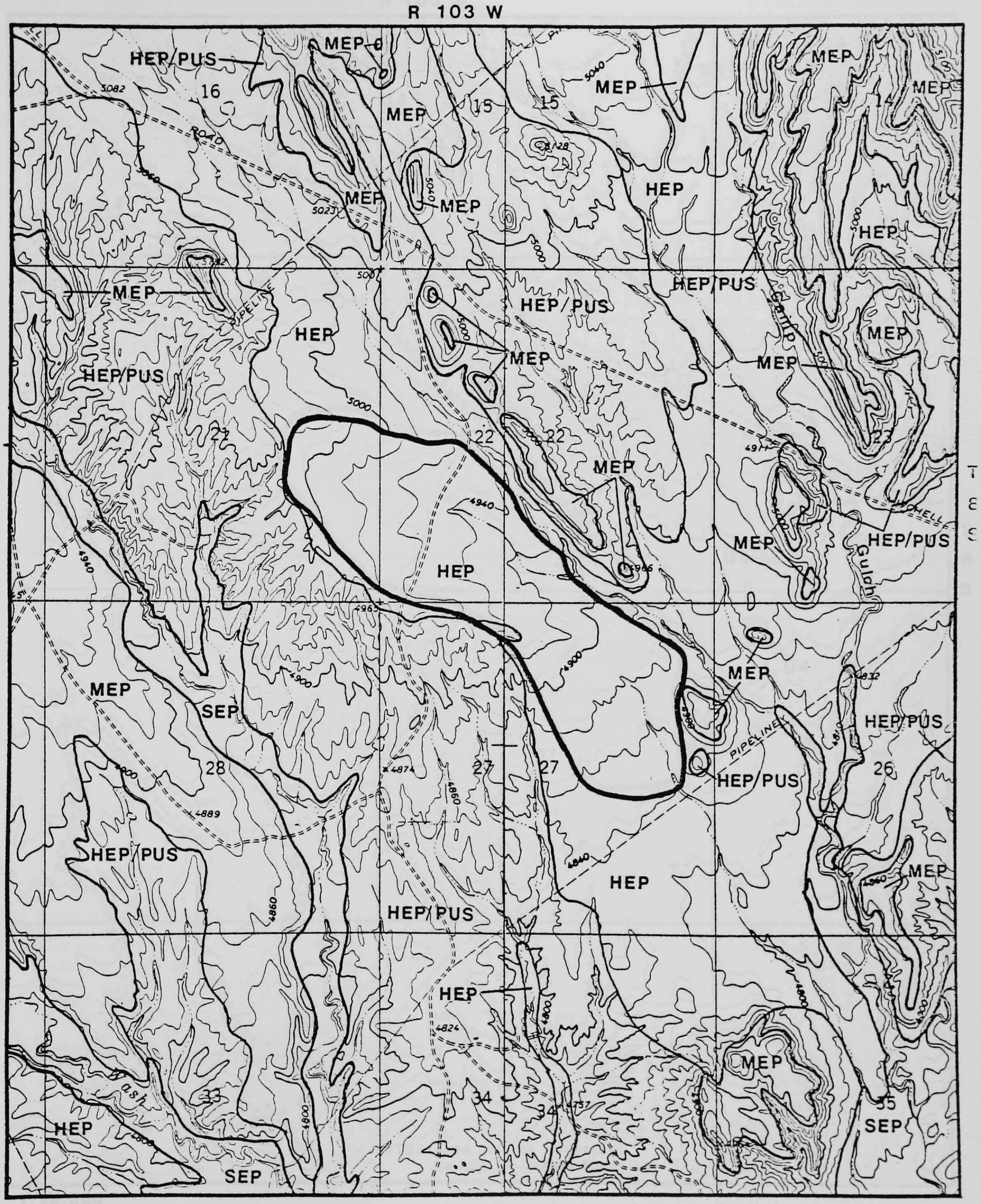


Figure 29. Geologic hazards map of the Camp Gulch site.

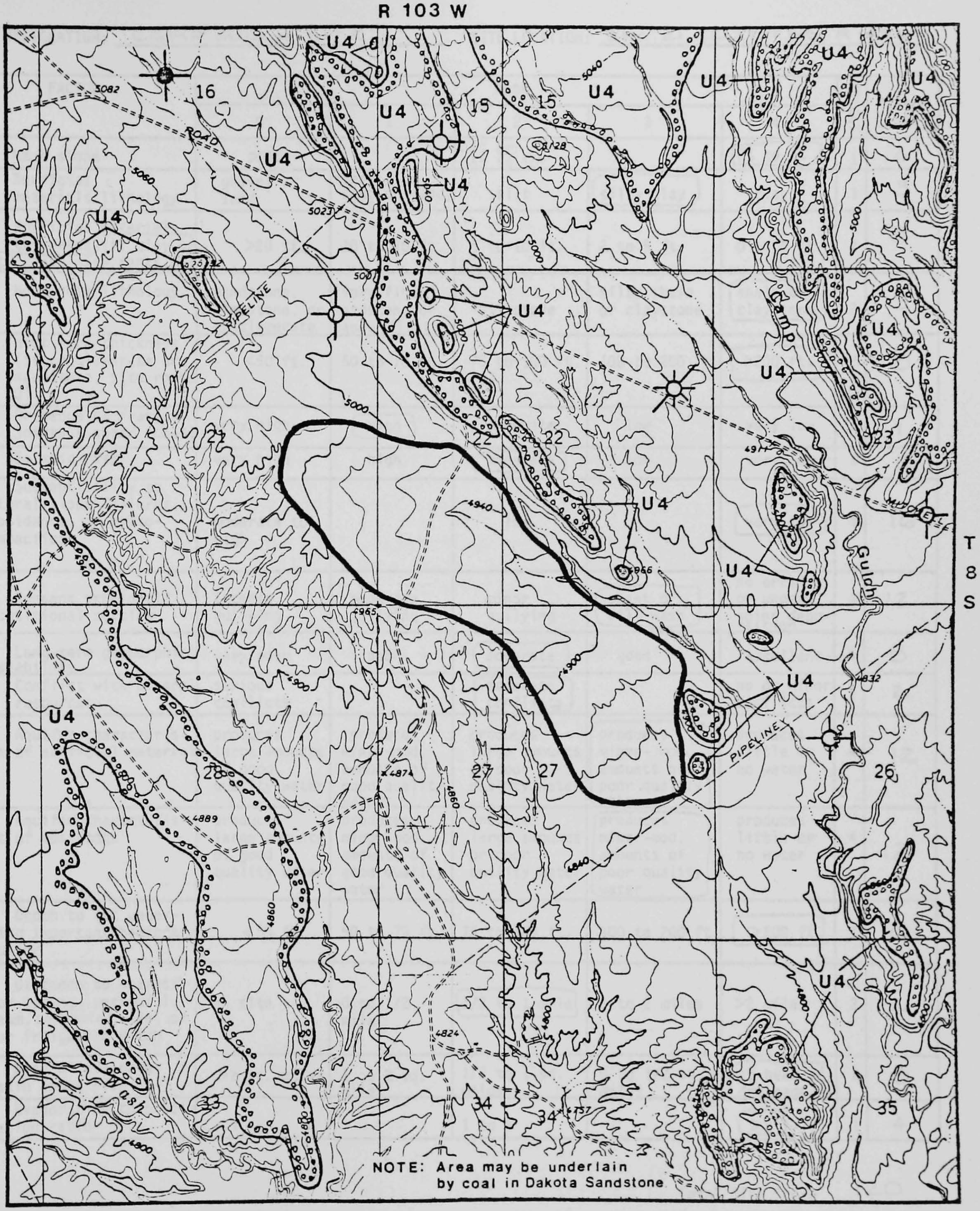


Figure 30. Mineral resources map of the Camp Gulch site.

SITE DESIGNATION: CAMP GULCH SITE SITE LOCATION: SEC. 21, 22, 27, T8S, R103W

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	[✓ silty clay]	clay	1	3
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	>20 ft.	10 to 20 ft.	5 to 10 ft.	2 to 5 ft.	0 to 2 ft.	2	8
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	[✓ shale or claystone]	2	8
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	[✓ high]	moderate	low	very low	1	1
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low		[✓ very low]	4	16
9. Present erosional/depositional setting	intense gullying	moderate gullying	minor gullying	[✓ sheet or rill wash]	no erosion or ongoing deposition	4	12
10. Long-term geomorphic stability	very poor	poor	[✓ moderate]	good	excellent	4	8
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	[✓ produces minor- mod. amounts of poor quality water]	produces little or no water	4	12
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts or poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	[✓ 1/2 to 1 mile]	1 to 2 miles	>2 miles	2	4
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	0 to 1/2 sq. miles	[✓ at head of drainage]	2	8
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 120

Figure 31. Geotechnical rating matrix for the Camp Gulch site.

4.5. EAST SALT CREEK SITE

4.5.1. General Site Description

4.5.1.1. Location

East Salt Creek site is located in Grand Valley about 24 air miles northwest of Grand Junction in parts of sections 7, 8, 17 and 18, T8S, R102W (Figure 32). The site lies immediately east of the Douglas Pass road and straddles the Mesa-Garfield County line.

4.5.1.2. Transportation Aspects

Only one feasible transportation route exists to the East Salt Creek site, if we assume that rail transportation out of the Grand Junction area is necessary to avoid the accident hazards of highway transportation of tailings. This route would involve rail transport from the piles to Siding Two (see Figures 1 and 32) near Loma. Truck transport from there to the East Salt Creek site would traverse 9.9 miles of paved highway (Colo-139), with no additional construction needed.

The minimum cost of transportation would be $17.6 million from Grand Junction and $44.3 million from Rifle, not including costs of manipulating and covering the tailings on the disposal site.

The route would pass through the populated Loma area and along Colorado Highway 139, which had a 1980 traffic volume of 789 vehicles per day.

As part of their proposed power plant, the Colorado-Ute Electric Association is planning to construct a railroad which would leave the Rio Grande Railroad main line near Mack and extent northward past the East Salt Creek site, only one mile away. Although this would extend the haul distance to this site, the all-rail route would offer an alternative transportation system which might cost only somewhat more than the proposed rail-truck system, because of the savings in loading and unloading costs.

4.5.1.3. Topographic Setting

East Salt Creek site lies on a gentle southwest sloping gravel-capped pediment surface (Figure 33). The surface is drained by several ephemeral streams which have cut 4 to 15 ft deep arroyos in places. Just north of the site is a small drainage basin separated from the site by a 60 ft high escarpment with slopes greater than 10 percent. This basin is topographically lower than the pediment surface. The pediment surface continues to the south and east of the site boundary, but is dissected more by gullying. Maximum relief across the site is about 190 feet.

4.5.1.4. Land Use and Ownership

Land use and ownership of the East Salt Creek site is shown on Figure 34. The site is wholly on public lands administered by the Bureau of Land Management that are subject to existing oil and gas leases. Range improvements including a small reservoir in the SW/4 SE/4 section 8, and furrowing and reseeding were noted on the site. Primary use of the site is for grazing purposes.

4.5.2. Geotechnical Evaluation

The geotechnical rating matrix for the East Salt Creek site is given in Figure 38. The site received a score of 117 and ranks fourth based on the evaluated geotechnical parameters.

4.5.2.1. Geology

Approximately 3,000 ft of Mancos Shale underlies the East Salt Creek site. The site lies on the southwest flank of the Garmesa anticline, a northwest-trending structure within Grand Valley. The southern end of the site is near the axis of an unnamed syncline between the Garmesa and Highline Canal anticlines. There are no bedrock exposures on site, but based on the structure contour mapping of Cashion, it appears that bedrock beneath the site dips southwestward at less than 3^o. No faults are known to exist in the immediate area (Cashion, 1973; Schwochow, 1978).

East Salt Creek site is situated on a southwestward sloping pediment surface and is entirely underlain by a clayey, silty pebble gravel that caps the pediment surface. Maximum thickness of the pediment gravel was not observed on site, but estimates based on exposures to the north and south of the site suggest it is 3 to 6 ft thick. Gravel clasts are generally in the small to large pebble size range but occasionally are as large as 1 to 2 ft in diameter. Angular and subangular sandstone clasts are the predominant lithology found in the gravel, but chert, shale, and other types of sedimentary clasts are also present.

Soils on the East Salt Creek site are described as loamy Aridisols of the Ustollic Haplargid sub-group.

Sheet wash and rill wash are the principal types of erosion presently active on the site. Minor gullying is occurring along one small drainage on site. Deep gullying (15 to 18 ft deep) is present along a drainage just southeast of the site. Erosion is also actively working on the exposed flank of the pediment surface north and northwest of the site. The erosion potential of the site is classified as moderate because of the presence of the pediment gravel and the type of erosion currently active on the site (Figure 36). Surrounding areas, however, are subject to a higher erosion potential. A severe erosion potential exists along East Salt Creek. Erosion-induced retreat of the cliff just north of the site will migrate towards the site in the future. The rate of retreat of this cliff will need to be considered when designing the final layout of the repository if this site is chosen. The deep gullying on the southeast side of the site and the moderate gullying to the southwest may advance toward the site by sideward erosion, headward erosion, or drainage capture. Protective riprap may be needed to assure long-term protection of this site.

East Salt Creek site lies on the southwest edge of the Garmesa gas field. Producing gas wells exist within one-half mile northeast of the site (Figure 37). No wells have yet been drilled on the site. East Salt

Creek site probably has the highest potential for future gas production of any of the nine sites herein being considered. A well location has been permitted just west of the site, but as of July 8, 1982, it had not been drilled. The results of this test will provide additional data regarding the gas potential of the East Salt Creek site.

Coal in the Dakota Sandstone may underlie the East Salt Creek site. Dakota coals are usually thin, and at this location they are about 3,000 ft deep. For these reasons, the Dakota coal is not considered an important mineral resource.

Pediment gravels on the East Salt Creek site are probably not potential sources of suitable riprap, because clasts in the pediment gravel may not be of acceptable durability. Riprap may have to be hauled to this site from sandstone quarries in the Book Cliffs or along the Uncompahgre Plateau, from gravel pits along the Colorado River, or from gravel pits in basalt-rich pediments or terraces west of Grand Mesa.

4.5.2.2. Hydrology

East Salt Creek site lies on a pediment surface near the head of a drainage basin. A drainage area of approximately one-fourth square mile drains into the site. The potential for any significant flooding on site is low. The washes on this site empty either directly into East Salt Creek about 2 miles below the site or into other unnamed ephemeral washes about one-fourth mile below the site. The unnamed ephemeral washes drain into East Salt Creek 3 to 4 miles below the site. East Salt Creek is only 0.6 miles from the site along a direct line.

Surficial deposits on the East Salt Creek site probably contain very little or no water. Following periods of considerable precipitation, some water may infiltrate into the surficial deposits, but this will rapidly be lost to evaporation. Host rock for the East Salt Creek site, the Mancos Shale, generally carries minor amounts of poor quality water that is concentrated in fractured zones (Boettcher, 1972; Lohman, 1965). The first underlying potential aquifer is the Dakota Sandstone. Any water present in this formation beneath the site will likely be very saline and/or contaminated with hydrocarbons.

The Colorado Division of Water Resources' records indicate there are no registered water wells or decreed springs near the East Salt Creek site.

4.5.3. Environmental Factors

Vegetation on the East Salt Creek site is desert grassland. Cheatgrass is dominant, possibly related to heavy grazing. Some Indian ricegrass and galleta grass are also present. Patches of sagebrush still exist, but much of the sagebrush has been burned. Shadscale occurs mostly as isolated bushes. Small mammals, birds, and small predators typical of desert grassland may be found here. They would provide a food-hunting area for Golden Eagles, Red-tailed Hawks, and Rough-legged Hawks, primarily. Some desert cottontails probably could be found by hunters. Pronghorn antelope are uncommon or rare.

There are no documented archaeologic or historic resources within the East Salt Creek site according to the records of the Colorado Historical Society.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

——→	Existing Surfaced Road
— →	Gravel Surfacing Required
– – → –	Road Construction & Gravel Surfacing Required
+++++++	Railroad Siding
⋯⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▨	Area Underlain by Unsuitable Formation
☐	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

├─┤├─┤├─┤ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•—•—•—	Transmission Line (with BLM Ref. No.)
·-·-·-	Telephone Line
→ →	Irrigation Ditch (with BLM Ref. No.)
→	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium,Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⌀	Abandoned Location (never drilled, permit expired)
●	Oil Well
-●-	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
-☼-	Plugged Gas Well
-○-	Plugged Dry Hole
⁘	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
⚒	Gravel Pit (may be abandoned)
▨	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

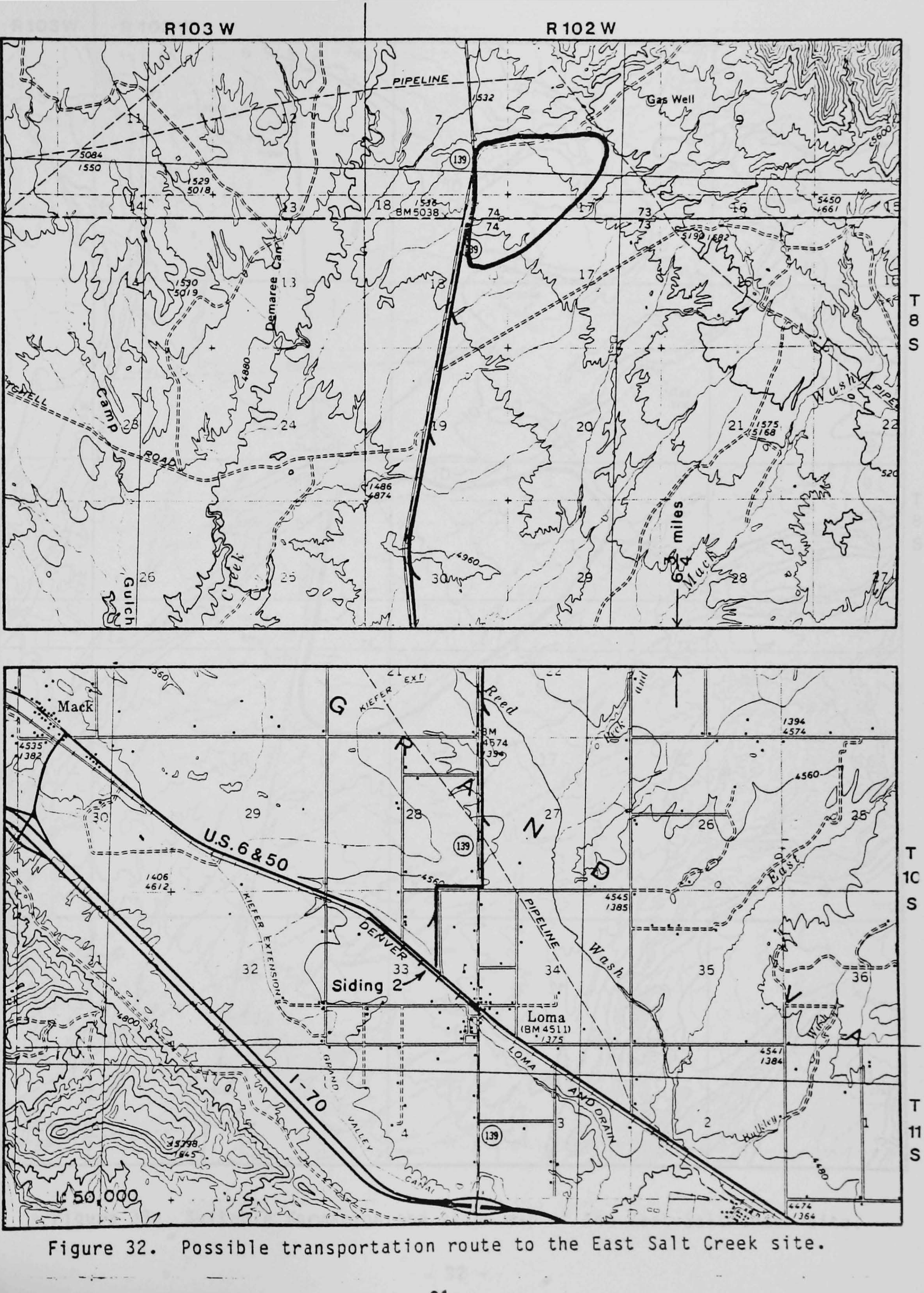


Figure 32. Possible transportation route to the East Salt Creek site.

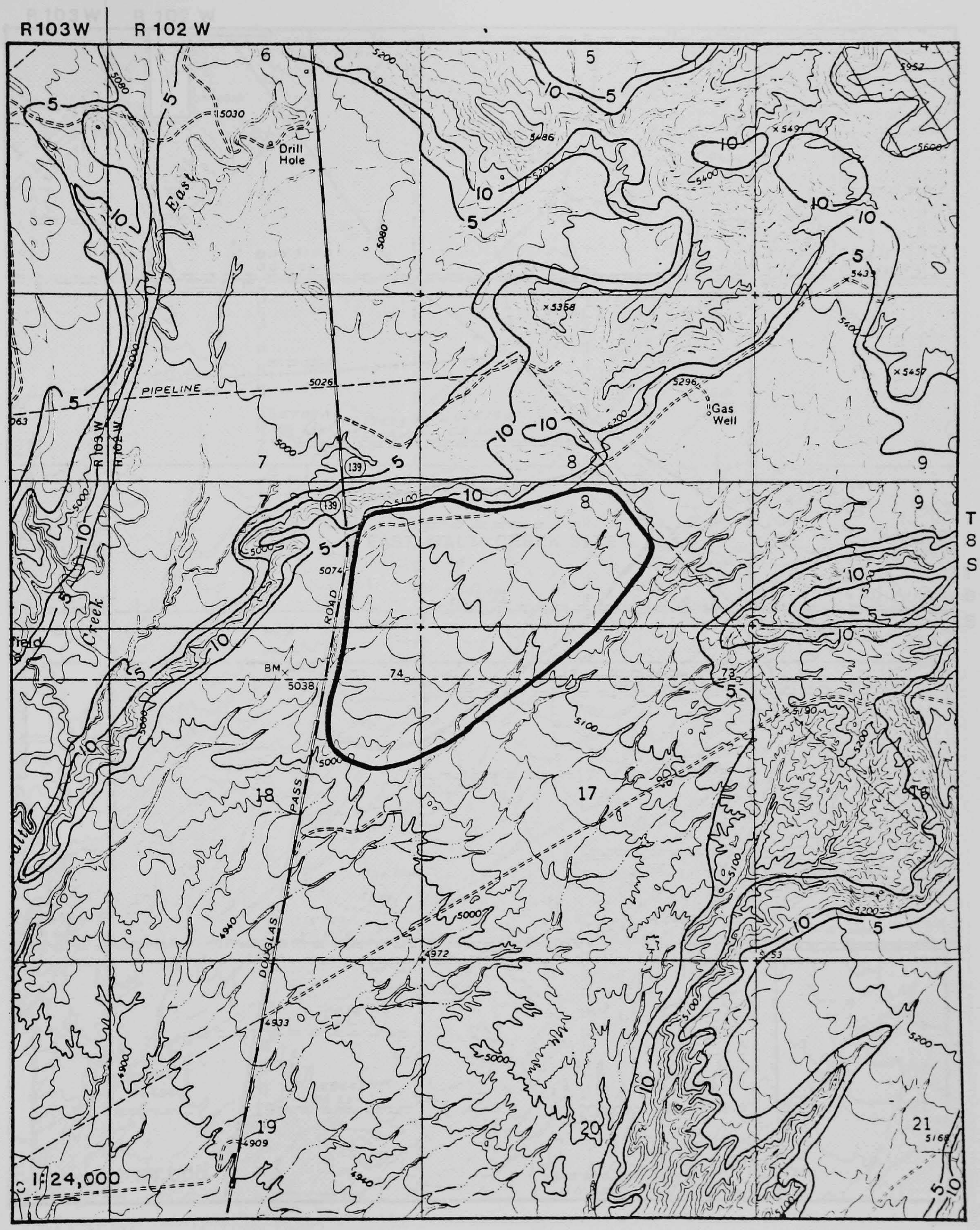


Figure 33. Suitable formation and slope map of the East Salt Creek site.

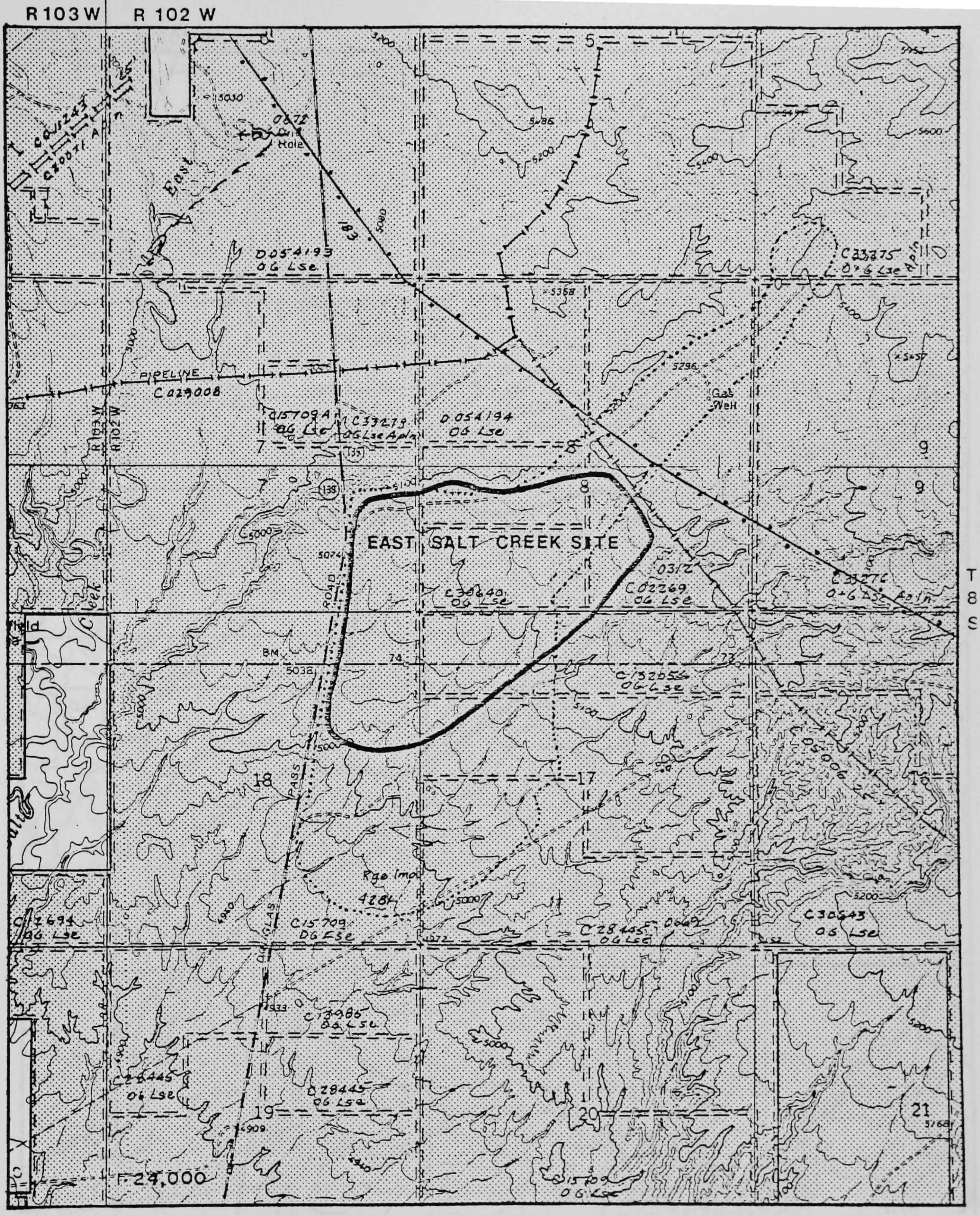


Figure 34. Land use and ownership map of the East Salt Creek site.

Figure 35. Surficial geology map of the East Salt Creek site.

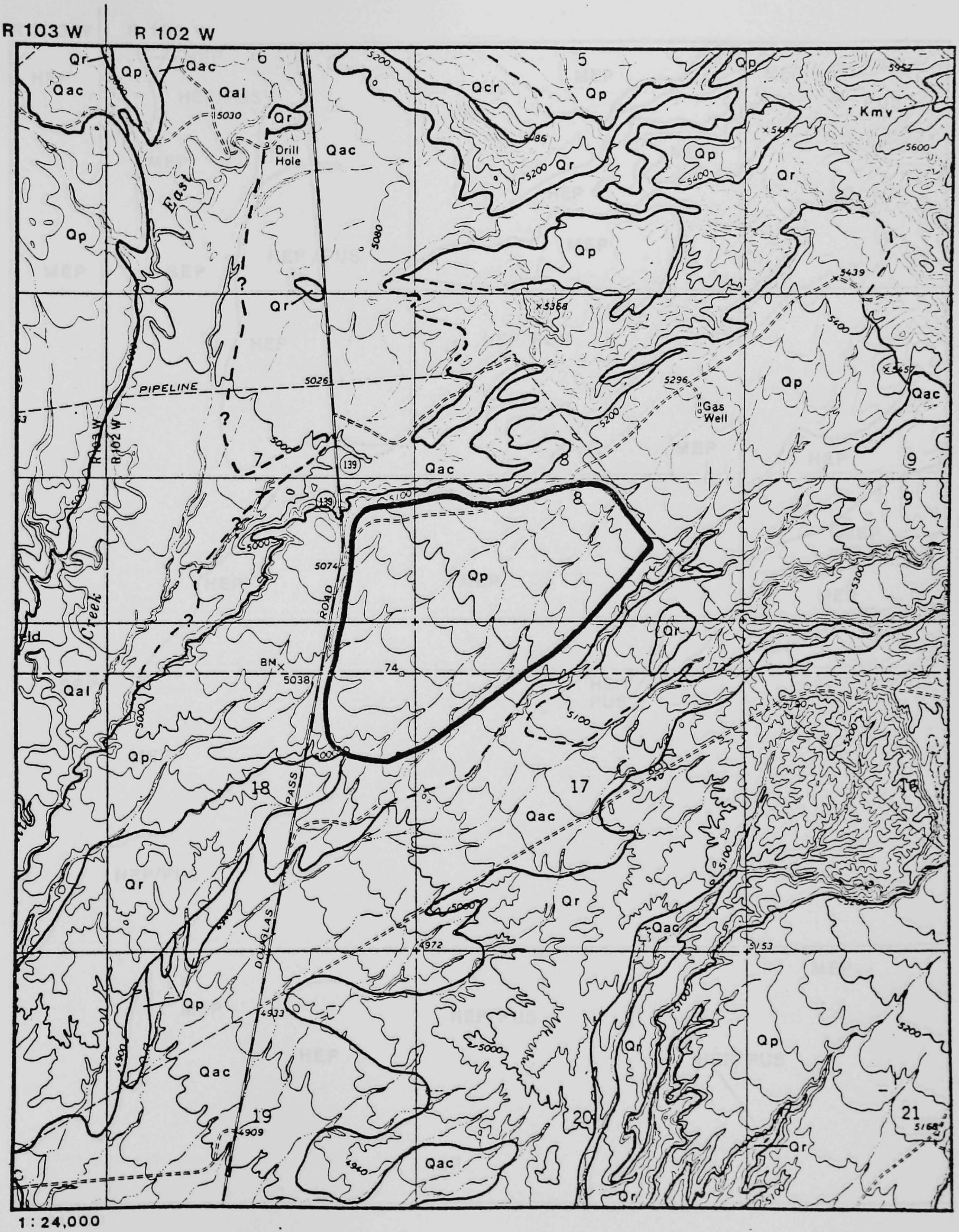


Figure 35. Surficial geologic map of the East Salt Creek site.

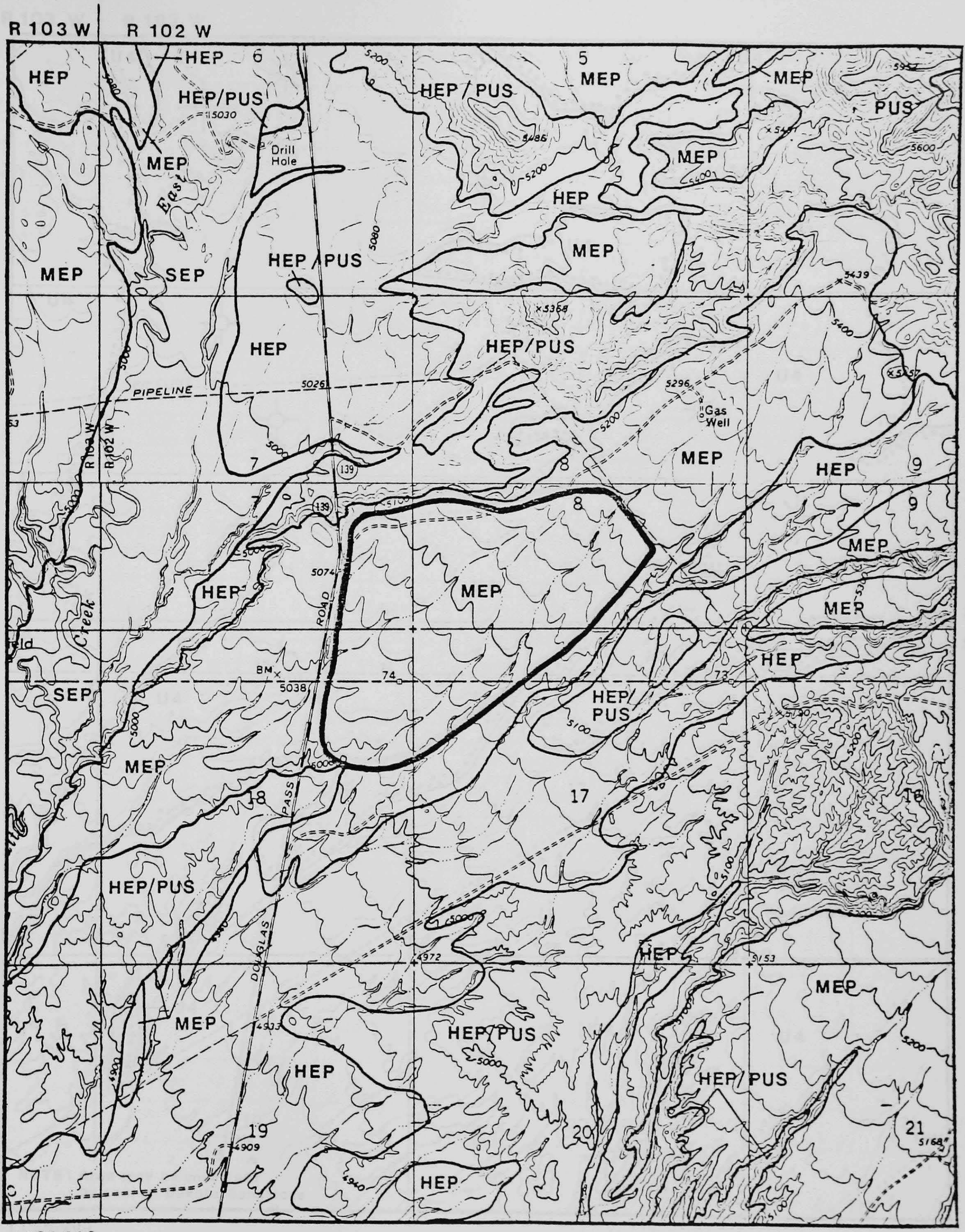
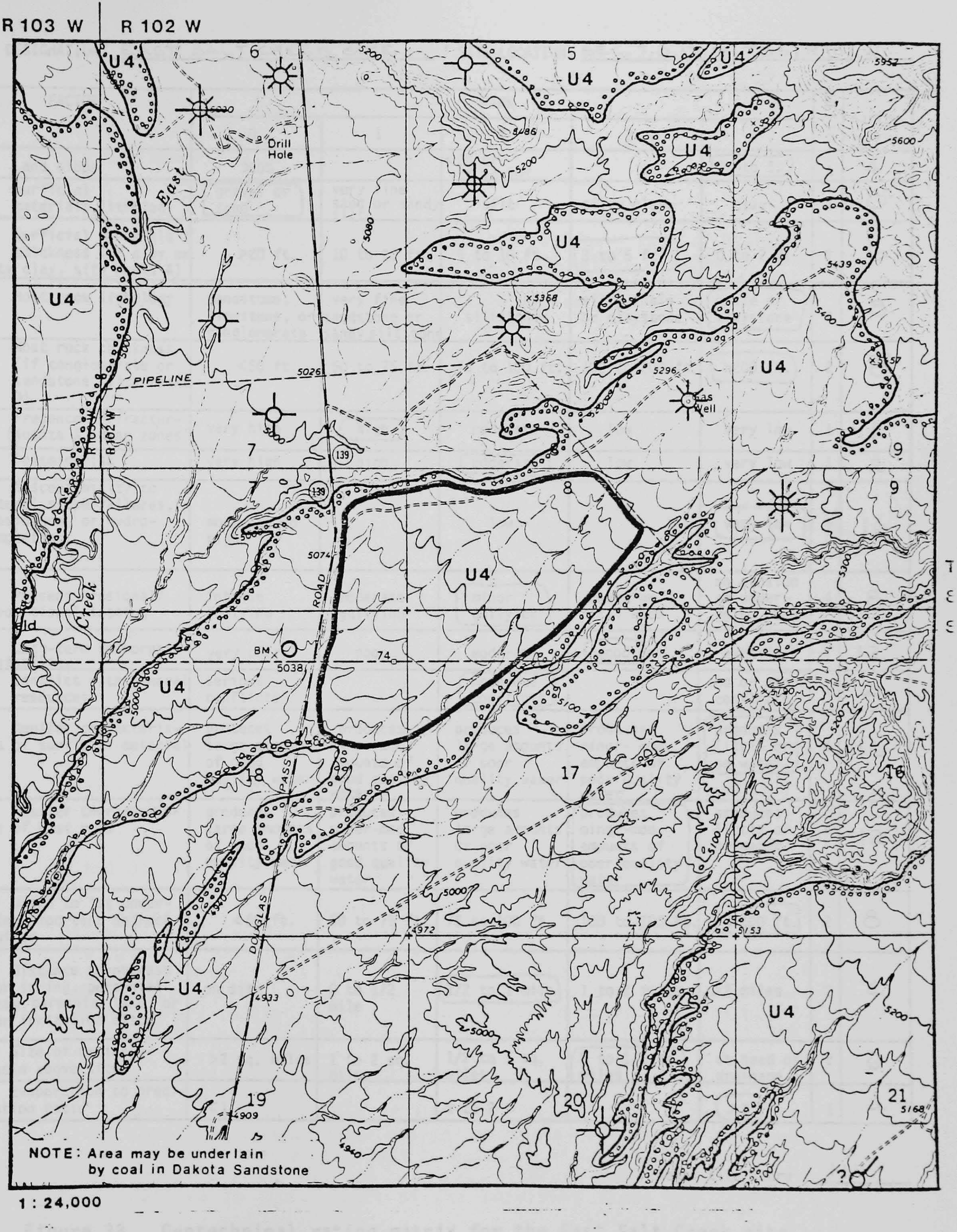


Figure 36. Geologic hazards map of the East Salt Creek site.



NOTE: Area may be underlain by coal in Dakota Sandstone

1 : 24,000

Figure 37. Mineral resources of the East Salt Creek site.

SITE DESIGNATION: EAST SALT CREEK SITE SITE LOCATION: SEC. 7, 8, 17, 18, T8S, R102W

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	[✓ gravel or sand]	very fine sand or sandy silt	silt	silty clay	clay	1	0
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	>20 ft.	10 to 20 ft.	5 to 10 ft.	[✓ 2 to 5 ft.]	0 to 2 ft.	2	6
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	[✓ shale or claystone]	2	8
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	[✓ high]	moderate	low	very low	1	1
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low		[✓ very low]	4	16
9. Present erosional/depositional setting	intense gullying	moderate gullying	[✓ minor gullying]	sheet or rill wash	no erosion or undergoing deposition	4	8
10. Long-term geomorphic stability	very poor	poor	moderate	[✓ good]	excellent	4	12
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	produces minor-mod. amounts of poor quality water	[✓ produces little or no water]	4	16
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts or poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	[✓ 1/2 to 1 mile]	1 to 2 miles	>2 miles	2	4
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	[✓ 0 to 1/2 sq. miles]	at head of drainage	2	6
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 117

Figure 38. Geotechnical rating matrix for the East Salt Creek site.

4.6 HALLS BASIN SITE

4.6.1. General Site Description

4.6.1.1. Location

The Halls Basin site is located in the southeast part of Grand Valley west of Grand Mesa in Mesa County. It is 14 miles southeast of Grand Junction, 5 miles south of Palisade, and 6 miles northeast of Whitewater and US-50. The site covers about one-half square mile in section 35, T1S, R2E, and section 2, T2S, R2E (Figure 39).

4.6.1.2. Transportation Aspects

Truck transportation directly from the Grand Junction pile to the Halls Basin site might be feasible because trucks leaving the pile would be rather quickly outside the downtown traffic congestion area. Therefore two alternative transportation systems are shown in Figure 39. Truck haulage would involve 6.7 miles of paved highway and 8.3 miles of new construction and gravel surfacing. A rail-truck system would include 11.4 miles by rail from Grand Junction or 72.6 miles from Rifle to Siding Three (see Figures 1 and 39), and 11.0 miles of new road construction and gravel surfacing.

The minimum cost of transportation would be $11 million by truck from Grand Junction, or $18.3 million from Grand Junction and $45.4 million from Rifle by the rail-truck system, not including costs of manipulating and covering the tailings on the disposal site.

Considerable traffic volume (10,078 vehicles per day in 1980) exists in the first few miles from the pile by highway. The accident rate is also quite high (8.7 accidents per million vehicle miles) in the first 2.5 miles. The bridge over the Colorado River in this same section is a potential bottleneck. The rail-truck system involves crossing U.S. Highway 50 near its intersection with Colorado Highway 146, with attendant dangers.

4.6.1.3. Topographic Setting

Halls Basin site is at the head of Halls Basin, a steeply walled basin between two higher, gravel-capped pediment surfaces (Figure 40). The floor of the basin gently slopes toward the ephemeral stream that drains the basin. The basin floor is dissected by a number of gullies that cut sharply into the basin fill. These gullies drain generally northwestward to Sink Creek. A bedrock hill extends into the basin from the south basin wall. Maximum relief across the site is about 200 ft.

4.6.1.4. Land Use and Ownership

Land use and ownership of the Halls Basin site is shown on Figure 41-A. The site is wholly on public lands administered by the Bureau of Land Management that are subject to existing oil and gas leases. Primary use of the site is for grazing purposes, although the range would probably be classified as poor. Much of the adjoining lands are owned by the

Somerville Cattle Company of Whitewater (Figures 41-A and 41-B) and are used for grazing purposes. Subdivision of some of the nearby lands has recently taken place. Such development will undoubtedly continue in the future as a result of growth pressures in the Grand Junction area.

4.6.2. Geotechnical Evaluation

The geotechnical rating matrix for the Halls Basin site is shown in Figure 45. The site received a score of 105 and ranks ninth based on the evaluated geotechnical parameters.

4.6.2.1. Geology

The Halls Basin site is underlain by approximately 1,500 to 2,500 ft of Mancos Shale, based on nearby petroleum drill holes and structure contour mapping by Cashion (1973). Structurally, the site is on a regional homocline between the Book Cliffs Monocline to the northeast and the Uncompahgre Uplift to the southwest. Bedrock exposures in the site area are generally poor. Structure contour data (Cashion, 1973) suggests bedrock dips to the northeast beneath the site at about 2° to 4°. No faults are known to exist in the area.

Halls Basin site lies in a basin that is mostly filled with unconsolidated alluvial and colluvial material (Figure 42). This fill material is primarily silty clay with occasional interbedded silty, clayey, sandy gravel and is probably a maximum of 10 to 12 ft thick. The interbedded gravels are interpreted to represent small, localized debris flows or mud flows. Part of the site is located on a bedrock knob that is covered with weathered bedrock or residuum. The residuum is a silty clay probably no more than a few feet thick.

Loamy Aridisols of the Ustic Torriorthents subgroup are the principal soils on the Halls Basin site.

Intense gullying is presently occurring on the Halls Basin site. Gullies up to 15 ft deep with near vertical walls have cut through the basin fill and underlying bedrock. Gullying becomes more severe and deeper downstream. The entire Halls Basin site is classified as having a high erosion potential (Figure 43). Potentially unstable slopes may be present in the bedrock knob area. An area with severe erosion potential exists just downstream of the site. This severe hazard could possibly work its way headward toward the site with time.

The long-term stability of the Halls Basin site is believed to be moderate. Gully erosion is the primary element that affects the long-term stability of the site. A properly engineered, protective riprap structure placed at the mouth of the Halls Basin should reduce the possibility of serious headward erosion extending onto site. Such a structure could turn Halls Basin into an excellent repository site with very good to excellent long-term stability. Continued colluvial activity within the basin above a riprap structure will add additional cover over the repository after completion of the project.

Few petroleum exploration wells have been drilled in the Halls Basin area. No wells have been actually drilled on site and the three wells within two miles of the site were dry and plugged (Figure 44). The status of a fourth well to the northwest in section 27, T1S, R2E is uncertain, but apparently no oil or gas in economic quantities were found. Halls Basin site may have a lower potential for oil or gas than the other eight sites.

Coal in the Dakota Sandstone may underlie the site. In this region Dakota coals are usually very thin. This fact, combined with the great depth of any possible underlying coal (1,500 to 2,500 ft), suggest the resource is not economically significant.

Minor amounts of riprap may be obtained on site from the basin fill which occasionally contains basalt clasts. More likely sources of riprap are the basaltic pediment gravels found north, south, and east of the site. Contained basalt clasts are probably very sound and offer high durability. These pediment gravels generally have a silty or clayey matrix and therefore do not represent a potential source of sand.

4.6.2.2. Hydrology

The Halls Basin site is at the head of a drainage basin. Because of this, there is virtually no possibility that damaging stream flooding will occur on site. Small debris flows may be mobilized on the basin walls and flow into the basin floor. Such events will not affect the stability of the repository.

The ephemeral creek that drains Halls Basin joins Sink Creek about 2 and 1/2 miles below the site. Sink Creek flows into the Colorado River about 3 miles below this junction. Three irrigation ditches (Brandon ditch, Long Mesa ditch, and an unnamed ditch) are less than one-half mile from the Halls Basin site. All, however, are in different drainage basins.

The surficial materials in Halls Basin may carry minor amounts of water seasonally. Local perched water zones may occur at the bedrock-surficial materials contact or in shallow fractured zones in the Mancos Shale.

Host rock for the Halls Basin site, the Mancos Shale, generally carries only minor amounts of poor quality water (Boettcher, 1972; Lohman, 1965). Water in the Mancos Shale is usually associated with fractured zones. The first underlying potentially important aquifer is the Dakota Sandstone, some 1,500 to 2,500 ft deep. Water in the Dakota Sandstone is often brackish and may be contaminated by hydrocarbons.

According to the records of the Colorado Division of Water Resources, as of 11/16/81, there are three registered water wells in the vicinity of the Halls Basin site. The wells are as follows:

Permit #	Date Drilled	Owner	Location	Distance From Site	Depth
22164	11/13/64	R. Summerville	SE SE sec. 1/2S/2E	1.2 miles	50 ft
22584	1/13/65	R. Summerville	SW NE sec. 1/2S/2E	0.7 miles	80 ft
22165	11/17/64	J. Lumbardy	NE NW sec. 10/2S/2E	1.2 miles	50 ft

The first two wells were drilled in the pediment gravel that caps the surface southwest of the site. Both wells are entirely above the level of the Halls Basin site. The third well is in a basin within the Whitewater Creek drainage south of the site. The hydrologic setting of this area will need to be evaluated in detail to determine any possible effects that placement of the tailings in Halls Basin could have on these water wells.

The Colorado Division of Water Resources' records indicate that no decreed springs are located near the Halls Basin site.

4.6.3. Environmental Factors

Vegetation on the Halls Basin site is saltbush desert. The predominant species is shadscale saltbush, with some Nuttall's and mat saltbushes. Dominant grasses are galleta, sand dropseed, and cheatgrass. Other species include winterfat, snakeweed, buckwheat, and prickly pear cactus. Forage productivity is low. White-tailed prairie dog burrows provide homes for Burrowing Owls and desert cottontails. Very few pronghorn antelope would be found on the site, but raptors such as Golden Eagles and Red-tailed Hawks use the area for food hunting. Black-tailed jackrabbits and coyotes will be seen occasionally.

There are no documented archaeologic or historic resources within the Halls Basin site according to the records of the Colorado Historical Society.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

——➤	Existing Surfaced Road
— ➤	Gravel Surfacing Required
– – ➤ –	Road Construction & Gravel Surfacing Required
+++++++	Railroad Siding
⋯⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▨	Area Underlain by Unsuitable Formation
☐	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

⊢—⊣⊢—⊣⊢—⊣ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
░	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•——•——•	Transmission Line (with BLM Ref. No.)
·—·—·—	Telephone Line
—➤ —➤	Irrigation Ditch (with BLM Ref. No.)
→⊃	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium,Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⌀	Abandoned Location (never drilled, permit expired)
●	Oil Well
-●-	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
☼	Plugged Gas Well
-○-	Plugged Dry Hole
⁘	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
✕	Gravel Pit (may be abandoned)
▨	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

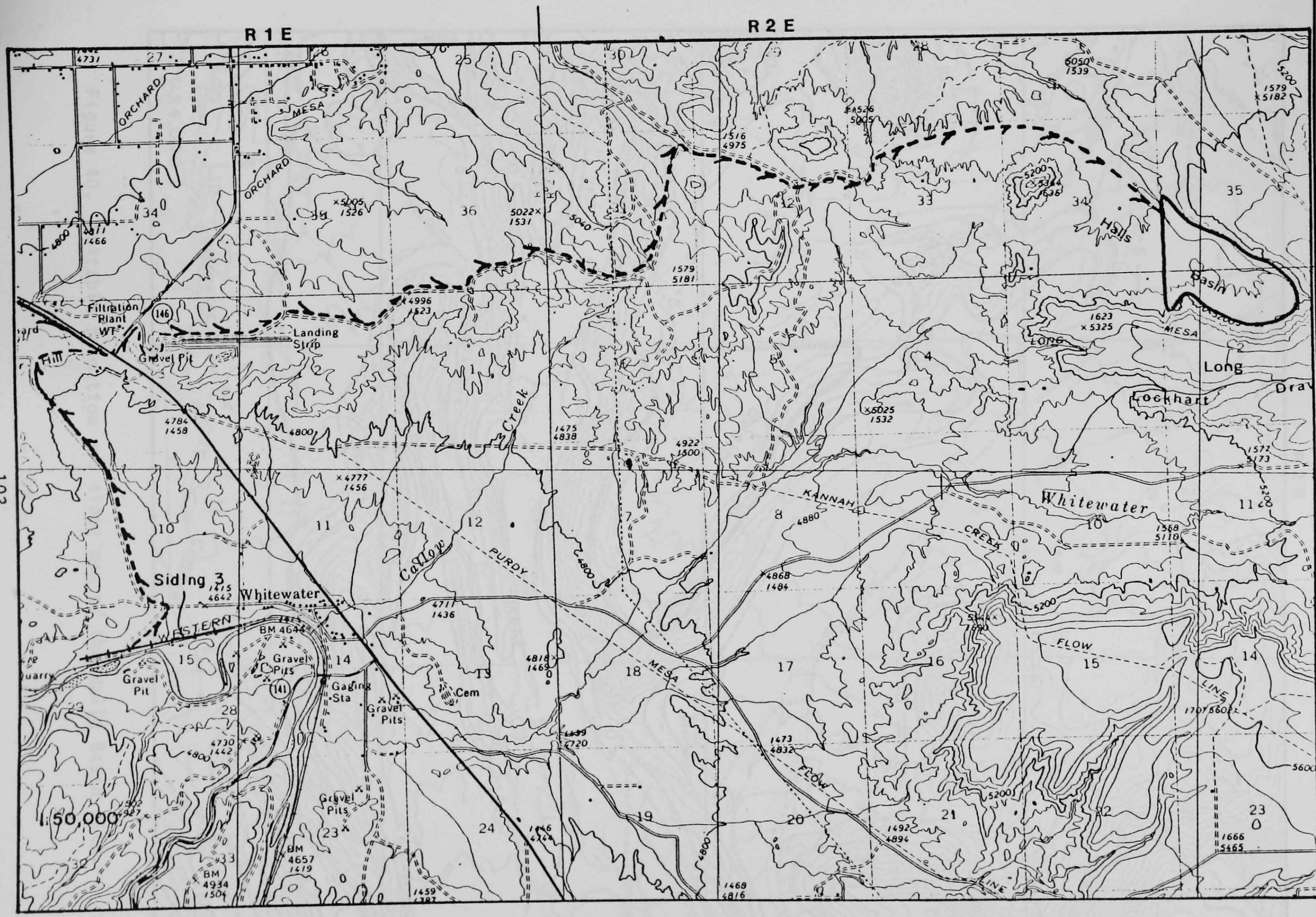


Figure 39. Possible transportation routes to the Halls Basin site.

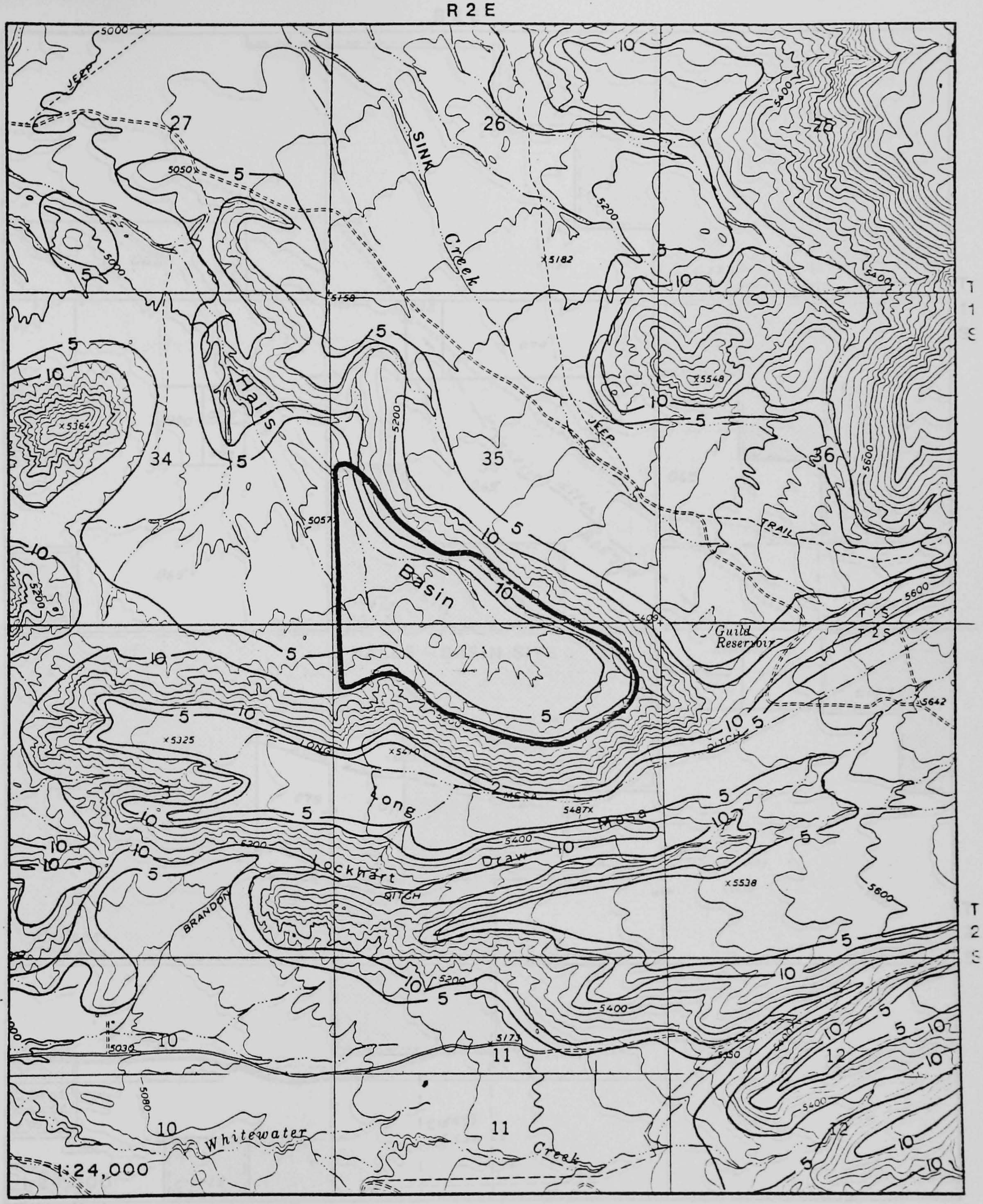


Figure 40. Suitable formation and slope map of the Halls Basin site.

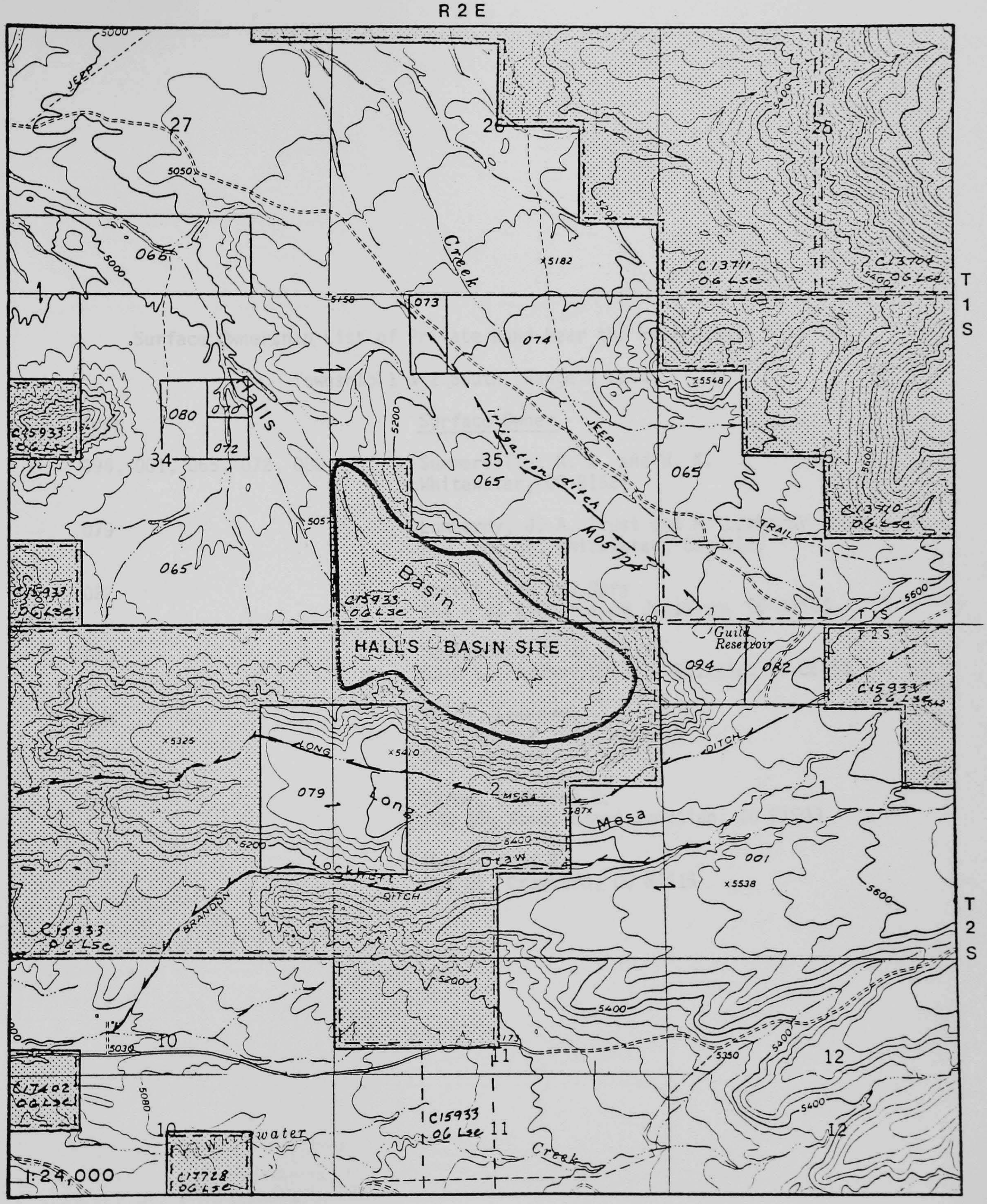


Figure 41-A. Land use and ownership map of the Halls Basin site.

Surface Ownership List of Private Land Near the Halls Basin Site

Township 1 & 2 South, Range 2 East

Code	Surface Owner
094, 001, 065, 072, 080	Summerville, R. D. and W. K. Whitewater, CO 81527
079	Lumbardy, J. A. Trust and M. Lumbardy Trust P.O. Box 86, Whitewater, CO 81527
082	Harris, Leo and Mary 184 - 32 Road, Grand Junction, CO 81503
073	Moslander, C. Jr. et al 6310 E. Pinchot Dr., Scottsdale, AZ 85251
074	Wolfe, Leonard J. 1810 Romona Ave., Apt. 15 So. Pasadena, CA 91030
066	Payne, Winifred R. 270 28½ Road, Grand Junction, CO 81503
070	Hagie, Fred E. Box 68, Crawford, CO 81415

Figure 41-B. Surface ownership list of private land near the Halls Basin site.

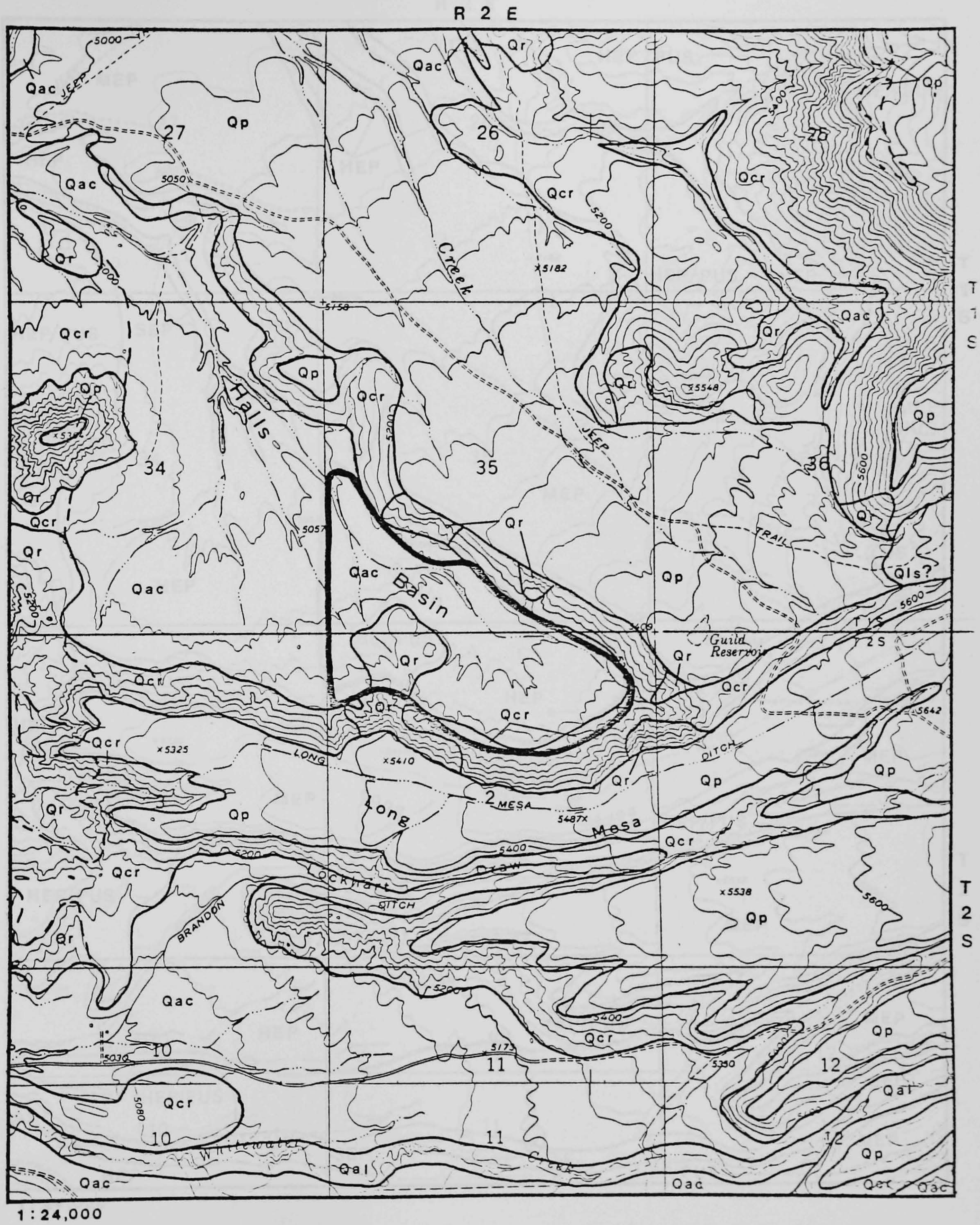


Figure 42. Surficial geologic map of the Halls Basin site.

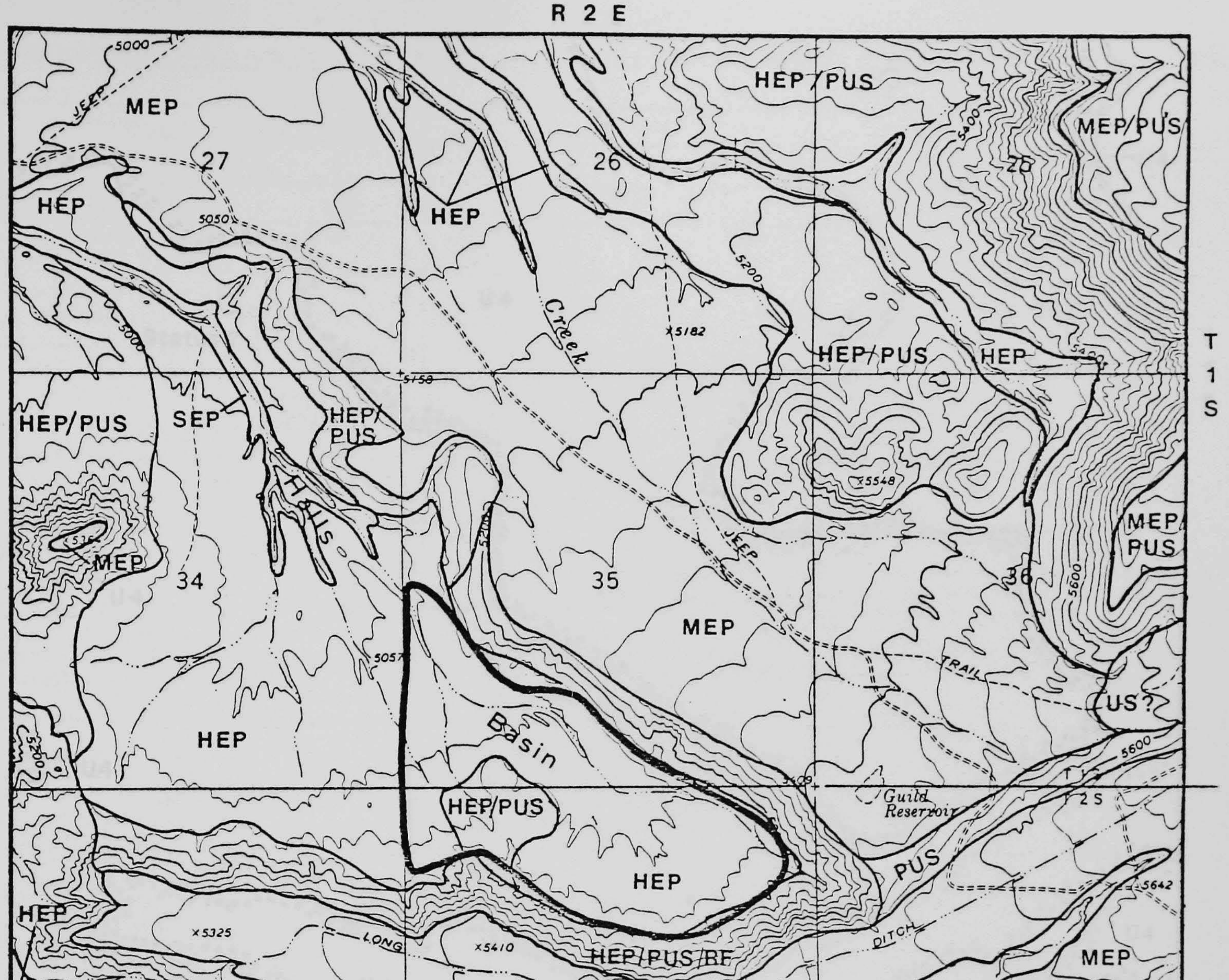


Figure 43. Geologic hazards map of the Halls Basin site.

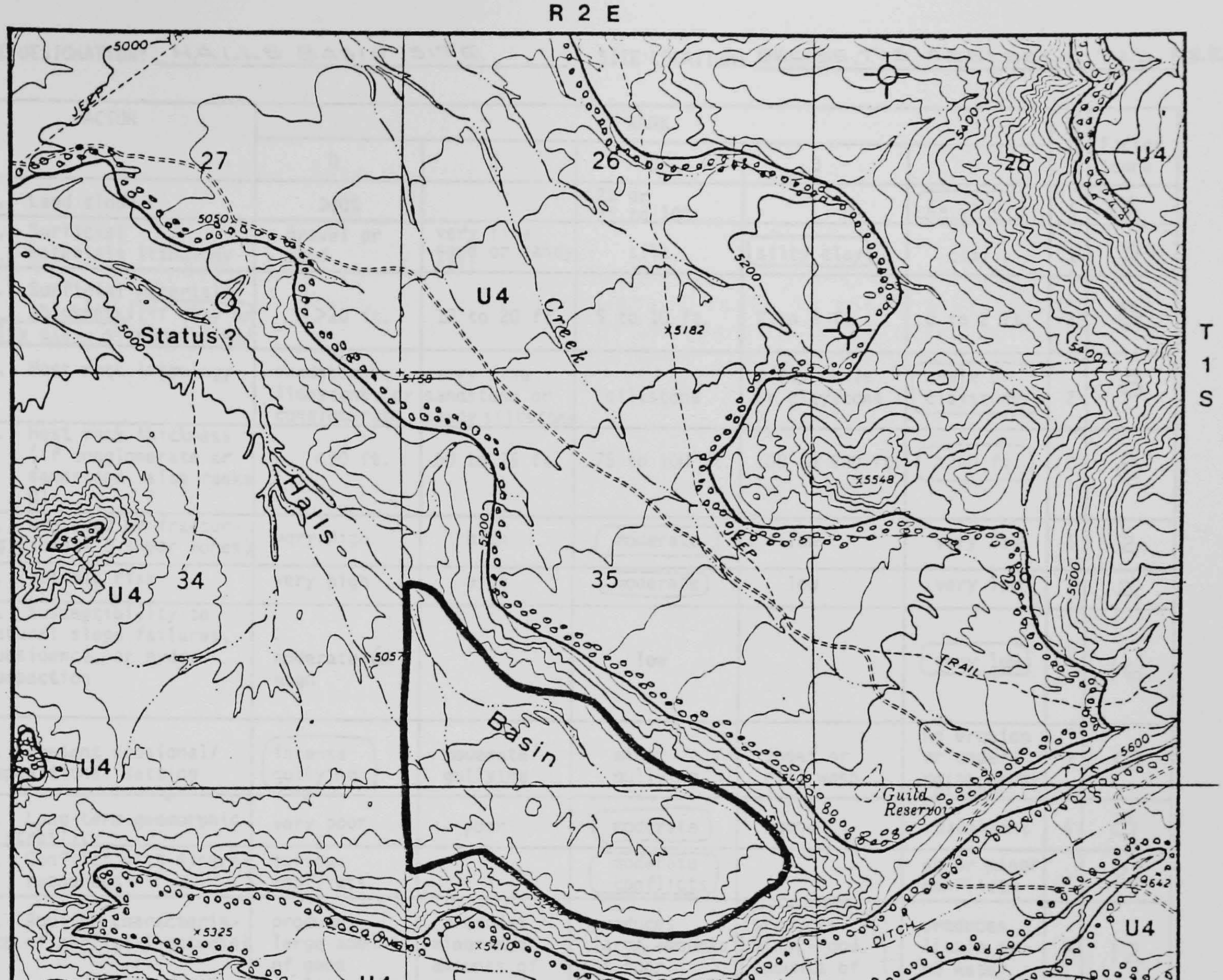


Figure 44. Mineral resources map of the Halls Basin site.

SITE DESIGNATION: HALLS BASIN SITE SITE LOCATION: SEC.35,T1S,R2E;SEC.2,T2S,R2E

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	gravel or sand	very fine sand or sandy silt	silt	[✓ silty clay]	clay	1	3
3. Surficial materials thickness [✓ (if clay or silty clay, site ranks 4)]	>20 ft.	10 to 20 ft.	5 to 10 ft.	2 to 5 ft.	0 to 2 ft.	2	8
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	[✓ shale or claystone]	2	8
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	high	[✓ moderate]	low	very low	1	2
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low		[✓ very low]	4	16
9. Present erosional/ depositional setting	[✓ intense gullying]	moderate gullying	minor gullying	sheet or rill wash	no erosion or undergoing deposition	4	0
10. Long-term geomorphic stability	very poor	poor	[✓ moderate]	good	excellent	4	8
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]	-	no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	[✓ produces minor- mod. amounts of poor quality water]	produces little or no water	4	12
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts or poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	[✓ 0 to 1/2 mile]	1/2 to 1 mile	1 to 2 miles	>2 miles	2	2
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	[✓ 0 to 1/2 sq. miles]	at head of drainage	2	6
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 105

Figure 45. Geotechnical rating matrix for the Halls Basin site.

4.7 CHENEY RESERVOIR SITE

4.7.1. General Site Description

4.7.1.1. Location

Cheney Reservoir site is located in the southeast part of Grand Valley west of Grand Mesa in Mesa County. It is 17 miles southeast of Grand Junction, 8.5 miles southeast of Whitewater, and 4 miles north of the Mesa-Delta County line. The site covers about one square mile in sections 11, 12, 13, and 14, T3S, R2E (Figure 46).

4.7.1.2. Transportation Aspects

Truck transportation directly from the Grand Junction pile to the Cheney Reservoir site might be feasible because trucks leaving the pile would be rather quickly outside the downtown traffic congestion area. Therefore, two alternative transportation systems are shown in Figure 46. Truck haulage would involve 16.8 miles of paved highway and 1.1 miles of new construction and gravel surfacing. A rail-truck system would include 13.4 miles by rail from Grand Junction or 74.6 miles from Rifle to Siding Four (see Figures 1 and 46), 8.1 miles of paved highway, and 1.1 miles of new road construction and gravel surfacing.

The minimum cost of transporation would be $8.4 million by truck from Grand Junction only, or $14.8 million from Grand Junction and $41.8 million from Rifle by the rail-truck system, not including the cost of manipulating and covering the tailings on the disposal site.

Considerable traffic volume (10,078 vehicles per day in 1980) and consequent accident hazard exists in the first few miles from the pile by highway. The accident rate is high (8.7 accidents per million vehicle miles) in the first 2.5 miles. The bridge over the Colorado River in this same section is a potential bottleneck. The fatal accident rate along U.S. 50 south of Grand Junction is 7.0 per 100 million vehicle miles, about the same as the rate on highways to the western sites. This could mean that 3.5 additional fatal accidents could occur as a result of truck haulage for the entire distance from the Grand Junction pile alone.

4.7.1.3. Topographic Setting

The Cheney Reservoir site is situated at the head of a low pediment surface that gently slopes to the southwest. Total relief across the site amounts to about 280 ft. The pediment surface forms a drainage divide between two small ephemeral washes that flow into Indian Creek. There are no distinct drainages on the site.

4.7.1.4. Land Use and Ownership

Land use and ownership of the Cheney Reservoir site is shown on Figure 48-A and 48-B. The site is wholly on public lands administered by the Bureau of Land Management that are subject to existing oil and gas leases. Cheney Reservoir (about 60 acres in size) is located about one mile south of the site. Primary use of the site is for grazing purposes.

A transmission line within a 75 ft right of way crosses the site in a general N-S direction. Application has been submitted for an underground pipeline which would extend near a portion of the south side of the site.

The site is within the drainage basin of the proposed Dominguez Reservoir, the dam of which is located one mile upstream (southerly) from Whitewater. Surface drainage from the Cheney Reservoir site is westerly into Indian Creek which flows into the Gunnison River about three miles above the dam site.

Ownership data for fee lands near the Cheney Reservoir site is shown on Figures 48-A and 48-B. The plat does not extend far enough south to show the junction of the access road and the highway. Fee lands at this junction (which includes a private gate) are labeled 033 on the ownership list in Figure 48-B.

An irrigation ditch of unknown nature crosses the upper part of the site. This ditch is in poor condition and does not appear to have been recently used. If the Cheney Reservoir site is recommended by the Committee, further investigation into this ditch will be required.

4.7.2. Geotechnical Evaluation

The geotechnical rating matrix for the Cheney Reservoir site is given in Figure 52. The site received a score of 116 and ranks fifth based on the evaluated geotechnical parameters.

4.7.2.1. Geology

Cheney Reservoir site appears to be underlain by about 300 to 700 ft of Mancos Shale, based on structure contour mapping by Williams (1964). Shale thickness increases from southwest to northeast. The site is on a broad homocline that separates the Uncompahgre Uplift from the Book Cliffs Monocline. No bedrock exposures occur on site, but rock dips beneath the site are probably around 1^{o} to 3^{o} to the northeast. The nearest mapped faults are several miles away and are associated with the northeast flank of the Uncompahgre Uplift.

Most of the Cheney Reservoir site is underlain by pediment gravels (Figure 49). There are no exposures of this deposit on the site. Based on similar deposits in other parts of Grand Valley we believe the unit is composed of silty, clayey cobble and boulder gravel that is perhaps 5 to 10 ft thick. The majority of clasts within the gravel are basalt. The northeast part of the site is underlain by mixed colluvium and residuum. Lithologic and thickness characteristics of this unit are probably similar to the pediment gravels, although the colluvium and residuum may have a higher percentage of fine-grained materials.

Soils on the Cheney Reservoir site are loamy Aridisols of the Ustic Torriorthents sub-group.

Sheet wash and rill wash are the primary erosive forces currently active on the Cheney Reservoir site (Figure 50). No gullying of even a minor nature was observed on the site. Minor gullying, however, is occurring on the small ephemeral washes that flank the site. Moderate to intense gullying was observed along Indian Creek.

Most of the Cheney Reservoir site is classified as having only a moderate potential for future erosion. The northeast part of the site, an area coincident with the colluvium and residuum, may have a moderate to high erosion potential and a slight tendency towards potentially unstable slopes when artificially oversteepened cuts are made. Areas with high erosion potential and potentially unstable slopes are associated with the small ephemeral washes that flank the site. A severe erosion potential is present along Indian Creek. It may be necessary to riprap the northwest bank of Indian Creek east of the site or construct diversion structures in this area to prevent possible migration of Indian Creek and assure the long-term stability of the site. Overall, the site is judged to have good long-term stability.

Very few wells have tested the general Cheney Reservoir area for oil and gas. One well location was permitted east of the site (Figure 51), but the location was abandoned before drilling began. A successful gas well was drilled a few miles northeast of the site.

Coal in the Dakota Sandstone may underlie the site at depths greater than 300 to 700 ft. Dakota coals are usually thin and are probably not of any economic significance beneath the Cheney Reservoir site.

Potential riprap sources are abundant on and adjacent to the Cheney Reservoir site. Although these deposits have not been tested for their durability and soundness, the basalt clasts will probably be adequate for riprap. Because the surficial deposits have a fine-grained silty clay matrix, they are not potential sources of sand.

4.7.2.2. Hydrology

The Cheney Reservoir site is on a drainage divide, and only a very small area drains into it from above. The potential for serious flooding on site is thus low. The small washes that drain the Cheney Reservoir site merge with Indian Creek 0.1 to 0.5 miles below the site. Indian Creek flows into Kannah Creek 4 to 5 miles below this junction, and Kannah Creek empties into the Colorado River about two miles below its confluence with Indian Creek. The closest important surface waters to the site are Indian Creek, slightly over one-half mile away, and Cheney Reservoir, about 0.8 miles from the site.

The surficial pediment gravels underlying Cheney Reservoir site may carry minor amounts of water seasonally. Localized perched water zones may be found along the bedrock-surficial contact or in fractured zones in the Mancos Shale.

Only minor amounts of generally poor quality water are produced from the Mancos Shale, host rock for the Cheney Reservoir site (Boettcher, 1972; Lohman, 1965). This water is usually associated with fractured zones. The first underlying potentially important aquifer is the Dakota Sandstone, found some 300 to 700 ft below the surface. Water in the Dakota may be brackish or contaminated by hydrocarbons.

As of November 16, 1981, the records of the Colorado Division of Water Resources indicate that the nearest registered water well to the site is about 2.5 miles northwest of the site. This well, permit number 19466, was drilled on 6/29/64 to a depth of 506 ft for F. Bradbury. Additionally, a well permit has been applied for by Mr. R. Sasser to drill in the NW/4 of section 14, T3S, R2E, just west of the site boundary. Detailed hydrologic investigations will be necessary during later stages to evaluate possible ground water problems if the Cheney Reservoir site is selected by the Committee.

No decreed springs appear in the records of the State Engineer for the area immediately around the Cheney Reservoir site.

4.7.3. Environmental Factors

Vegetation on the Cheney Reservoir site is saltbush desert. The dominant species is shadscale, with bud sage, galleta grass, prickly pear cactus, and some squirreltail grass. About 50 to 75 pronghorn antelope use this site and the surrounding area, and antelope hunting is permitted here. Prairie dogs, black-tailed jackrabbits, desert cottontails, coyotes, Burrowing Owls, Golden Eagles, Red-tailed Hawks and other small mammals, birds, and small predators typical of desert shrubland are found here.

The Colorado Historical Society indicates there is lithic scatter located within the boundaries of Cheney Reservoir site (index numbers 5ME01373A, 5ME01373B, 5ME01373C, 5ME01373D). Additional information will be required to evaluate the historical or cultural eligibility status of this area.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

——➤	Existing Surfaced Road
— ➤	Gravel Surfacing Required
– – ➤ –	Road Construction & Gravel Surfacing Required
┼┼┼┼┼┼	Railroad Siding
⋯⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▨	Area Underlain by Unsuitable Formation
☐	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

├─┼─┤ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•——•——	Transmission Line (with BLM Ref. No.)
·-·-·	Telephone Line
——➤ ——➤	Irrigation Ditch (with BLM Ref. No.)
—▷	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium,Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⌀	Abandoned Location (never drilled, permit expired)
●	Oil Well
-●-	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
☼	Plugged Gas Well
-○-	Plugged Dry Hole
⁘	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
✕	Gravel Pit (may be abandoned)
▨	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

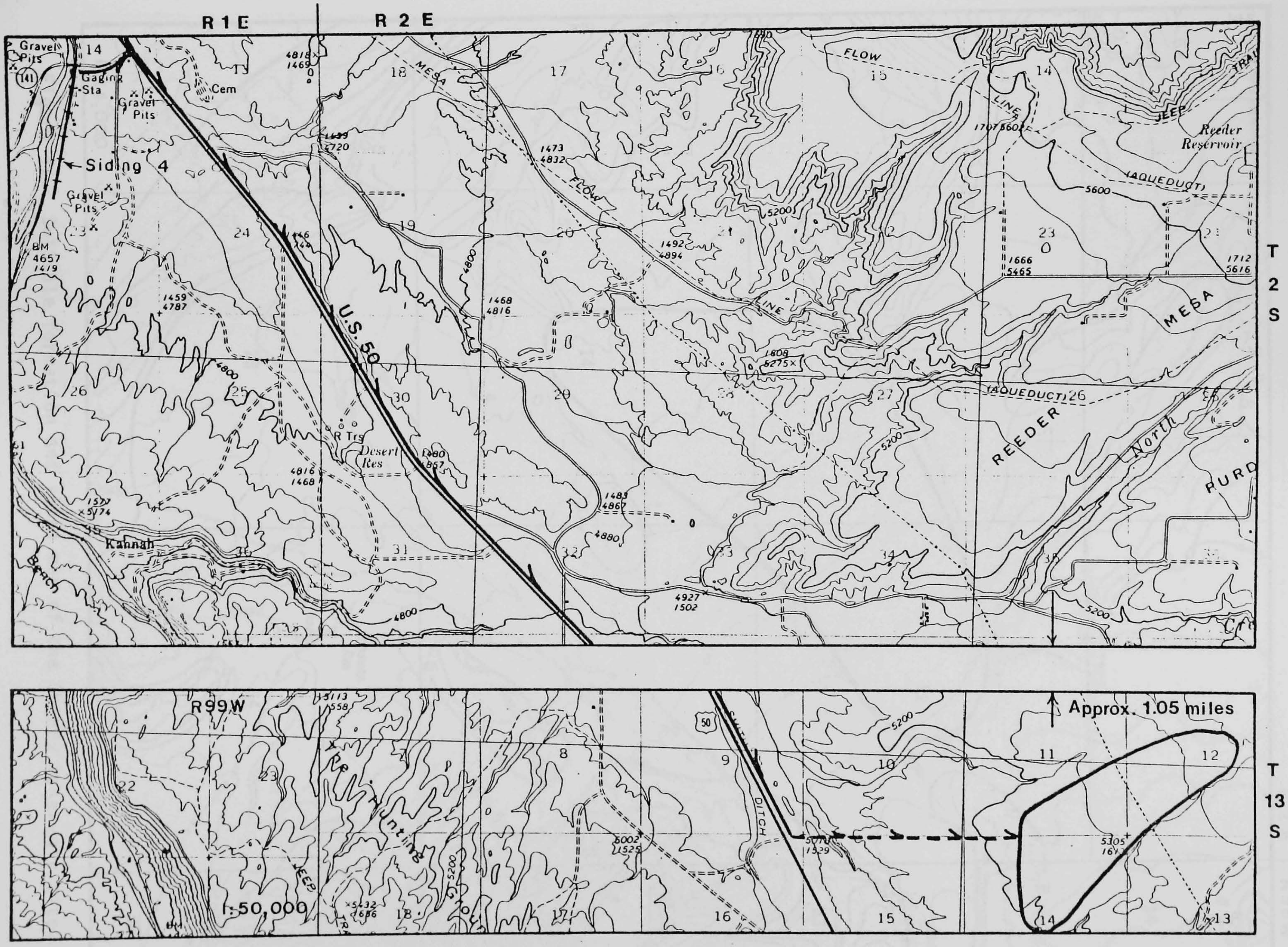


Figure 46. Possible transportation routes to the Cheney Reservoir site.

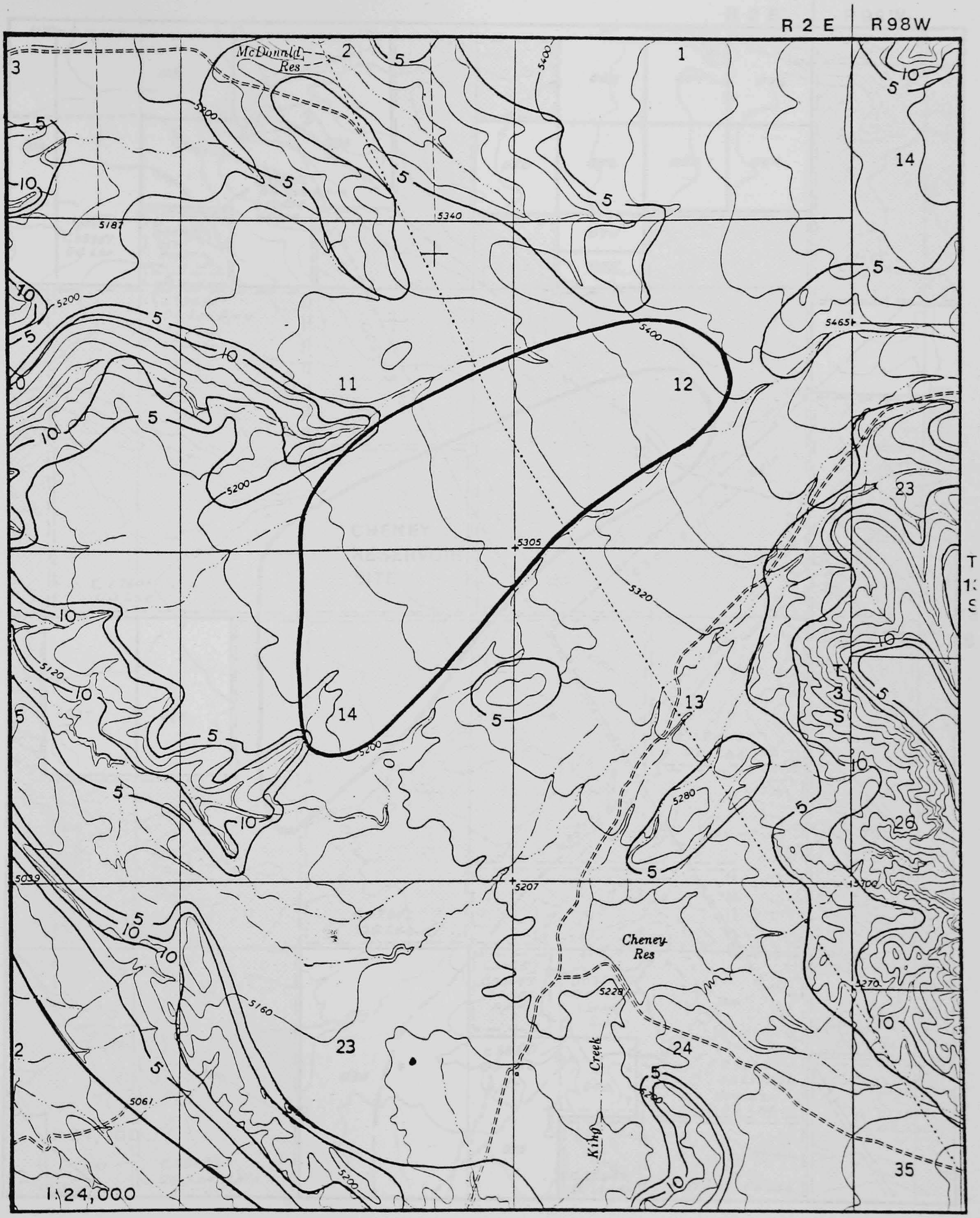


Figure 47. Suitable formation and slope map of the Cheney Reservoir site.

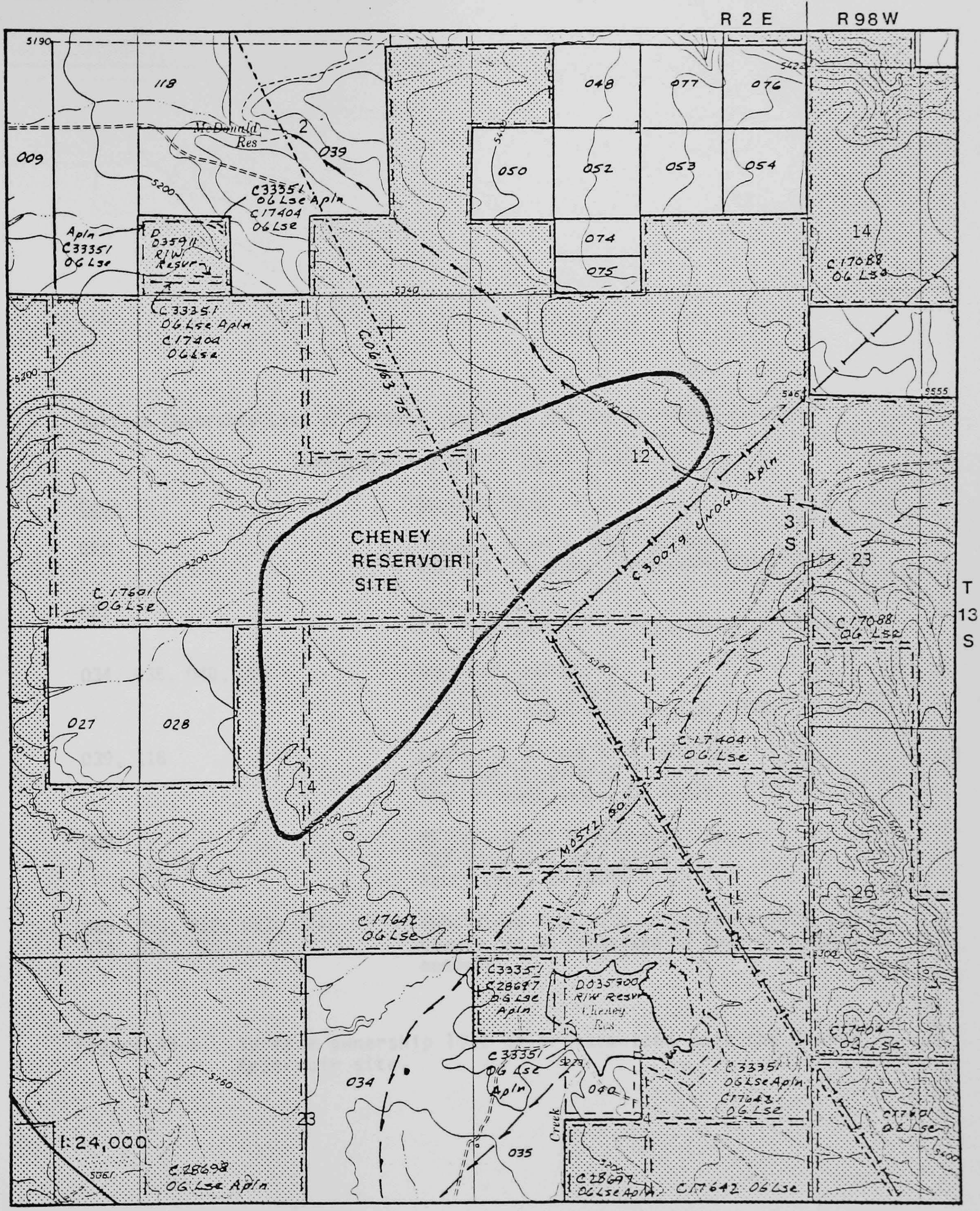


Figure 48-A. Land use and ownership map of the Cheney Reservoir site.

Surface Ownership List of Private Land Near the Cheney Reservoir Site

Township 2 & 3 South, Range 2 East

Code	Surface Owner
028	Sasser, Ralph J. and Mae Belle 2235 So. Broadway, Grand Junction, CO 81503
027	Hartman, Suzan M. 960 Bookcliff Ave., Grand Junction, CO 81501
034, 035, 040, 033	Weymeyer, Walter K. c/o Wakefield MGN Co. Box 2206, Grand Junction, CO 81502
039, 118	Lewis, J. B. and R. L. Whiting c/o John L. Whiting Rte. 1, Whitewater, CO 81527
009	Miller, Cecil R. and Sons, Inc. 333 Spreading Oaks Drive Santa Cruz, CA 95066
048, 050, 052, 053, 054, 074, 075, 076	Subdivided area with varied ownership; County can be contacted if ownership data needed.

Figure 48-B. Surface ownership list of private land near the Cheney Reservoir site.

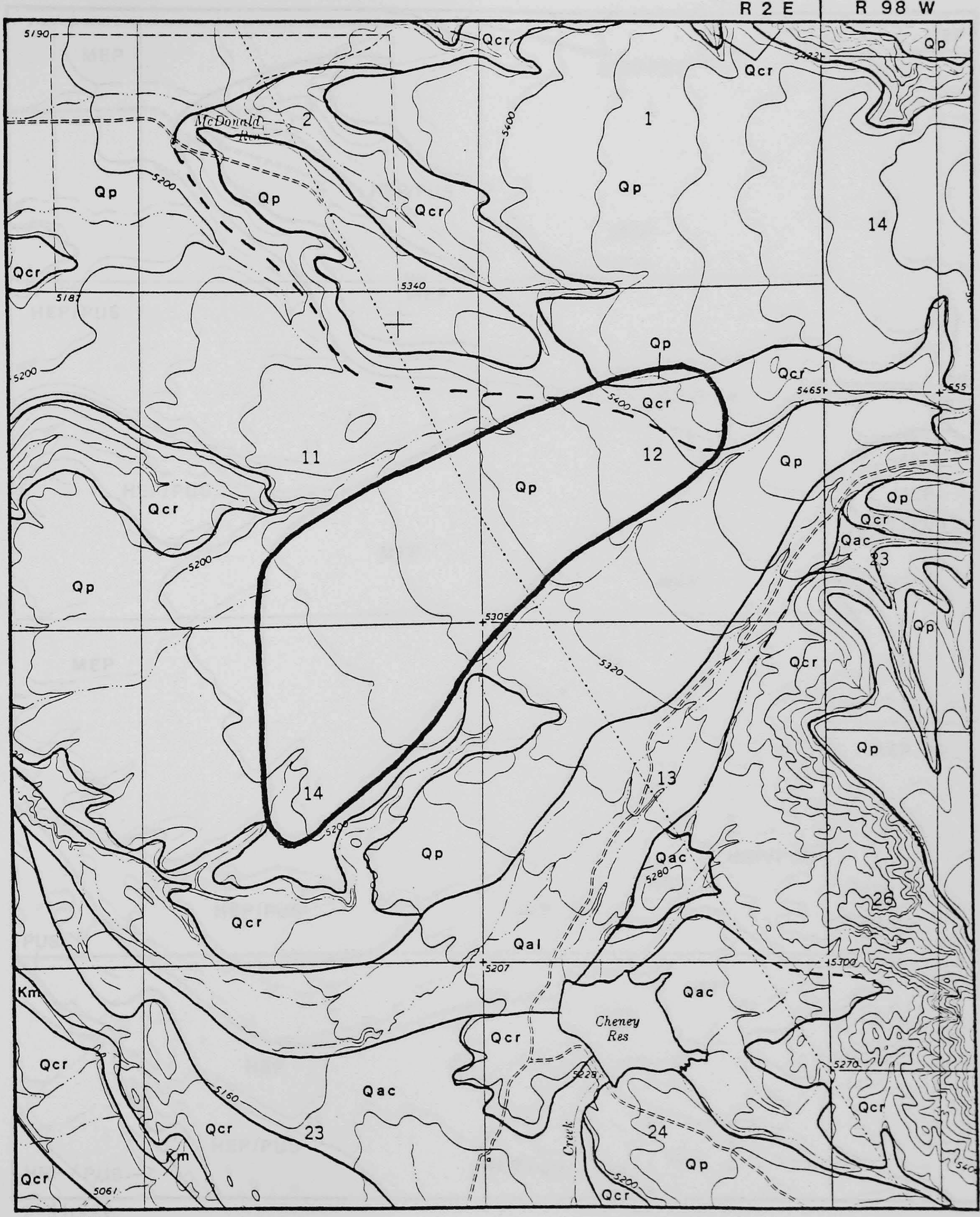


Figure 49. Surficial geologic map of the Cheney Reservoir site.

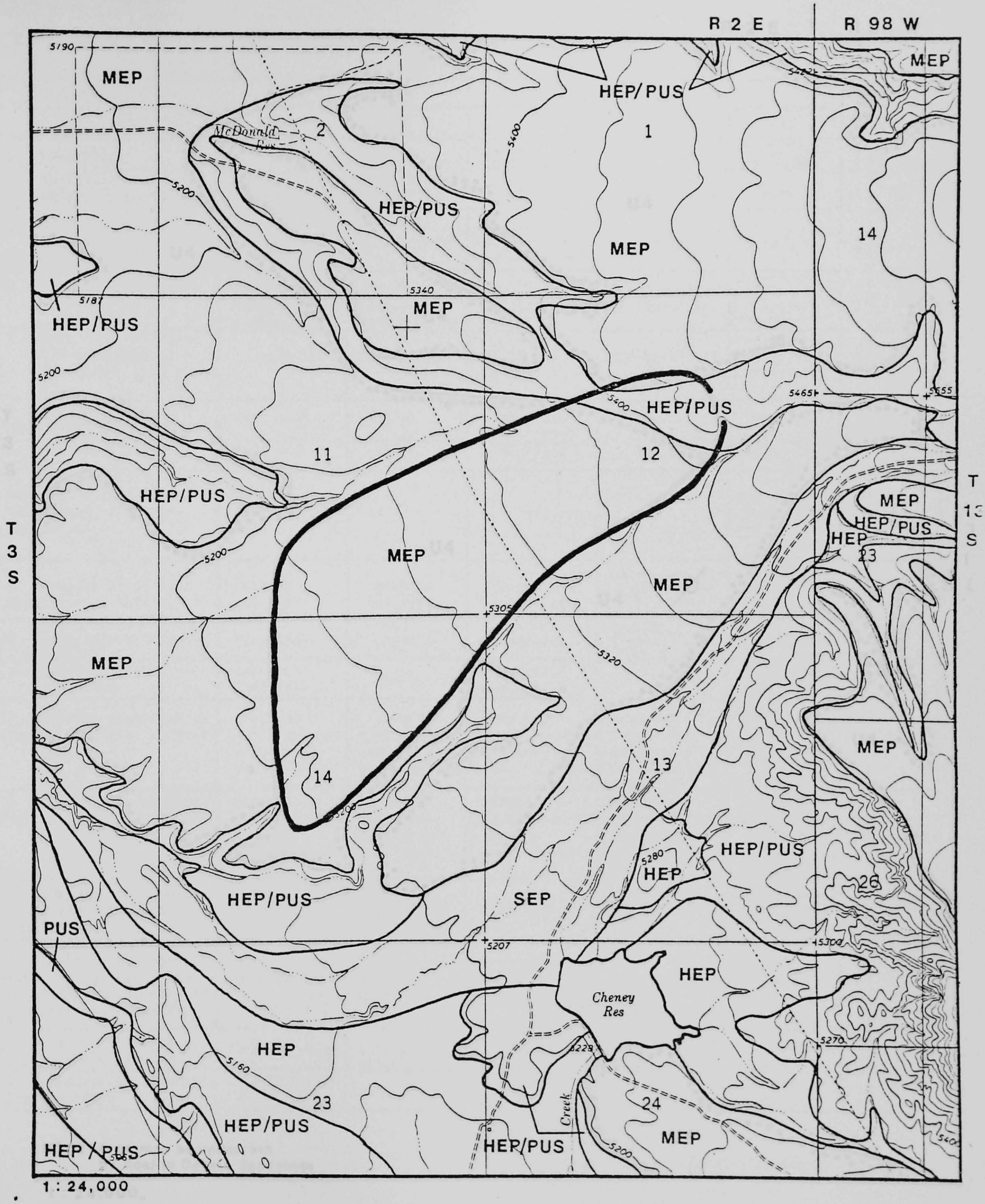


Figure 50. Geologic hazards map of the Cheney Reservoir site.

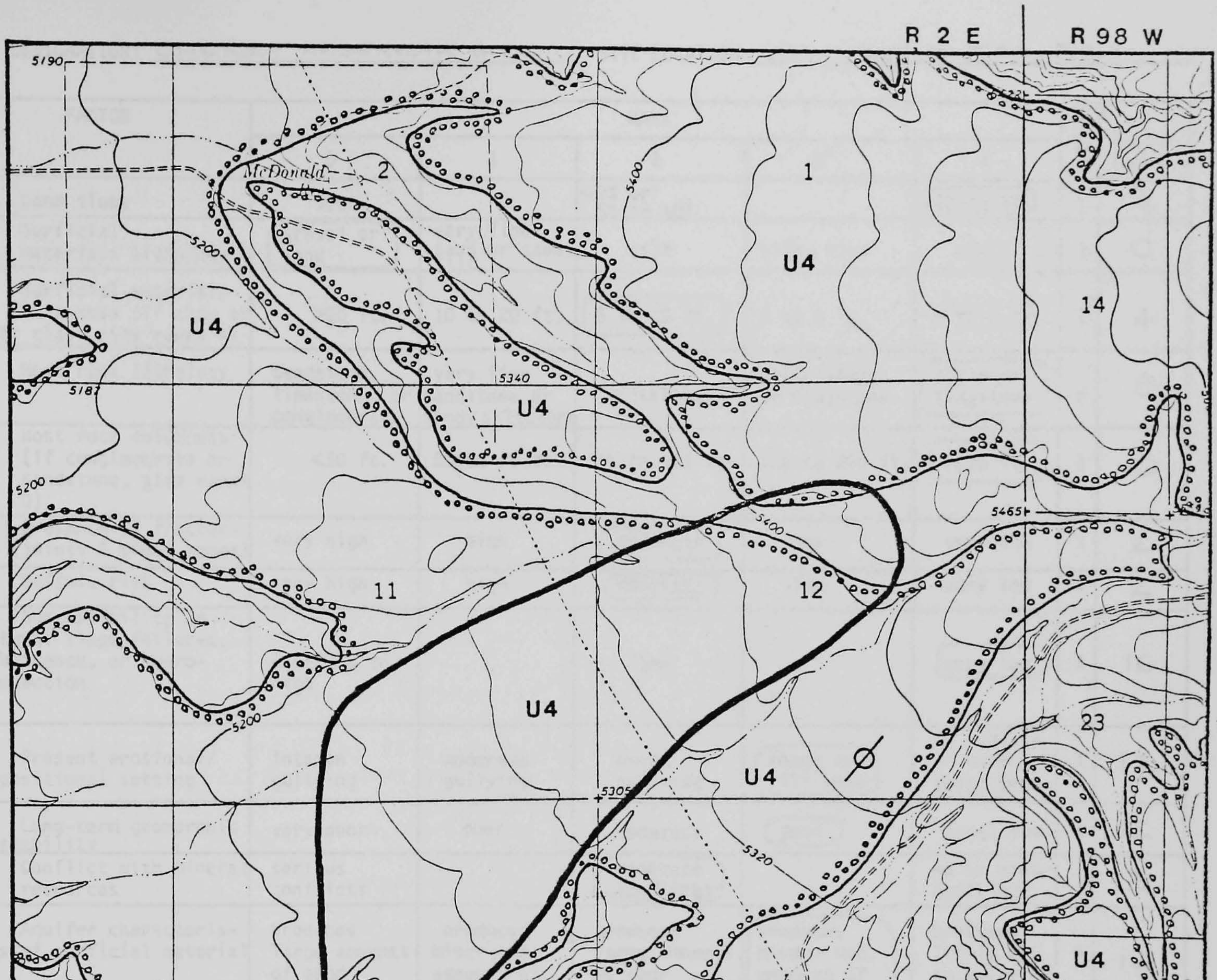


Figure 51. Mineral resources map of the Cheney Reservoir site.

SITE DESIGNATION: CHENEY RESERVOIR SITE SITE LOCATION: SEC. 11, 12, 13, 14, T35, R2E

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	[✓ gravel or sand]	very fine sand or sandy silt	silt	silty clay	clay	1	0
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	>20 ft.	10 to 20 ft.	[✓ 5 to 10 ft.]	2 to 5 ft.	0 to 2 ft.	2	4
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	silty shale or claystone	[✓ shale or claystone]	2	8
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	high	[✓ moderate]	low	very low	1	2
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low		[✓ very low]	4	16
9. Present erosional/depositional setting	intense gullying	moderate gullying	minor gullying	[✓ sheet or rill wash]	no erosion or undergoing deposition	4	12
10. Long-term geomorphic stability	very poor	poor	moderate	[✓ good]	excellent	4	12
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts or poor quality water	[✓ produces minor-mod. amounts of poor quality water]	produces little or no water	4	12
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	[✓ 1/2 to 1 mile]	1 to 2 miles	>2 miles	2	4
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	[✓ 0 to 1/2 sq. miles]	at head of drainage	2	6
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 116

Figure 52. Geotechnical rating matrix of the Cheney Reservoir site.

4.8 LUCAS MESA SITE

4.8.1. General Site Description

4.8.1.1. Location

Lucas Mesa site is located high above the Colorado River on a remnant of an old pediment surface on the west side of Battlement Mesa. The surface is not named on the U.S.G.S. DeBeque 7 1/2' quadrangle map, but according to sources at the Bureau of Land Management, it is called Lucas Mesa. The site is about midway between the Grand Junction and Rifle tailings piles on the southeast side of the Colorado River. DeBeque is about 3 miles west of the site, and Parachute is about nine miles to the northeast. Lucas Mesa site occupies a little over three-fourths of a square mile in sections 19, 20, 29, and 30, T8S, R96W in Mesa County.

4.8.1.2. Transportation Aspects

The Lucas Mesa site is located nearly mid-way between the Grand Junction and Rifle tailings piles. Rail transport is the only feasible transportation method for hauling the Grand Junction pile, because highway traffic is severely congested all the way from the pile to the east end of DeBeque Canyon. Near DeBeque, two transportation options are feasible to the site. One is by truck from Siding Five (Figures 1 and 53), some 2.3 miles by surfaced road and 4.5 miles by newly constructed and graveled road. The other is by conveyor from Siding Six, 2.1 miles to the site. Both routes are shown in Figure 53.

The Rifle tailings piles could be transported either by truck or rail to the Lucas Mesa site. If by truck, they would best be moved all the way to the site by truck, which would involve 26.5 miles of paved highway for the new Rifle pile and 29.0 miles for the old Rifle pile, plus 2.3 miles of graveled road and 4.5 miles of newly constructed road in mountainous terrain with a gravel surface. If. transportation from Rifle is by train to near DeBeque, the final transport to the site could be via truck 3.1 miles by surfaced road and 4.5 miles by newly constructed and graveled road from Siding Five, or 2.1 miles by conveyor from Siding Six. Figure 53 shows these alternatives.

The minimum cost of transportation by these options is as follows:

Grand Junction pile:

Rail and truck	$29.8 million
Rail and conveyor	24.4 million

Rifle piles (new and old):

Truck only	$15.8 million
Rail and truck	23.8 million
Rail and conveyor	17.4 million

These estimates do not include the cost of manipulating and covering the tailings on the disposal site.

The 2.3 miles of graveled road from DeBeque to where new road construction would be necessary, has several right-angle turns. This would slow travel and possibly increase accident hazards. DeBeque is experiencing rapid growth, so the increased truck traffic near the town from Siding Five would be both hazardous and irritating. The conveyor system would involve crossing two channels of the Colorado River and a rather steep climb to the mesa top.

4.8.1.3. Topographic Setting

Lucas Mesa site lies on a remnant of an old pediment surface on the west side of Battlement Mesa. The remnant now forms a mesa that stands 550 to 1,300 ft above the Colorado River. Elevations on the site range from 5,630 to 6,100 ft, resulting in a maximum relief of 470 ft across the site. On the site the mesa surface slopes 5 to 10^{0} to the north-northwest. Several northwest-trending drainages have begun to cut through the surface. The largest of the drainages have been avoided, but some shallow drainages are within the site. The flanks of the mesa slope steeply downward to Smith Gulch on the northeast, Moffat Gulch on the southwest, and the Colorado River on the northwest.

4.8.1.4. Land Use and Ownership

Figure 55-A illustrates land use and ownership of the Lucas Mesa site. The site is wholly on public lands administered by the Bureau of Land Management and is subject to existing oil and gas leases. Primary use of the site is for grazing purposes. Eight permittees comingle cattle in a permit area which includes Lucas Mesa. Range improvements include water catchment structures, and water pipelines extending across the center of the site to stock watering tanks. Ownership of private lands near the site is indicated in Figure 55-B.

In view of the problem of transporting tailings by truck up a rather steep grade from the railroad, a conveyor or tramway system might be considered. Therefore the plat includes data on surface ownership for the lands between Lucas Mesa and the most likely railroad unloading sites.

4.8.2. Geotechnical Evaluation

The geotechnical rating matrix for the Lucas Mesa site is given in Figure 59. The site received a score of 108 and ranks eighth based on the evaluated geotechnical parameters.

4.8.2.1. Geology

Over 1,000 ft of shale, claystone, siltstone, and interbedded sandstone within the Wasatch Formation underlies the Lucas Mesa site. The site is situated in the upper part or Shire member of the Wasatch Formation. In general, this part of the Wasatch is predominantly shale and claystone (Donnell, 1961b; Johnson and May, 1978; Johnson and others, 1979). We estimate there is at least 200 to 400 ft of the Shire member beneath the site, based on exposures to the southwest and west, and on regional correlation of petroleum drill holes.

Structurally, the Lucas Mesa site lies well within the Piceance Basin. The site is situated on a slight syncline that is associated with the DeBeque anticline (Cashion, 1973). Bedrock beneath the site dips northeastward approximately at 2^{o} to 3^{o}. No known faults exist on the site. The nearest mapped faults are about 4.5 miles to the southwest (Cashion, 1973).

As shown in Figure 56, the entire Lucas Mesa site is underlain by pre-Wisconsin (older than approximately 200,000 years) pediment gravel. Slope of the pediment surface steepens near the head of the mesa, possibly suggesting a former position of the northwestern flank of Battlement Mesa. The gravel underlying the surface is dominantly a silty, sandy, and clayey boulder gravel with most clasts composed of basalt. Clast diameter is generally 0.5 to 2 ft, but boulders as much as 8 to 10 ft in diameter are also present. Many of the clasts are heavily coated with calcium carbonate. The base of the pediment gravel is not exposed along the flanks of the mesa or in drainages cut into the surface. Maximum thickness of the gravel is estimated to exceed 20 ft. Because of this thickness it may be necessary to use an engineered liner for a repository constructed on Lucas Mesa. Excavated gravel would provide abundant riprap material that could be used in the cap, for diversion structures, and as fill in drainages on the mesa to prevent or minimize future erosion.

A thin veneer of red-brown wind-blown silt covers much of the gravel on Lucas Mesa. Thickness of this wind-blown material probably ranges from a few inches to a few feet. The soil of the Lucas Mesa site is described as loamy Entisols of the Lithic Ustic Orthents subgroup.

Sheet wash and rill wash are the primary types of erosive forces active on the site. Minor stream incision is occurring along a few drainages on site. Two large drainages have cut 80 to 120 ft into the pediment gravel at the lower (northern) end of the mesa. Site boundaries were selected to avoid these deeply eroded areas.

The flanks of Lucas Mesa are retreating, primarily the result of colluvial processes triggered by stream downcutting in Smith and Moffat Gulches. Landslides are present on the lower parts of the mesa flank on the south and southeast sides. Slope retreat on the mesa flanks must be considered for the design of a repository on this site. Lucas Mesa will eventually be destroyed by colluvial processes and landsliding, but it is our belief that this will probably take well over 10,000 years and possibly as much as 100,000 years.

Lucas Mesa site is classified as having moderate erosion potential (Figure 57). The flanks of the entire mesa and the drainages on the lower end of the mesa have a high erosion potential. Excess gravel excavated for the repository could be used to reduce the erosion potential of the drainages on the lower end of the mesa. An area of unstable slopes occurs on the south and southeast side of the site. This hazard, along with the potentially unstable slopes present in Smith and Moffat Gulches may have to be accounted for in the design of haul routes for the Lucas Mesa site. Long-term (10,000 years) stability of the site is believed to be good.

Very few oil and gas test holes have been drilled in the Lucas Mesa area, and none have been drilled on site. The nearest well, located in the SE/4 section 25, T8S, R97W, apparently did encounter economic quantities of gas and is currently shut-in. Coal in both the Mesaverde Group and Dakota Sandstone may underlie the site. Dakota coals are generally thin and, if present, are over 9,000 ft beneath the site. They are not economically significant. The Mesaverde coal beds, however, often are several feet thick, and a number of mines in the Piceance Basin currently work this formation. Mesaverde coals are probably at least 1,000 ft beneath Lucas Mesa site. These coals are not currrently economically mineable, but as energy economics evolve, they may become valuable.

Potential gravel sources are present on the Lucas Mesa site. These gravels would probably be adequate for riprap used for the repository. Depending on the amount of gravel excavated, there may be enough material to backfill drainages on the mesa below the site to prevent further erosive incision. The pediment gravels probably do not contain signficant sources of sand.

4.8.2.2. Hydrology

The Lucas Mesa site is located at the head of a drainage divide and has virtually no drainage basin above it. Potential for stream flooding is therefore very low. Drainages on the site flow into ephemeral creeks in Smith Gulch or Moffat Gulch, or into the Bluestone Valley irrigation ditch 0.3 to 1.8 miles below the site. The creeks in both gulches join the Colorado River one to two miles below the site. The Bluestone Valley irrigation ditch is about one mile from the site in a direct line, and the Colorado River is only 1.2 miles away.

The surficial pediment gravels that underlie Lucas Mesa site probably carry little or no water. No springs, seeps, or moist areas were noted around the flanks of the mesa. At certain times of the year following periods of heavy precipitation, minor amounts of water may infiltrate into the gravel. Localized perched ground-water zones may also exist seasonally within the surficial deposits or at the surficial-bedrock contact.

The Wasatch Formation, host rock for the Lucas Mesa site, has highly variable ground-water characteristics (Repplier and others, 1981). In some areas the Wasatch yields virtually no water, but other wells may produce over a hundred gallons per minute. The only published information on the aquifer characteristics of the Wasatch Formation are very brief and sketchy. Based on our preliminary observations in the area, it appears as though the upper member (Shire member) and lower member (Atwell Gulch member) of the Wasatch generally produce only minor amounts of water, whereas the middle member (Molina member) is capable of producing large amounts of water. Water in the Wasatch Formation is reportedly often poor in quality and may be contaminated with hydrocarbons.

According to the records of the Colorado Division of Water Resources, there are no registered water wells or decreed springs on or adjacent to the Lucas Mesa site.

4.8.3. Environmental Factors

Vegetation on the Lucas Mesa site consists of moderately dense sagebrush which is one to three feet high. Sagebrush usually indicates a productive site. Very little vegetative understory exists on the site, but cheatgrass is locally abundant, especially on the slopes. Side slopes are mostly moderately dense juniper stands with very little pinyon. The mesa is slated for treatment by herbicide spray or plowing, followed by reseeding with grass for livestock range improvement. Topsoil on this site is productive and could be saved for reclamation of the disposal site. Mule deer are abundant in the area, especially during a spring influx, and elk might occasionally be found on the site. Other common wildlife would include cottontails, jackrabbits, coyotes, chipmunks, golden-mantled ground squirrels, Goshawks, Scrub Jays, and rock squirrels.

There are no documented archaeologic or historic resources within the Lucas Mesa site according to the records of the Colorado Historical Society.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

——➤	Existing Surfaced Road
— ➤	Gravel Surfacing Required
– – ➤ –	Road Construction & Gravel Surfacing Required
++++++	Railroad Siding
⋯⋯	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▧	Area Underlain by Unsuitable Formation
▭	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

⊢—⊣⊢—⊣ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
········	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•——•——	Transmission Line (with BLM Ref. No.)
–·–·–	Telephone Line
—➤—➤	Irrigation Ditch (with BLM Ref. No.)
—⊳	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
HEP	High Erosion Potential
MEP	Moderate Erosion Potential
US	Unstable Slope
PUS	Potentially Unstable Slope
DF	Debris Flow Area
RF	Rock Fall Area
	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
Qac	Alluvium and Colluvium, Mixed
Qt	Terrace Deposits
Qp	Pediment Deposits, Undifferentiated
Qp1	Pediment Deposits, Pre-Wisconsin
Qdf	Debris Fan Deposits
Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
Qr	Residuum
Tw	Tertiary Wasatch Formation
Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
∅	Abandoned Location (never drilled, permit expired)
●	Oil Well
–●–	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
☼	Plugged Gas Well
–○–	Plugged Dry Hole
⁘	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
⚒	Gravel Pit (may be abandoned)
▧	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

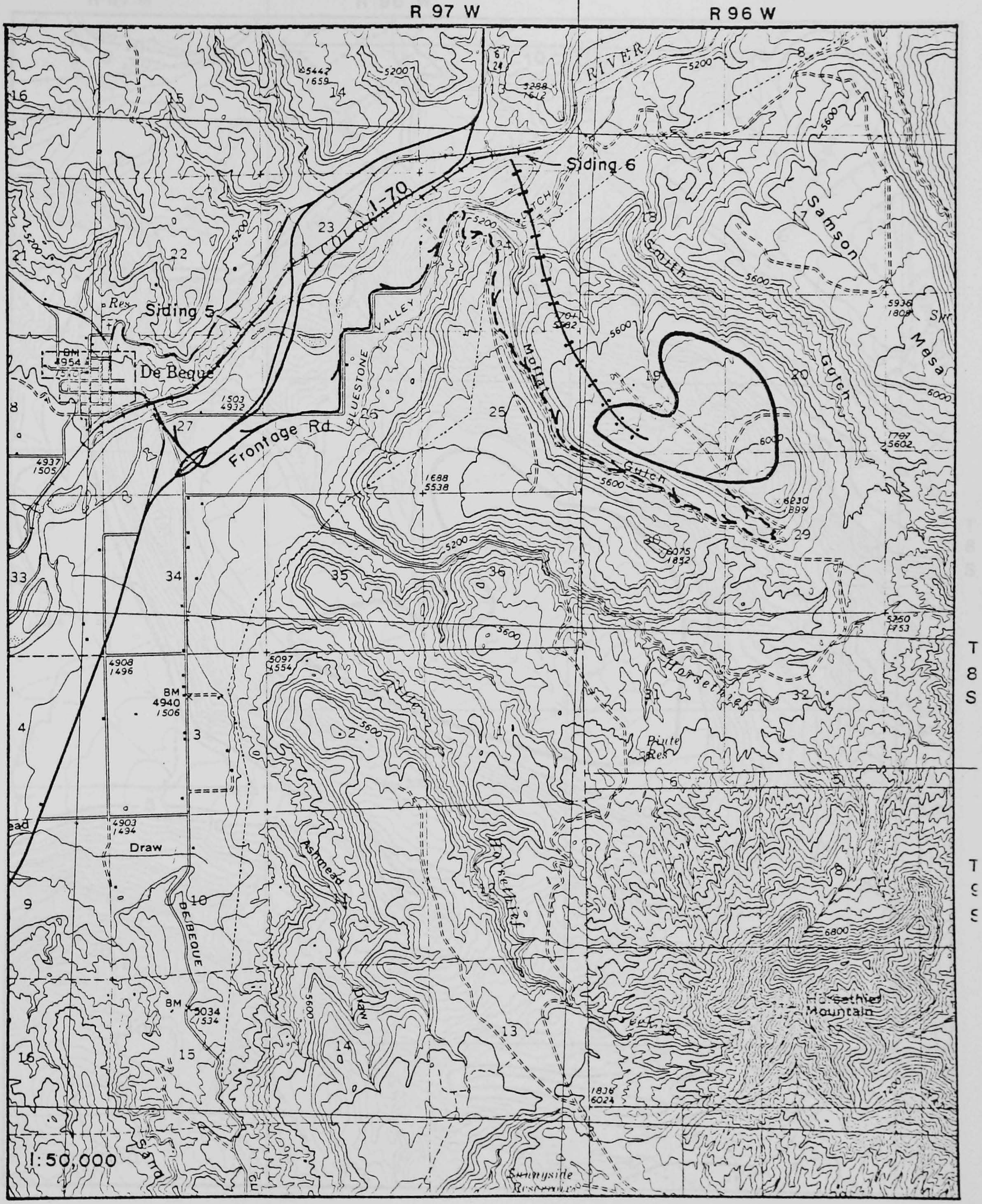


Figure 53. Possible transportation routes to the Lucas Mesa site.

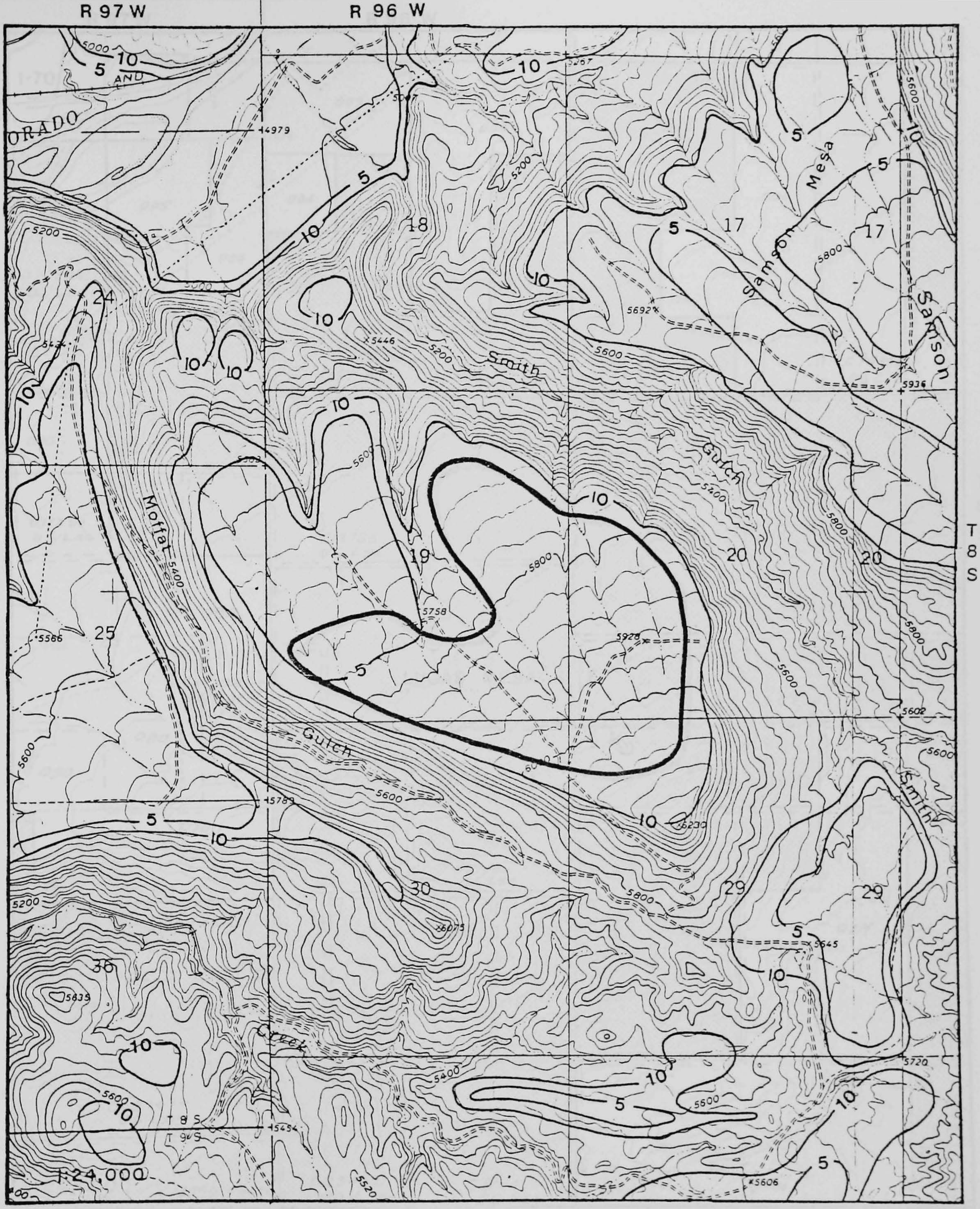


Figure 54. Suitable formation and slope map of the Lucas Mesa site.

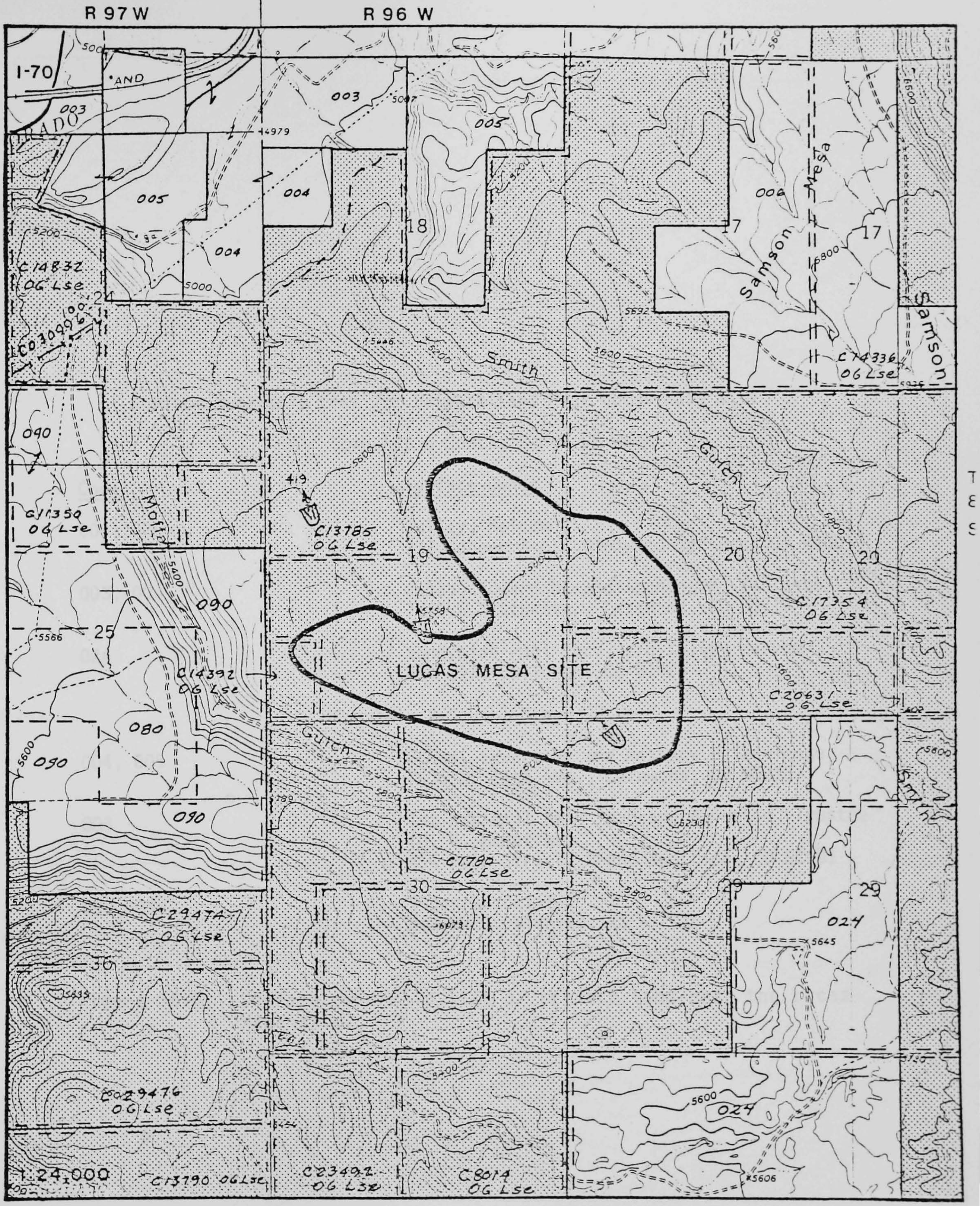


Figure 55-A. Land use and ownership map of the Lucas Mesa site.

Surface Ownership List for Private Land Near Lucas Mesa Site

Township 8 South, Range 96 West

Code	Surface Owner
006, 005	Jolley, Malcom C. 717 Cooper Ave., Glenwood Springs, CO 81601
003, 004	Juhan, Edward N. and Anthony F. Zarlengo 7675 W. 14th Ave., Lakewood, CO 80215
024	Sunnyside Pool Inc., c/o Kelley Harvey Box 117, Collbran, CO 81624

Township 8 South, Range 97 West

004, 005	Juhan, Edward N. and Anthony F. Zarlengo 7675 W. 14th Ave., Lakewood, CO 80215
003	1st National Bank in Grand Junction, Trustee (O. V. Mahaffee) 464 Main Street, Grand Junction, CO 81501
090, 080	Viper Associates Box 2281, Wichita, KS 67201

Figure 55-B. Surface ownership list of private land near the Lucas Mesa site.

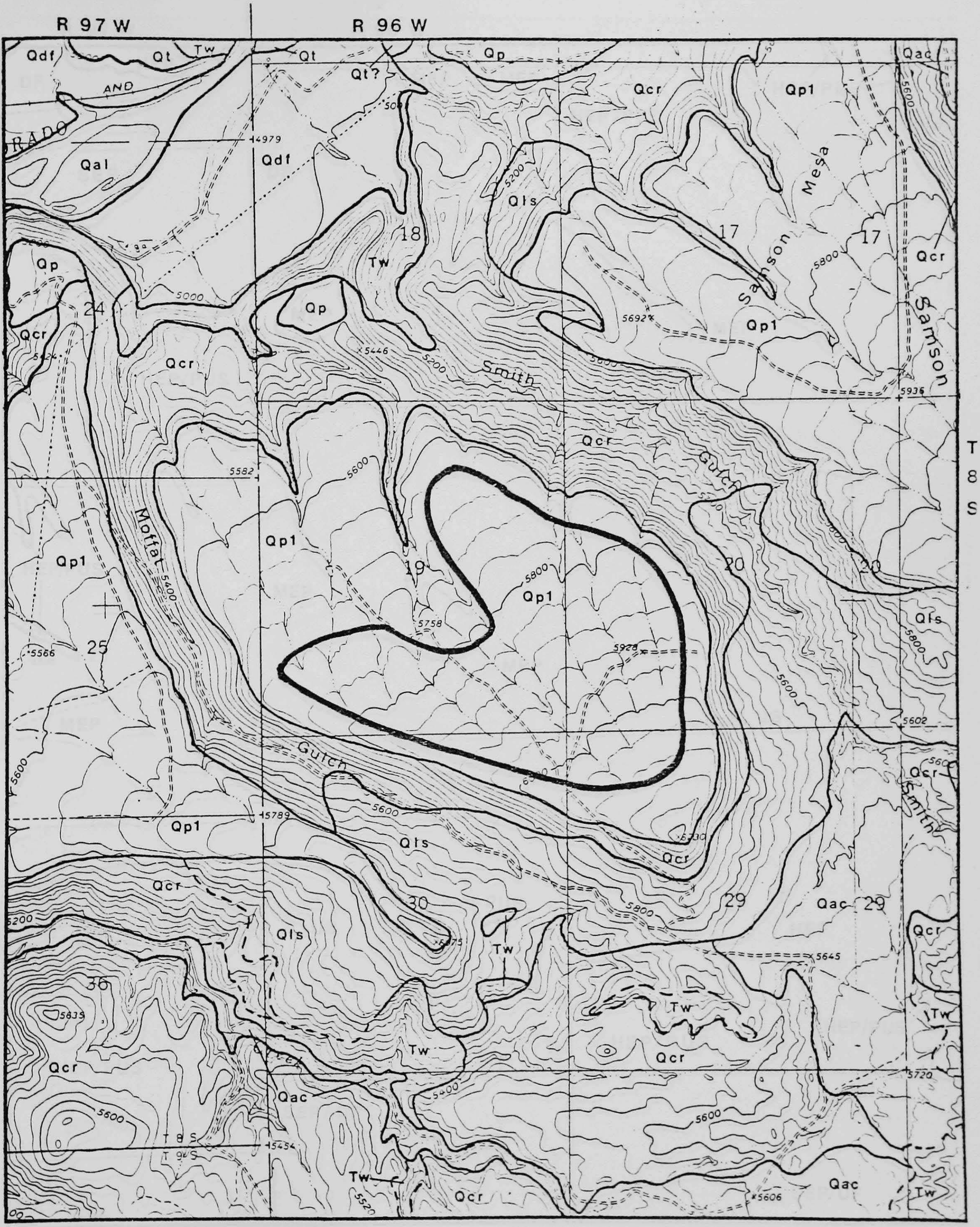


Figure 56. Surficial geologic map of the Lucas Mesa site.

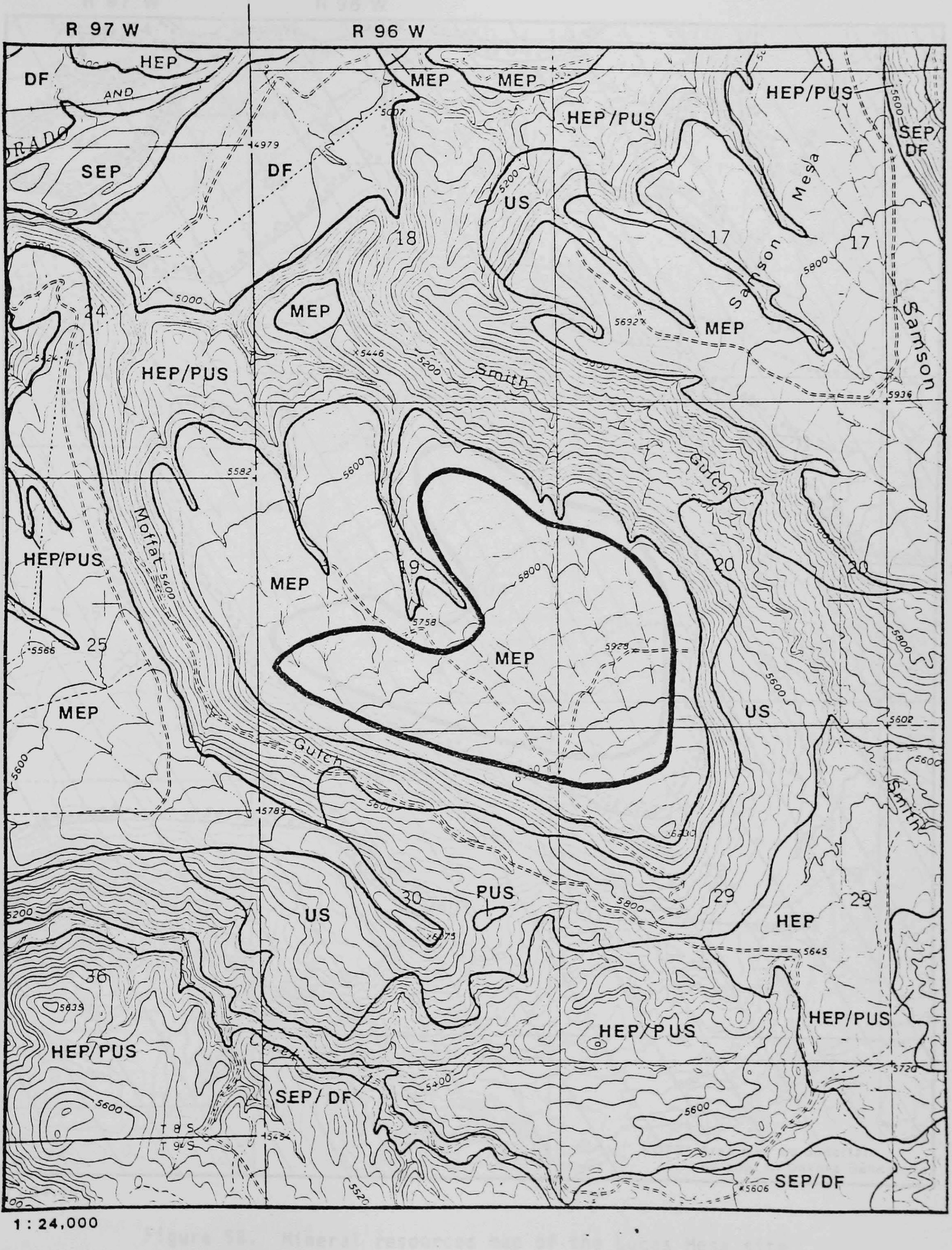


Figure 57. Geologic hazards map of the Lucas Mesa site.

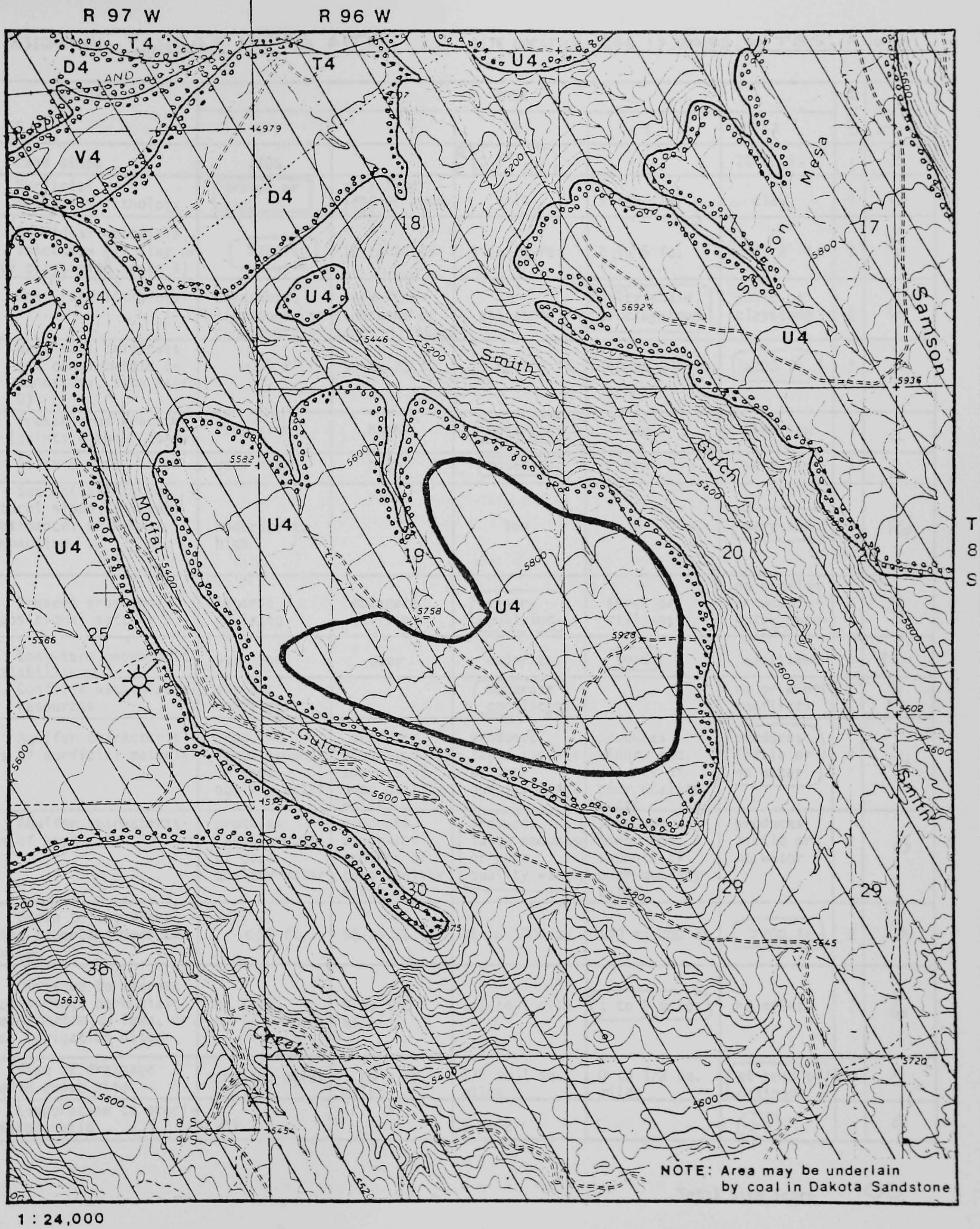


Figure 58. Mineral resources map of the Lucas Mesa site.

SITE DESIGNATION: LUCAS MESA SITE SITE LOCATION: SEC. 19, 20, 29, 30 T8S, R96W

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		[✓ <2% or 5% to 10%]		2% to 5%	1	2
2. Surficial materials lithology	[✓ gravel or sand]	very fine sand or sandy silt	silt	silty clay	clay	1	0
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	[✓ >20 ft.]	10 to 20 ft.	5 to 10 ft.	2 to 5 ft.	0 to 2 ft.	2	0
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	[✓ silty shale or claystone]	shale or claystone	2	6
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	high	[✓ moderate]	low	very low	1	2
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydrocompaction	moderate to high		low		[✓ very low]	4	16
9. Present erosional/depositional setting	intense gullying	moderate gullying	[✓ minor gullying]	sheet or rill wash	no erosion or undergoing deposition	4	8
10. Long-term geomorphic stability	very poor	poor	moderate	[✓ good]	excellent	4	12
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	produces minor-mod. amounts of poor quality water	[✓ produces little or no water]	4	16
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	[✓ produces large amounts or poor quality water]	produces minor-mod. amounts of poor quality water	produces little or no water	4	8
14. Depth to 1st underlying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	1/2 to 1 mile	[✓ 1 to 2 miles]	>2 miles	2	6
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	0 to 1/2 sq. miles	[✓ at head of drainage]	2	8
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 108

Figure 59. Geotechnical rating matrix for the Lucas Mesa site.

4.9 FLATIRON MESA SITE

4.9.1. General Site Description

4.9.1.1. Location

The Flatiron Mesa site is located high above the Colorado River on a remnant of an old pediment surface on the northeast flank of Battlement Mesa. The site is about 4 miles south-southeast of, and across the river from Rifle. Flatiron Mesa site occupies a little over one-half square mile in sections 5, 6, 7, and 8, T7S, R93W in Garfield County.

4.9.1.2. Transportation Aspects

Both the old and new Rifle piles can be moved to the Flatiron Mesa site either by truck or by conveyor. If transported by conveyor they could either be moved over two separate routes (Figure 60) or over one common route. Another alternative would involve use of a conveyor from the old to the new pile, followed by re-use of this conveyor as part of the conveyor system from the new pile to the Flatiron Mesa site. This would require a longer period of movement, but would save the cost of the 2.8 miles of conveyor, approximately $2.8 million.

The most logical common route would be the one from the new Rifle pile to the site (Figure 60). This would require trucking the tailings 2.8 miles from the old Rifle pile to the conveyor loading area at the new pile. Trucking would be possible from both piles over 5.3 miles of surfaced road for the new pile and 3.8 miles of surfaced road for the old pile. An additional 4.6 miles would require improvement and gravel surfacing for either pile to reach Flatiron Mesa site. Conveyors from the new and old piles to the site would be 3.3 and 4.5 miles long respectively. The Grand Junction pile could be moved either by rail (47.5 miles) and truck (9.9 miles) as above, or by rail (47.5 miles) and conveyor (3.3 miles) as above.

The minimum cost of moving the piles by each of these alternatives is:

Rifle piles (new and old):	
Truck only	$10.3 million
Conveyors only	7.4 million
Conveyor and truck	6.0 million
Grand Junction pile:	
Rail and truck	$38.3 million
Rail and conveyor	33.0 million

These estimates do not include the cost of manipulating and covering the tailings on the disposal site.

Either trucks or conveyors in the congested area south of Rifle will be a somewhat hazardous irritant. Conveyors would be less dangerous, and would require a shorter time to move the piles. However, they would require rights-of-way across valuable private land in the Colorado River bottom. This expense was not included in the above costs. The steep grades which are necessary to reach Flatiron Mesa, either by truck or conveyor, will also add to the expense. This has been mostly accounted for in the cost figures. If only conveyors are used, it is assumed that only one conveyor will be purchased, and that it will be moved to the second pile after the first one has been moved. This will prolong the total period of operation in the area.

4.9.1.3. Topographic Setting

Flatiron Mesa site lies on a remnant of an old pediment surface on the northeast side of Battlement Mesa. This pediment remnant now forms an isolated mesa between Beaver Creek and Grass Mesa that stands 2,180 to 2,600 ft above the Colorado River. Elevations on the site range from 7,480 to 7,780 ft, giving a maximum relief across the site of 300 ft. The mesa surface uniformly slopes to the northwest at 4 to 5%. The surface has experienced virtually no stream incision and is not disrupted by any noticeable drainages. The flanks of Flatiron Mesa are formed by steep valley walls about 200 ft high that extend from the mesa surface down to adjacent drainages.

4.9.1.4. Land Use and Ownership

Land ownership and use for the Flatiron Mesa site are shown on Figure 62-A. The site is wholly on public lands administered by the Bureau of Land Management and is subject to existing oil and gas leases. Primary use of the site is for grazing purposes.

In addition to the land use and ownership map, a plat showing surface ownership of the area between the Union Carbide tailings sites and Flatiron Mesa is included to assist in the evaluation of possible roadway or conveyor access routes (Figure 62-B). Ownership of private lands is shown in Figure 62-C.

4.9.2. Geotechnical Evaluation

The geotechnical rating matrix for the Flatiron Mesa site is given in Figure 66. The site received a score of 112 and ranks sixth based on the evaluated geotechnical parameters.

4.9.2.1. Geology

Over 1,000 ft of shale, claystone, siltstone, and interbedded sandstone within the Wasatch Formation underlie the Flatiron Mesa site. The site is within the upper part of the Wasatch Formation. This part of the Wasatch Formation generally is predominantly shale and claystone (Donnell, 1961b). We estimate there is at least 200 ft of mainly shale and claystone beneath the site. To the west in the DeBeque area the Wasatch Formation can be readily subdivided into three members. In the Flatiron Mesa area the sandstone beds of the middle member are less thick and less persistent (Johnson and others, 1979). Because of this, it is difficult to identify the various members of the Wasatch Formation in the Flatiron Mesa area.

Structurally, the Flatiron Mesa site lies in the southeastern part of the Piceance Basin along its axial trend. Bedrock beneath the site is not exposed in the area, but is believed to dip a few degrees to the north or northeast. No faults are known to exist on the site. The nearest mapped faults are found along the Grand Hogback over 10 miles away (Tweto and others, 1978).

The site is entirely underlain by a pre-Wisconsin (older than about 200,000 years) pediment gravel (Figure 63). The pediment deposit may be as old as Pliocene (Yeend, 1969). There are not any good exposures of the gravel on the site, but it probably is a silty, clayey, occasionally sandy boulder gravel. Most gravel clasts are basalt and are generally less than 2 ft in diameter. Some clasts, however, are as large as 8 to 10 ft in diameter. Maximum thickness of the pediment gravel is unknown, but is estimated to be greater than 20 ft. Because of this thick gravel layer, it may be necessary to use an engineered clay and/or artificial liner for a repository constructed on Flatiron Mesa. Excavated gravel could be used for riprap as needed. Parts of the site have a thin veneer of red-brown wind-blown silt on the surface.

The soils on the Flatiron Mesa site are classified as loamy Mollisols of the Aridic to Torriorthentic Haploborolls subgroup.

Sheet wash and rill wash are the only types of erosion occuring on the Flatiron Mesa site. Virtually no stream erosion is present on the site. Landsliding, however, has attacked the flanks of the mesa (Figure 63). The majority of the landsliding probably took place during glacial periods many thousands of years ago. At this time more ground moisture was available to lubricate slide planes, and the streams were carrying more water and actively undercutting unstable slopes. Recent movement in the landslide areas was not identified during this investigation. This, however, does not preclude possible future movement of these unstable areas. Probably the greatest potential hazard to a repository placed on Flatiron Mesa is disruption by landsliding. This problem will need to be fully evaluated during later stages to assure sufficient set-back of the repository from the edge of the mesa.

As shown in Figure 64, no geologic hazards are mapped on the actual site. The erosion potential on Flatiron Mesa is low. Because of this, the site is judged to have good to excellent geomorphic stability for the next 10,000 years. As described above, the greatest natural hazard affecting the site is related to slope instability. Flatiron Mesa will eventually be destroyed by landsliding. It is our opinion that this will almost certainly take longer than a few thousand years and possibly as long as 100,000 to 200,000 yeras. A haul route to the site would not only have to deal with these unstable slopes, but also the severe erosion potential and debris flow hazard present along Beaver Creek.

Several wells have tested the oil and gas potential of the general Flatiron Mesa area, but none have actually been drilled on the mesa. Two wells, one about 1 mile southeast of the site and a second just over 1 mile to the northwest encountered produceable amounts of natural gas. Both wells are now plugged and abandoned, however. Two dry holes have been drilled west of the site about three-fourths to one mile away. The well in section 1, T7S, R94W is shown as a gas well on the U.S.G.S. North Mamm Creek 7 1/2' quadrangle map, but it was dry and plugged according to the records of the Colorado Oil and Gas Conservation Commission.

Coal in both the Mesaverde Group and Dakota Sandstone may underlie the site. Dakota coals are generally thin, and, if present, would be over 9,000 ft deep. These coals are not considered economically important. The Mesaverde coal beds, however, are often several feet thick, and a number of mines extract coal from this formation in the Piceance Basin. Mesaverde coals are probably at least 1,000 ft deep beneath the site. The Mesaverde coal is presently not economically mineable, but it may become a valuable resource in the future.

Potential riprap sources are found on the Flatiron Mesa site. The pediment gravel that caps the mesa contains abundant basalt clasts that probably are suitable for riprap. The pediment gravel, however, does not contain any likely sand resources.

4.9.2.2. Hydrology

The Flatiron Mesa site lies at the head of a drainage divide and has for all practical purposes no drainage basin above it. Potential for stream flooding on site is extremely low. Most runoff from the site drains into an ephemeral creek in Helmer Gulch about one-half to one mile below the site. A small part of the site drains into Beaver Creek. Helmer Gulch flows into the Colorado River about 3 to 4 miles below the site.

Beaver Creek, about 3/4 mile west of the site, is the nearest important surface water. Beaver Creek is being utilized for domestic water for the Rifle community. Public water storage reservoirs are planned in section 32 north and northeast of the site, and in section 7 south of the site.

The surficial pediment gravels that cap Flatiron Mesa probably carry little or no water. A few moist areas just off the north end of the mesa may result from seepage out of the pediment gravel, but it may also result from precipitation trapped within the upper part of the landslide deposits. At certain times of the year following periods of heavy precipitation, minor amounts of water may infiltrate into the gravel. Localized perched water zones may occur at the base of the gravel at its contact with bedrock.

The Wasatch Formation, host rock for the Flatiron Mesa site, possesses highly variable ground-water characteristics (Repplier and others, 1981). In some areas the Wasatch yields almost no water, whereas in other areas Wasatch wells may produce over a hundred gallons per minute. Based on our preliminary interpretation, we believe there are no significant aquifers for at least 150 to 200 ft beneath the Flatiron Mesa site.

Examination of the records of the Colorado Division of Water Resources indicates several registered or permitted water wells and decreed springs are in the Flatiron Mesa area. Information on these water sources is as follows:

Water Wells (as of 11/16/81)

Permit #	Date Drilled	Owner	Location	Distance from site	Depth
32393	8/10/67	W. Massey	C SE NW sec. 31/6S/93W	0.7 miles	142 ft
71917	11/5/73	B. Ammerman	NE SE sec. 36/6S/94W	1.5 miles	100 ft
119511	not yet drilled	J. Parker	NE NE sec. 16/7S/93W	-	-
118605	not yet drilled	D. Dorrell	NW NE sec. 36/6S/94W	-	-

Decreed Springs (as of 11/16/81)

Name	Location	Adj. Date	Adj. Production	Distance from site
Lee Spring #1	NE SW sec. 33/6S/93W	12/31/74	.011 cfs	0.8 miles
Rinehart #6	SW NE sec. 18/7S/93W	7/9/65	.03 cfs	1.1 miles (?)

Other decreed springs and registered wells exist in this area, but are farther from the site. The State Engineer's record also indicates that a well permit (#18851F) was issued to J. Savage on 9/26/74 for a well in the SE/4 NE/4 NE/4 sec. 1, T7S, R94W. Apparently this well has been drilled, because it was adjudicated at .033 cfs on 12/31/74. However, a "Beneficial Use Statement" was never received by the State Engineer, and the permit has expired.

Detailed hydrologic studies will be necessary to determine the impact on these wells and springs of placing tailings at Flatiron Mesa.

4.9.3. Environmental Factors

Vegetation on the Flatiron Mesa site is a fairly dense stand of big sagebrush which is three to five feet high. Very little ground cover exists, but clumps of needle-and-thread grass, wheatgrass, gambel oak, and serviceberry are found scattered throughout the site. Pinon-juniper (mostly juniper) stands occur on the south and west sides where they are mixed with gambel oak. A fairly dense oak stand occupies the north side. The soil is very productive on this site. Mule deer are abundant in the area, especially in winter and spring, and elk also use the site. It is a well-known hunting area for big game. Other common wildlife would include cottontail rabbits, jackrabbits, coyotes, chipmunks, golden-mantled ground squirrels, Goshawks, Scrub Jays, and rock squirrels. A rattlesnake was observed on the site.

There are no documented archaeologic or historic resources within the Flatiron Mesa site according to the records of the Colorado Historical Society.

EXPLANATION SHEET FOR INDIVIDUAL SITE MAPS

Transportation Map

⟶	Existing Surfaced Road
— ⟶	Gravel Surfacing Required
– – ⟶ –	Road Construction & Gravel Surfacing Required
┼┼┼┼┼┼	Railroad Siding
⁚⁚⁚⁚⁚⁚	Conveyor

Suitable Formation and Slope Map

5	Slope Contour Line in Percent
▧	Area Underlain by Unsuitable Formation
▭	Area Underlain by Suitable or Possibly Suitable Formation

Land Use and Ownership Map

├─┤├─┤├─┤ C029006 25' Apln	Existing Pipeline, With Permit No. and R.O.W. Width "Apln" Indicates Permit Applied For
— — — 028445 OG LSE Apln	Oil & Gas Lease Boundary, With Lease No. "Apln" Indicates Lease Applied For
••••••••	Range Improvement Project (with BLM Ref. No.)
▒	BLM Land
080	Private Land With Ownership Code (see Site Map for owner's name)
•—·—·——	Transmission Line (with BLM Ref. No.)
·–·–·–	Telephone Line
⟶ ⟶	Irrigation Ditch (with BLM Ref. No.)
⟶▷	Water Impoundment (with BLM Ref. No.)

Geologic Hazards Map

SEP	Severe Erosion Potential
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	No Hazard

Surficial Geologic Map

Qal	Modern Stream Alluvium
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Qp1	Pediment Deposits, Pre-Wisconsin
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Qls	Landslide Deposits
Qcr	Colluvium and Residuum, Mixed
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Kmv	Cretaceous Mesaverde Group
Km	Cretaceous Mancos Shale
Kdb	Cretaceous Dakota Sandstone and Burro Canyon Fm.
Jm	Jurassic Morrison Formation

Mineral Resources Map

○	Drill Hole Location (well to be drilled)
⌀	Abandoned Location (never drilled, permit expired)
●	Oil Well
⊕	Plugged Oil Well
☼	Gas Well
☼	Suspended (Shut-in) Gas Well
☼	Plugged Gas Well
⊕	Plugged Dry Hole
⁙	Underlain by Potential Gravel Resource
T	Terrace Deposit
U	Upland Deposit
V	Valley Fill
D	Debris Fan Deposit
4	Unevaluated Deposit
⚒	Gravel Pit (may be abandoned)
▧	Underlain by Mesaverde Coal

Note: All base maps from U.S.G.S. 7 1/2-minute quadrangle maps or County Map Series

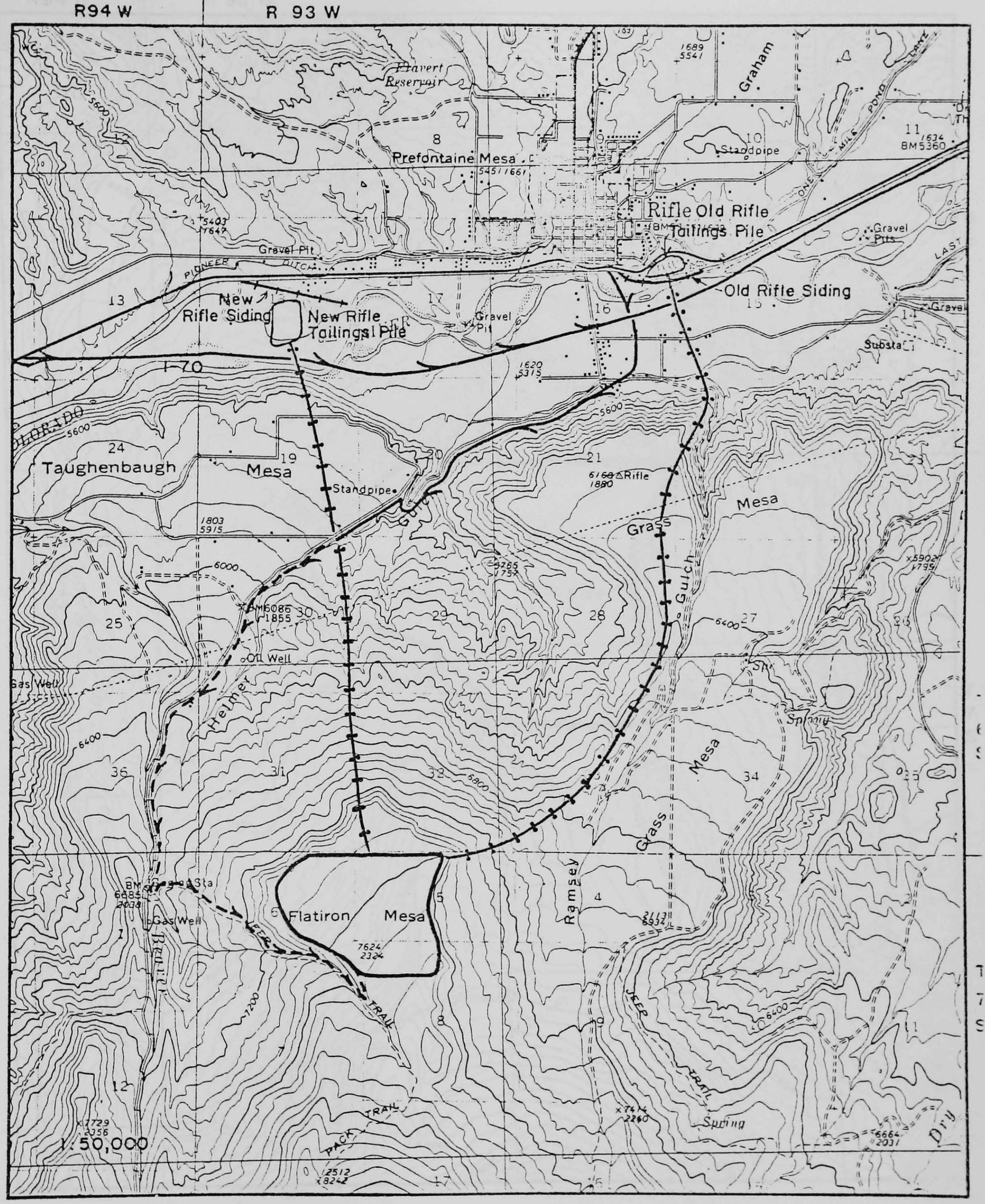

Figure 60. Possible transportation routes to the Flatiron Mesa site.

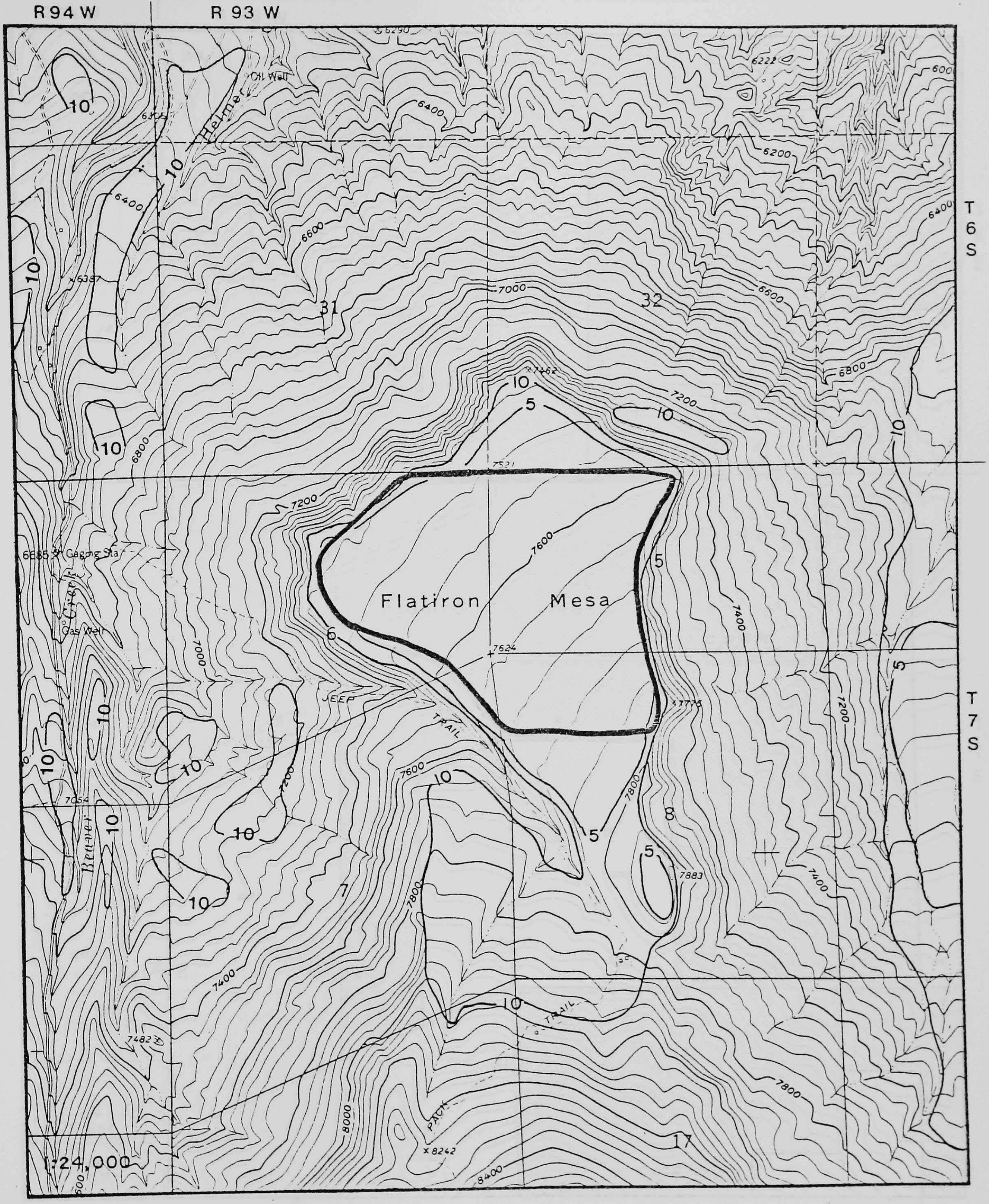

Figure 61. Suitable formation and slope map of the Flatiron Mesa site.

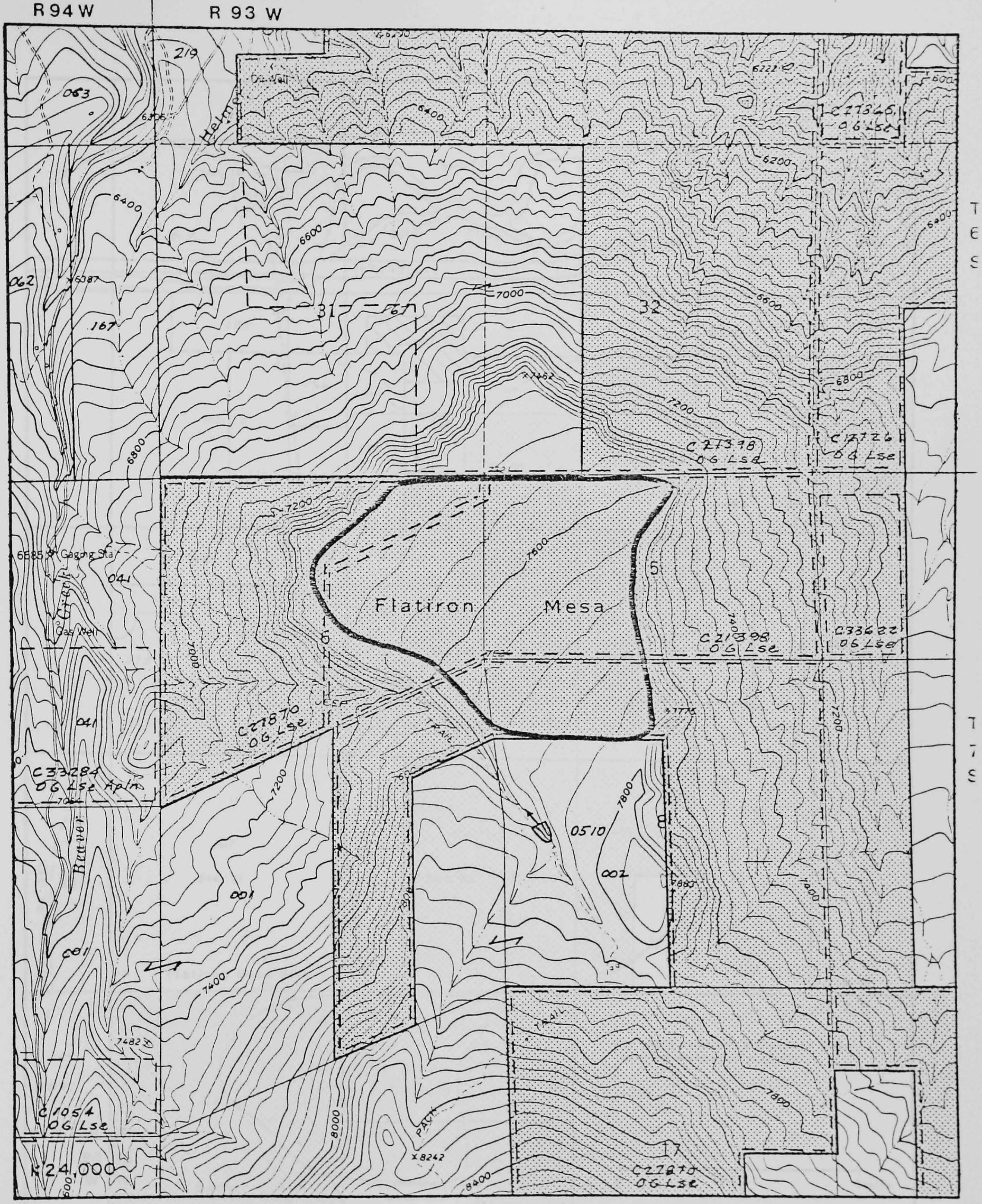

Figure 62-A. Land use and ownership map of the Flatiron Mesa site.

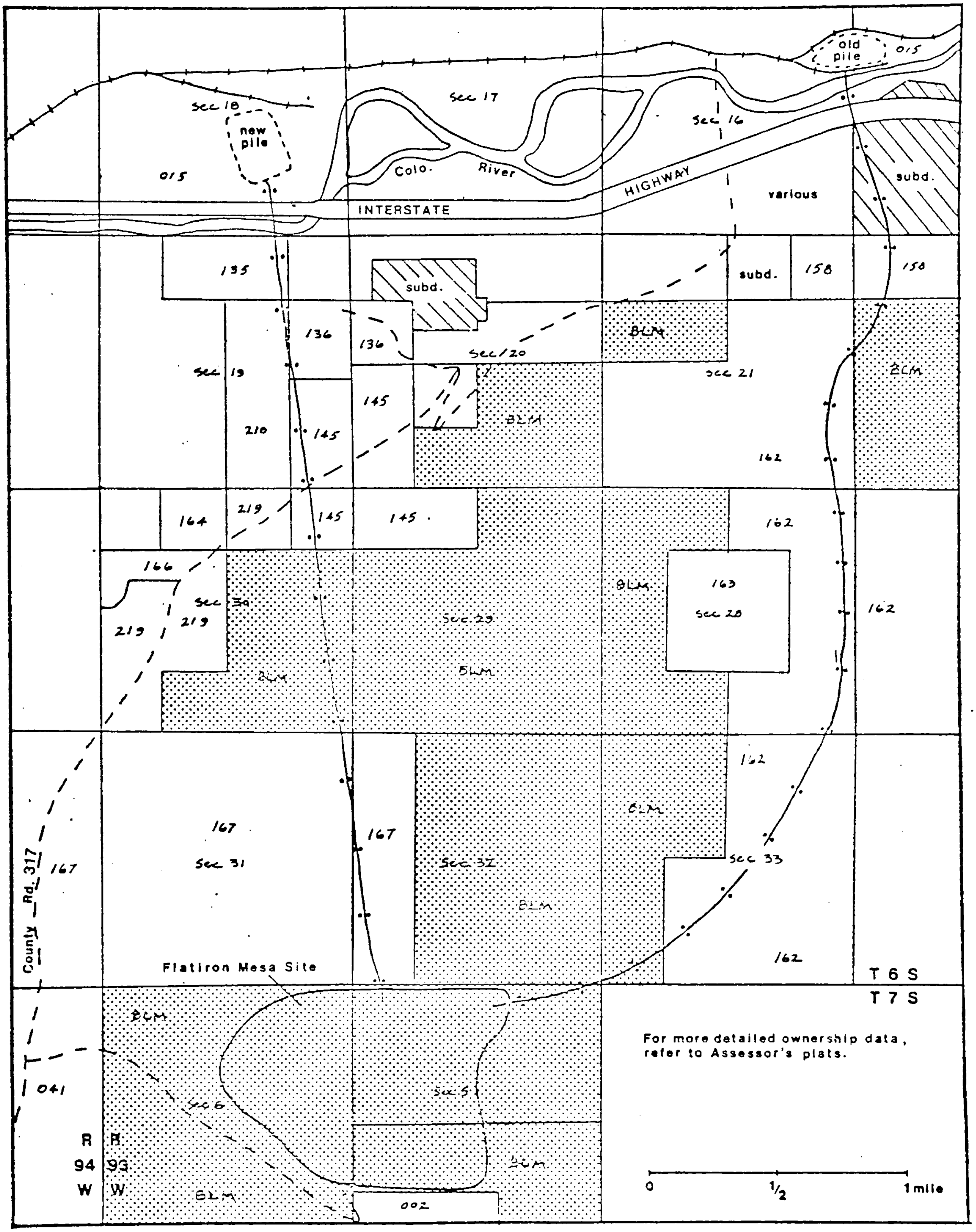

Figure 62-B. Surface ownership plat map for possible transportation routes to the Flatiron Mesa site.

Surface Ownership List of Private Land Near the Flatiron Mesa Site and Along Transportation Routes

Township 6 South, Range 93 & 94 West

Code	Surface Owner
167, 062	Dorell, Donald C. and JoAnn c/o Mamm Peak Assoc. Box 187, Rifle, CO 81650
219	Mead, Verner Donn and E.M. 212 Glendale Drive, Hot Springs, AR 71901
166	Squires, Walter and Audrey 0663 Co. Rd. 317, Rifle, CO 81650
165	McCormick, Glen E. and Beverly E. 8432 Co. Rd. 320, Rifle, CO 81650
145	Mangurian, Pierce 7101 Co. Rd. 117, Glenwood Springs, CO 81601
236	City of Rifle
226	Upton, Linda Marie 10467 Co. Rd. 320, Rifle, CO 81601
225	Murray, Martha J. 9899 Co. Rd. 320, Rifle, CO 81650
136	Johnson, Mary Margaret 17618 San Benito Way, Los Gatos, CA 95030
186	Anderson, S.W. 0016 Remington, Rifle, CO 81650
135	Squires, Jesse W. and Betty Jo Box 997, Rifle, CO 81650
014, 015, 016	Union Carbide Nuclear Corp. Grand Junction, CO 81501
041, 063	Savage, John W. 1122 293 Rd., Rifle, CO 81650
001	Youberg, David Medical Arts Bldg., Sac City, IA 50583
002	Grass Mesa Ranch P.O. Box 1599, Aspen, CO 81612

Figure 62-C. Surface ownership list of private land near the Flatiron Mesa site and along transportation routes.

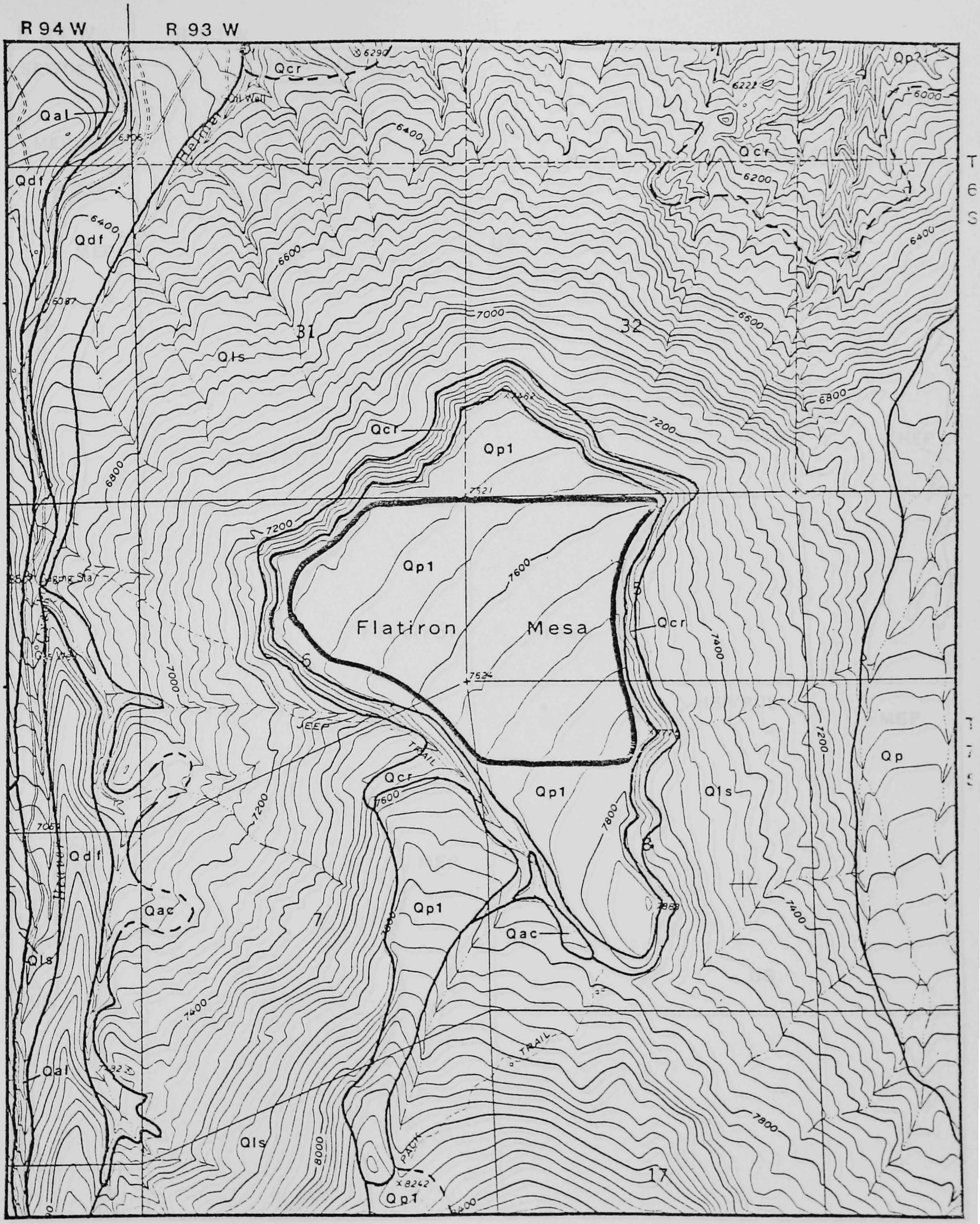

Figure 63. Surficial geologic map of the Flatiron Mesa site.

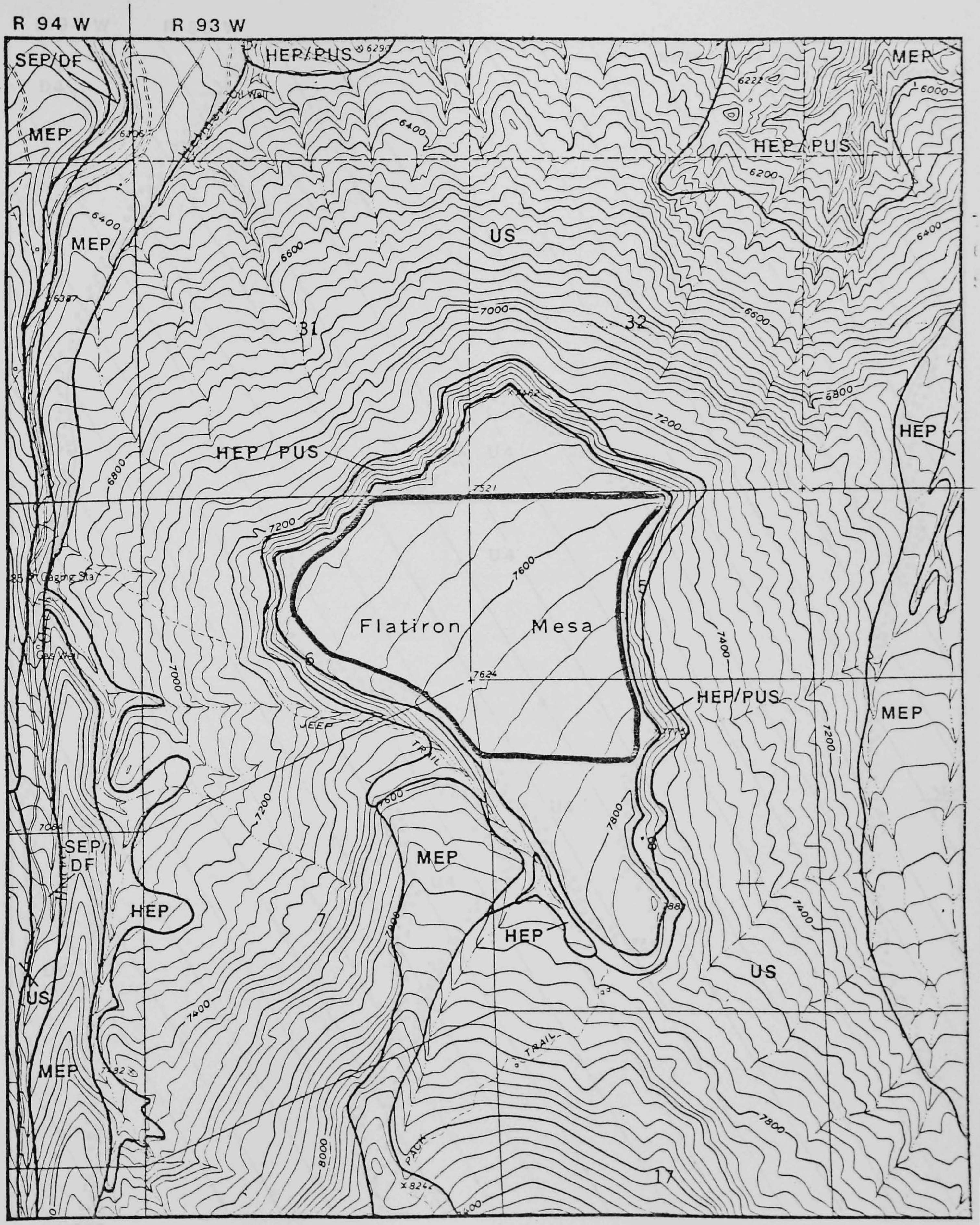

Figure 64. Geologic hazards map of the Flatiron Mesa site.

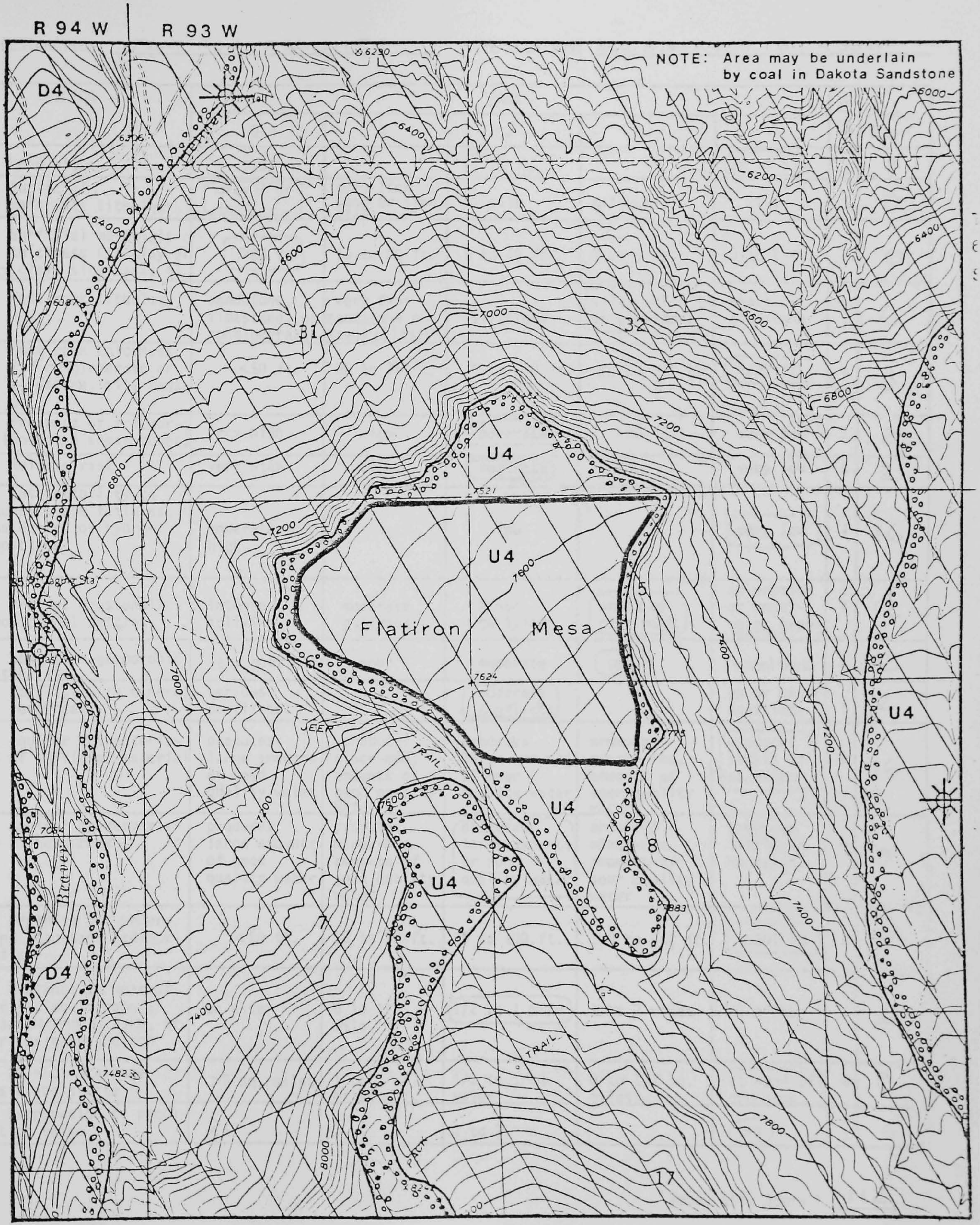

Figure 65. Mineral resources map of the Flatiron Mesa site.

SITE DESIGNATION: FLATIRON MESA SITE SITE LOCATION: SEC. 5, 6, 7, 8, T 7 S, R 93 W

FACTOR	RANK					WEIGHT	Factor Score
	0	1	2	3	4		
1. Land slope	>10%		<2% or 5% to 10%		[✓ 2% to 5%]	1	4
2. Surficial materials lithology	[✓ gravel or sand]	very fine sand or sandy silt	silt	silty clay	clay	1	0
3. Surficial materials thickness (if clay or silty clay, site ranks 4)	[✓ >20 ft.]	10 to 20 ft.	5 to 10 ft.	2 to 5 ft.	0 to 2 ft.	2	0
4. Host rock lithology	sandstone, limestone, or conglomerate	very fine sandstone or sandy siltstone	siltstone	[✓ silty shale or claystone]	shale or claystone	2	6
5. Host rock thickness (if conglomerate or sandstone, site ranks 0)	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
6. Presence of fracturing (joints & shear zones)	very high	high	[✓ moderate]	low	very low	1	2
7. Seismic risk	very high	high	[✓ moderate]	low	very low	1	2
8. Susceptibility to natural slope failures, subsidence, or hydro-compaction	moderate to high		low.		[✓ very low]	4	16
9. Present erosional/ depositional setting	intense gullying	moderate gullying	minor gullying	[✓ sheet or rill wash]	no erosion or under-going deposition	4	12
10. Long-term geomorphic stability	very poor	poor	moderate	[✓ good]	excellent	4	12
11. Conflict with mineral resources	serious conflicts		[✓ moderate conflicts]		no or minor conflicts	1	2
12. Aquifer characteristics of surficial material	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	produces large amounts of poor quality water	produces minor- mod. amounts of poor quality water	[✓ produces little or no water]	4	16
13. Aquifer characteristics of host rock	produces large amounts of good quality water	produces minor-mod. amounts of good quality water	[✓ produces large amounts or poor quality water]	produces minor-mod. amounts of poor quality water	produces little or no water	4	8
14. Depth to 1st under-lying important bedrock aquifer	<50 ft.	50 to 75 ft.	75 to 100 ft.	100 to 200 ft.	[✓ >200 ft.]	2	8
15. Distance to nearest major spring, perennial stream, perennial lake, or major irrigation ditch	on site	0 to 1/2 mile	[✓ 1/2 to 1 mile]	1 to 2 miles	>2 miles	2	4
16. Size of drainage basin above site	>2 sq. miles	1 to 2 sq. miles	1/2 to 1 sq. miles	0 to 1/2 sq. miles	[✓ at head of drainage]	2	8
17. Evaporation to precipitation ratio	<1		1 to 2		[✓ >2]	1	4

Total Site Score 112

Figure 66. Geotechnical rating matrix for the Flatiron Mesa site.

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APPENDIX A. DESCRIPTION OF SITES CONSIDERED BUT NOT RECOMMENDED

A number of sites in addition to the nine recommended potential sites were evaluated during this study but were not recommended. Twenty-four such sites were within target areas, but were eliminated because they did not meet the limiting criteria. Additional locations that were investigated, but not recommended, had been identified in previous studies conducted for the U.S. Department of Energy.

The following summary briefly describes the twenty-four sites within target areas that were excluded because of conflicts with the limiting criteria. They are listed in order of their approximate geographic position, starting at the Colorado-Utah border and working eastward. Included in the list are site name, general location, and rationale for not recommending the site for further consideration. The locations of these sites are shown on Plate 2.

1. West Salt Creek site - Garfield & Mesa Counties; SE/4 sec. 8, sec. 9, sec. 16, N/2 sec. 16, NE/4 sec. 21, NW/4 sec. 22 T8S, R104W; critical mineral resources - gas wells and permitted drill locations on site; severe erosion.
2. Mitchell Road site - Garfield & Mesa Counties; S/2 sec. 3, W/2 sec. 10, S/2 sec. 11, sec 14, N/2 sec. 23 T8S, R104W; critical mineral resources-- gas wells and permitted drill locations on site.
3. Mack West site - Mesa County; S/2 sec. 10, sec. 15, W/2 & S/2 sec. 14, NE/4 sec. 22, N/2 sec. 23, NW/4 sec. 24 T9S, R104W; severe erosion potential.
4. Dry Canyon site - Mesa County; S/2 sec. 20, SW/4 sec. 21, sec. 28, E/2 sec. 29, N/2 sec. 33 T8S, R103W; Severe erosion potential; insufficient size.
5. Railroad site - Mesa County; W/2 sec. 28, N/2 sec. 29, NE/4 sec. 30, T2N, R3W; insufficient size; densely populated rural area; future growth area; partially irrigated agricultural land; partially used for feed-lot operation.
6. Dry Gulch site - Mesa County; E/2 sec. 25, sec. 36 T8S, R102W; severe erosion potential.
7. Lipan Wash site - Mesa County; E/2 Sec. 4, W/2 sec. 3 T2N, R2W; part of site subject to severe erosion and flash flooding; insuffcient size; high relief.
8. Persigo Wash site - Mesa County; sec. 2, SE/4 sec. 3, NE/4 sec. 10 T1N, R1W; severe erosion potential; susceptible to flash flooding; severe transportation hazards - truck haul route must pass through densely populated areas of Grand Junction and surrounding area on heavily used roads.
9. Leach Creek site - Mesa County; N/2 sec. 5 T1N, R1E, S/2 sec. 12, sec. 13 T10S, R100W; severe erosion potential; severe transportation hazards - truck haul route passes through densely populated parts of Grand Junction and surrounding area on heavily used roads.
10. Indian Wash site - Mesa County; S/2 sec. 16, SE/4 sec. 17, E/2 sec. 20, sec. 21 T1N, R1E; severe erosion potential; designated BLM mineral resource area; susceptible to flash flooding; severe transportation hazards - truck haul route passes through densely populated parts of Grand Junction on heavily used roads.

11. Race Track site - Mesa County; NW/4 sec. 5, NE/4 sec. 6 T2S, R2E, sec. 31, SW/4 sec. 32 T1S, R2E; insufficient size; severe erosion problems.

12. Long Mesa Ditch site - Mesa County; N/2 sec. 4 T2S, R2E, S/2 sec. 33 T1S, R2E; severe erosion potential; insufficient size; high relief.

13. Sink Creek site - Mesa County; sec. 15, E/2 sec. 16, N/2 sec. 22 T1S, R2E; future growth area; severe tranportation hazards - truck haul route passes through densely populated parts of Grand Junction and Orchard Mesa on heavily traveled roads.

14. Kannah site - Mesa County; sec. 15, E/2 sec. 16 T2S, R2E; insufficient size; adjacent to Kannah Creek flow line - public water supply.

15. Whitewater Creek site - Mesa County; S/2 sec. 12, NW/4 sec. 13, NE/4 sec. 14 T2S, R2E; severe erosion potential; insufficient size; high relief.

16. Pyramid Rock North site - Mesa County; S/2 sec. 29, S/2 sec. 30, NE/4 sec. 31, NW/4 sec. 32 T8S, R97W; prime development land; near populated area (DeBeque); gas wells and gas pipeline on site; partly irrigated agricultural land.

17. Pyramid Rock South site - Mesa County; W/2 sec. 5, sec. 6 T9S, R97W; prime development land; near populated area (DeBeque).

18. Hubbard site - Garfield County; N/2 sec. 34, W/2 sec. 35 T5S, R93W; insufficient size; severe erosion potential; potential growth area; severe transportation hazards - truck haul route passes through densely populated parts of Rifle on heavily used roads.

19. Dry Creek site - Garfield County; W/2 sec. 25, E/2 sec. 26, NE/4 sec. 35, NW/4 sec. 36 T6S, R93W; insufficient size; future growth area.

20. Grass Valley #1 site - Garfield County; sec. 1 T5S, R92W, W/2 sec. 6 T5S, R91W; high transportation hazards - truck haul route passes through moderately populated rural area (with high growth potential) on well traveled roads; near several homes; potential growth area; near Grass Valley Reservoir (but in different drainage basin); mapped fault adjacent to site; steeply dipping bedrock.

21. Grass Valley #2 site - Mesa County; SW/4 sec. 5, W/2 sec. 7, sec. 8 T5S, R91W; high transportation hazards - truck haul route passes through moderately populated rural area (with high growth potential) on well traveled roads; near several homes; partly irrigated agricultural land; future growth area; near Grass Valley Reservoir (but in different drainage basin); steeply dipping bedrock.

22. Weible Peak site - Garfield County; W/2 sec. 13, sec. 14 T6S, R92W; partly irrigated; partly subdivided; critical ground water recharge area - in direct communication with Colorado River.

23. Garfield Creek site - Garfield County; sec. 9, NE/4 sec. 16 T6S, R91W; insufficient size; severe erosion potential; irrigated agricultural land.

24. Elk Creek site - Garfield County; sec. 30, N/2 sec. 31 T5S, R90W; primarily irrigated agricultural land; future growth area; near population (New Castle); severe transportation hazards - truck haul route passes through the town of New Castle.

Ford, Bacon & Davis Utah Inc. (1977a, 1977b, 1981) identified a number of sites which they believed were acceptable relocation sites for the Grand Junction and/or Rifle uranium tailings piles. These sites were evaluated as part of this investigation, but are not herein recommended for consideration. The sites chosen by Ford, Bacon & Davis Utah Inc. may be suitable for certain types of tailings disposal, but each conflicts with one or more of the limiting criteria used in this study to assess the viability of a particular site for below grade disposal.

APPENDIX B. METHODS OF CALCULATING TRANSPORTATION COSTS, AND COMPONENTS OF THE TRANSPORTATION COSTS TO EACH SITE.

B-1. Methods of Calculating Transportation Costs in Table 3.

Estimates of cost were difficult to obtain because of the many variables involved and the reluctance of haulers to make general statements of cost unless they had a simple established rate structure. The estimates in Table 3 should be considered as approximate only. They give some degree of comparability among transportation systems and disposal sites, but they should in no way be considered as final estimates of all costs of disposal of the piles.

Costs were derived by multiplying the per ton, per mile, or per ton mile cost in Table 3 times the number of tons in each pile (Table 2) and/or the number of miles to each site (Tables 4 and 5). The resulting costs of loading, road construction, hauling, and railroad siding construction are totaled in Table B-1 to show the cost of transportation to each site from each tailings pile, by each transportation system.

B-1.1. Loading

Estimates for loading ranged from $0.22 to $0.66/ton. Burnett Construction of Durango reported that a 6-yard loader, which charges $100/hour, could load 25 tons of sand in a truck in three to five minutes. At the 5-minute rate, this means a cost of $0.33/ton. Ranchers Exploration and Development Corporation estimated that loading mill tailings at their Naturita operation three years ago cost them $0.30/ton.

B-1.2. Truck Haulage

Road construction costs were computed from Procedural Directive 1608.1 (7-10-80) of the Colorado Department of Highways, entitled "Cost Estimating Procedures for Five Year Plan and Construction Budget Requests". Ton-mile hauling costs were taken directly from the schedule of McFarland-Hollinger of Tooelle, Utah, except for the short haul on winding mountain graveled roads. Standard Metals of Silverton, Colorado provided the $0.194/ton mile estimate for this latter category, based on their standard quote for a similar haul.

B-1.3. Rail Haulage

Siding construction costs were computed from estimates provided by the Rio Grande Railroad. These included $80/foot of siding and $20,000 for each switch. Hauling costs were estimated at $0.15/ton mile by one Rio Grande Railroad official.

B-1.4. Conveyor Haulage

Most conveyor cost estimates came from PEMCO (Product Engineering and Manufacturing Company) of Murray, Utah, manufacturers of conveyor systems. The cost of a 36- or 42-inch-belt system was estimated by both PEMCO and Michael DeWitte of Sandia National Laboratories at $1 million per mile.

Power line construction costs along the conveyor were estimated by La Plata Electric, Durango, as an additional $10,000 per mile.

Maintenance and operational costs were approximated from data provided by PEMCO, based on estimates of maintenance (parts and supplies) at $100 per day per mile, power (estimated by La Plata Electric) at $443 per day per mile, and operational labor at $944 per day per mile. At a movement rate of 750 tons per hour for 18 hours each day (with 6-hour shutdown and maintenance time), the 13,500 tons per day would mean a $0.14/ton mile cost of maintenance and operation. This estimate could be off by at least 50 percent. A 1977 publication of the U.S. Bureau of Mines gave figures which would result in an estimate of closer to $0.045 to $0.050/ton mile.

B-2. Components of the transportation cost to each site.

The following table details the various components used to calculate the minimum transportation costs to each site.

Table B-1. Cost breakdown of transporting the tailings to the various sites.

TWO ROAD SITE				
	GRAND JUNCTION PILE:			
		Railroad		
			Loading	$ 1,151,700
			Hauling	11,150,550
			Siding	924,800
		Truck		
			Loading	1,151,700
			Road constr.	230,400
			Hauling	4,958,592
				$19,567,742
	RIFLE PILES:			
		Railroad		
			Loading	$ 1,009,800
			Hauling	38,007,900
			Siding	1,387,200*
		Truck		
			Loading	1,009,800
			Road constr.	230,400**
			Hauling	4,347,648
				$45,992,748
MCDONALD CREEK SITE				
	GRAND JUNCTION PILE:			
		Railroad		
			Loading	$ 1,151,700
			Hauling	11,150,550
			Siding	924,800
		Truck		
			Loading	1,151,700
			Road constr., gravel	105,600
			Road constr., complete	1,096,200
			Hauling	5,673,344
				$21,253,894
	RIFLE PILES:			
		Railroad		
			Loading	1,009,800
			Hauling	38,007,900
			Siding	1,387,200*
		Truck		
			Loading	1,009,800
			Road constr., gravel	105,600**
			Road constr., complete	1,096,200
			Hauling	4,974,336
				$47,590,836

* $462,400 of this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by RR & truck.

** this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by the same transportation system.

TABLE B-1 (CONT.)

6 & 50 RESERVOIR SITE	
GRAND JUNCTION PILE:	
Railroad	
Loading	$ 1,151,700
Hauling	11,150,550
Siding	924,800
Truck	
Loading	1,151,700
Road constr., complete	189,000
Hauling	4,130,066
	$18,697,816
RIFLE PILES:	
Railroad	
Loading	$ 1,009,800
Hauling	38,007,900
Siding	1,387,200*
Truck	
Loading	1,009,800
Road constr.	189,000**
Hauling	3,621,204
	$45,224,904
CAMP GULCH SITE	
GRAND JUNCTION PILE:	
Railroad	
Loading	$ 1,151,700
Hauling	9,056,550
Siding	924,800
Truck	
Loading	1,151,700
Road constr., complete	1,512,000
Hauling	6,522,112
	$20,318,862
RIFLE PILES:	
Railroad	
Loading	$ 1,009,800
Hauling	36,171,900
Siding	1,387,200*
Truck	
Loading	1,009,800
Road constr., complete	1,512,000**
Hauling	5,718,528
	$46,809,228

* $462,400 of this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by RR & truck.

** this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by the same transportation system.

TABLE B-1 (CONT.)

EAST SALT CREEK SITE	
GRAND JUNCTION PILE:	
Railroad	
Loading	$ 1,151,700
Hauling	9,056,550
Siding	924,800
Truck	
Loading	1,151,700
Hauling	5,360,640
	$17,645,390
RIFLE PILES:	
Railroad	
Loading	$ 1,009,800
Hauling	36,171,900
Siding	1,387,200*
Truck	
Loading	1,009,800
Hauling	4,700,160
	$44,278,860
HALLS BASIN SITE	
GRAND JUNCTION PILE:	
Truck only	
Loading	$ 1,151,700
Road Constr.	3,137,400
Hauling	6,700,800
	$10,989,900
RR & Truck	
Rail	
Loading	$ 1,151,700
Hauling	5,967,900
Siding	924,800
Truck	
Loading	1,151,700
Road Constr.	4,158,000
Hauling	4,958,592
	$18,312,692
RIFLE PILES:	
RR & Truck	
Rail	
Loading	$ 1,009,800
Hauling	33,463,800
Siding	1,387,200*
Truck	
Loading	1,009,800
Road Constr.	4,158,000**
Hauling	4,347,648
	$45,376,248

* $462,400 of this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by RR & truck.

** this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by the same transportation system.

TABLE B-1 (CONT.)

CHENEY RESERVOIR SITE

GRAND JUNCTION PILE:	
Truck only	
Loading	$ 1,151,700
Road Constr.	415,800
Hauling	6,871,810
	$ 8,439,310
RR & Truck	
Rail	
Loading	$ 1,151,700
Hauling	7,014,900
Siding	924,800
Truck	
Loading	1,151,700
Road Constr.	415,800
Hauling	4,109,824
	$14,768,724
RIFLE PILES:	
RR & Truck	
Rail	
Loading	$ 1,009,800
Hauling	34,381,800
Siding	1,387,200*
Truck	
Loading	1,009,800
Road Constr.	415,800**
Hauling	3,603,456
	$41,807,856

* $462,400 of this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by RR & truck.

** this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by the same transportation system.

TABLE B-1 (CONT.)

FLATIRON MESA SITE	
GRAND JUNCTION PILE:	
RR & Truck	
Rail	
Loading	$ 1,151,700
Hauling	24,866,250
Siding	924,800
Truck	
Loading	1,151,700
Road Constr.	3,509,800
Hauling	6,702,894
	$38,307,144
RR & Conveyor	
Rail (above)	$26,942,750
Conveyor	
System	3,333,000
Loading	1,151,700
Maint.	1,612,380
	$33,039,830
RIFLE PILES:	
Truck only	
Loading	$ 1,009,800
Road Constr.	3,509,800**
Hauling New	5,185,620
Hauling Old	586,656
	$10,291,876
Conveyors (2) only	
System	$ 4,545,000**
Loading	1,009,800
Maint.	1,474,200
Move Conv.(10%)	333,300**
	$ 7,362,300
Conveyor (1) & truck	
Conveyor	
System	$ 3,333,000**
Loading	1,009,800
Maint.	1,413,720
Truck	
Loading	118,800
Hauling	115,200
	$ 5,990,520

* $462,400 of this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by RR & truck.

** this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by the same transportation system.

TABLE B-1 (CONT.)

LUCAS MESA SITE

GRAND JUNCTION PILE:	
RR & Truck	
Rail	
Loading	$ 1,151,700
Hauling	18,008,400
Siding	924,800
Truck	
Loading	1,151,700
Road Constr.	3,433,500
Hauling	5,145,656
	$29,815,756
RR & Conveyor	
Rail (above)	$20,084,900
Conveyor	
System	2,121,000
Loading	1,151,700
Maint.	1,026,060
	$24,383,660
RIFLE PILES:	
Truck only	
Loading	$ 1,009,800
Road Constr.	3,433,500**
Hauling	11,307,780
	$15,751,080
RR & Truck	
Rail	
Loading	$ 1,009,800
Hauling	12,441,600
Siding	1,387,200*
Truck	
Loading	1,009,800
Road Constr.	3,433,500**
Hauling	4,511,664
	$23,793,564
RR & Conveyor	
Rail	
Loading	$ 1,009,800
Hauling	11,018,700
Siding	1,387,200*
Conveyor	
System	2,121,000
Loading	1,009,800
Maint.	899,640
	$17,446,140

* $462,400 of this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by RR & truck.

** this amount will be saved if both the Grand Junction and Rifle piles are moved to the same site by the same transportation system.

Colorado Geological Survey
Open-File 82-2
Plate 1

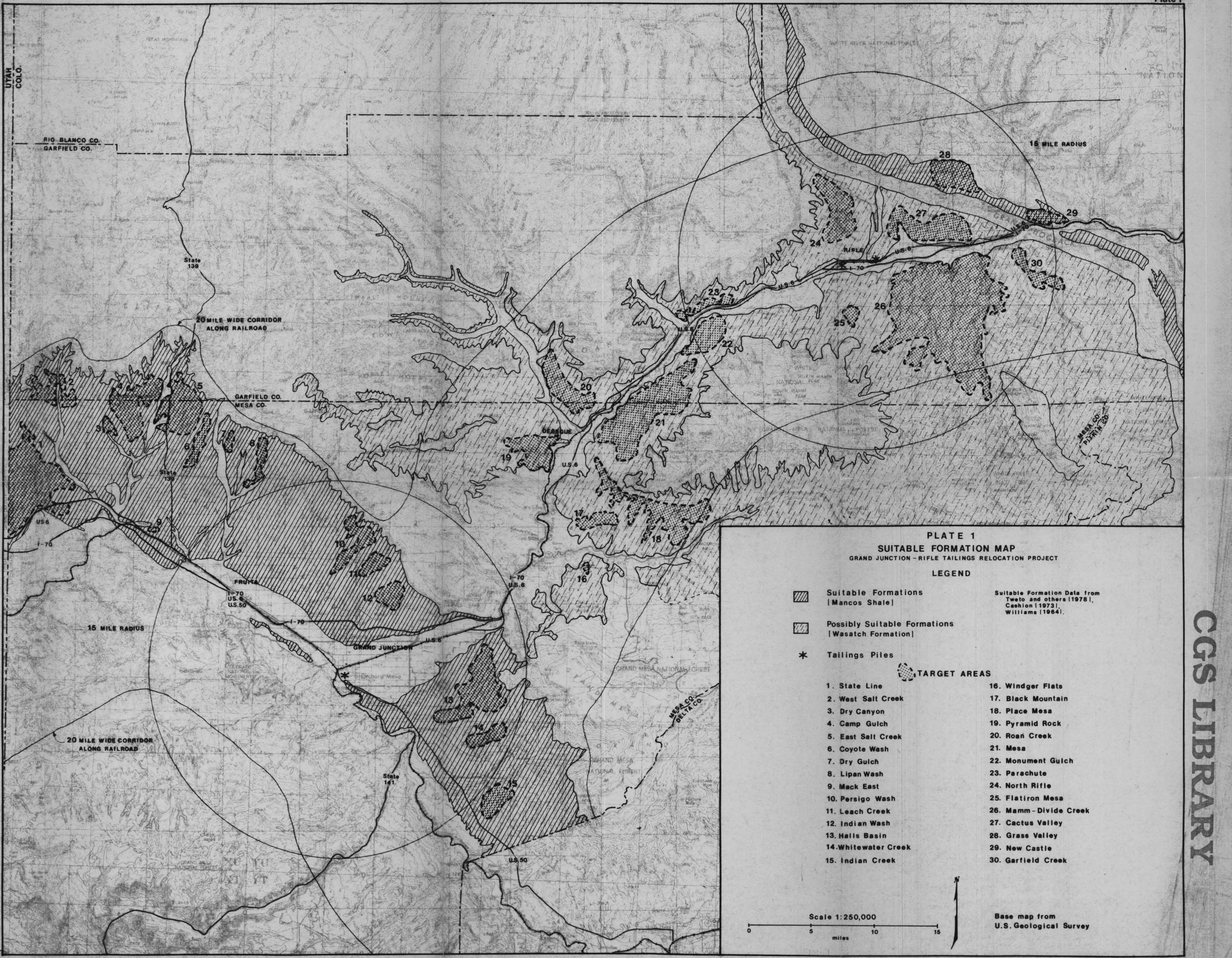

PLATE 1

SUITABLE FORMATION MAP

GRAND JUNCTION – RIFLE TAILINGS RELOCATION PROJECT

LEGEND

▨ Suitable Formations [Mancos Shale]

▨ Possibly Suitable Formations [Wasatch Formation]

* Tailings Piles

Suitable Formation Data from Tweto and others [1978], Cashion [1973], Williams [1964].

TARGET AREAS

1. State Line
2. West Salt Creek
3. Dry Canyon
4. Camp Gulch
5. East Salt Creek
6. Coyote Wash
7. Dry Gulch
8. Lipan Wash
9. Mack East
10. Persigo Wash
11. Leach Creek
12. Indian Wash
13. Halls Basin
14. Whitewater Creek
15. Indian Creek
16. Windger Flats
17. Black Mountain
18. Place Mesa
19. Pyramid Rock
20. Roan Creek
21. Mesa
22. Monument Gulch
23. Parachute
24. North Rifle
25. Flatiron Mesa
26. Mamm-Divide Creek
27. Cactus Valley
28. Grass Valley
29. New Castle
30. Garfield Creek

Scale 1:250,000

0 5 10 15
miles

Base map from U.S. Geological Survey

Colorado Geological Survey
Open-File 82-2
Plate 2

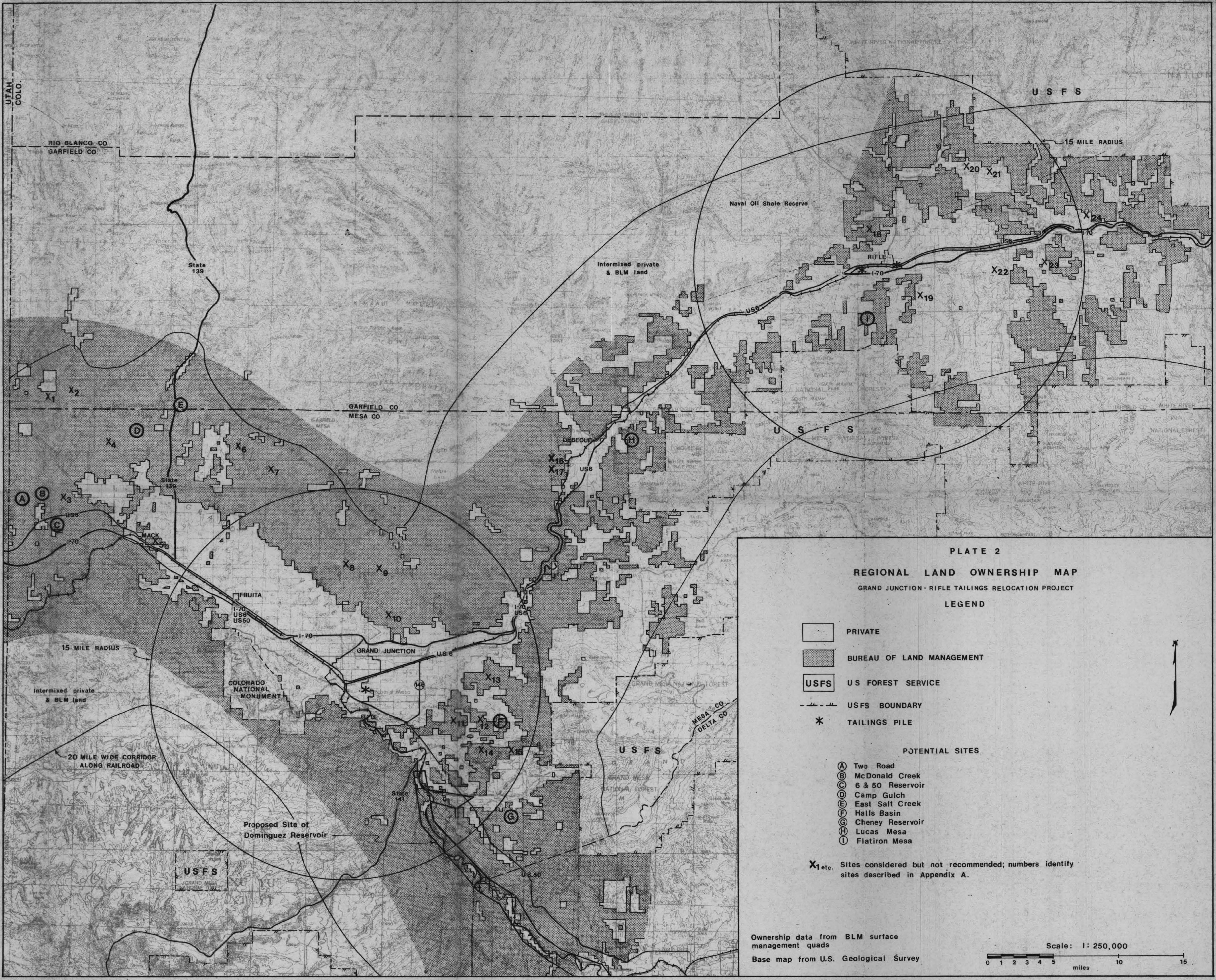

PLATE 2

REGIONAL LAND OWNERSHIP MAP

GRAND JUNCTION - RIFLE TAILINGS RELOCATION PROJECT

LEGEND

☐	PRIVATE
▨	BUREAU OF LAND MANAGEMENT
USFS	U S FOREST SERVICE
- -ll- - -ll-	USFS BOUNDARY
*	TAILINGS PILE

POTENTIAL SITES

Ⓐ Two Road
Ⓑ McDonald Creek
Ⓒ 6 & 50 Reservoir
Ⓓ Camp Gulch
Ⓔ East Salt Creek
Ⓕ Halls Basin
Ⓖ Cheney Reservoir
Ⓗ Lucas Mesa
Ⓘ Flatiron Mesa

X_1 etc. Sites considered but not recommended; numbers identify sites described in Appendix A.

Ownership data from BLM surface management quads

Base map from U.S. Geological Survey

Scale: 1: 250,000

0 1 2 3 4 5 10 15
miles

PLATE 2

[illegible]