APPENDIX 5-1

ADDITIONAL ARCHEOLOGICAL INVESTIGATIONS IN THE EMERY MINE PERMIT AREA IN EMERY COUNTY, UTAH

Mine Plan Applicant:
Consolidation Coal Company
of the Emery Mine Project

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ARCHEOLOGICAL-ENVIRONMENTAL
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ABSTRACT

In July, 1981, personnel of the Archeological-Environmental Research Corporation (AERC) conducted an intensive surface survey of 400 acres in the Emery Mine project extension area in Emery County, Utah. The purpose of the survey was to locate and record cultural resources and assess the potential for the disruption of significant sites in the Emery Mine developmental area.

A total of three archeological sites was recorded during the course of the survey, one prehistoric and two historic habitations. Two of the cultural resource sites are considered eligible for the National Register under criteria d established in 36 CFR 60.6. In addition, all three sites have a low potential for disturbance during mine service area development.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter I

INTRODUCTION

A. General Data on the Project

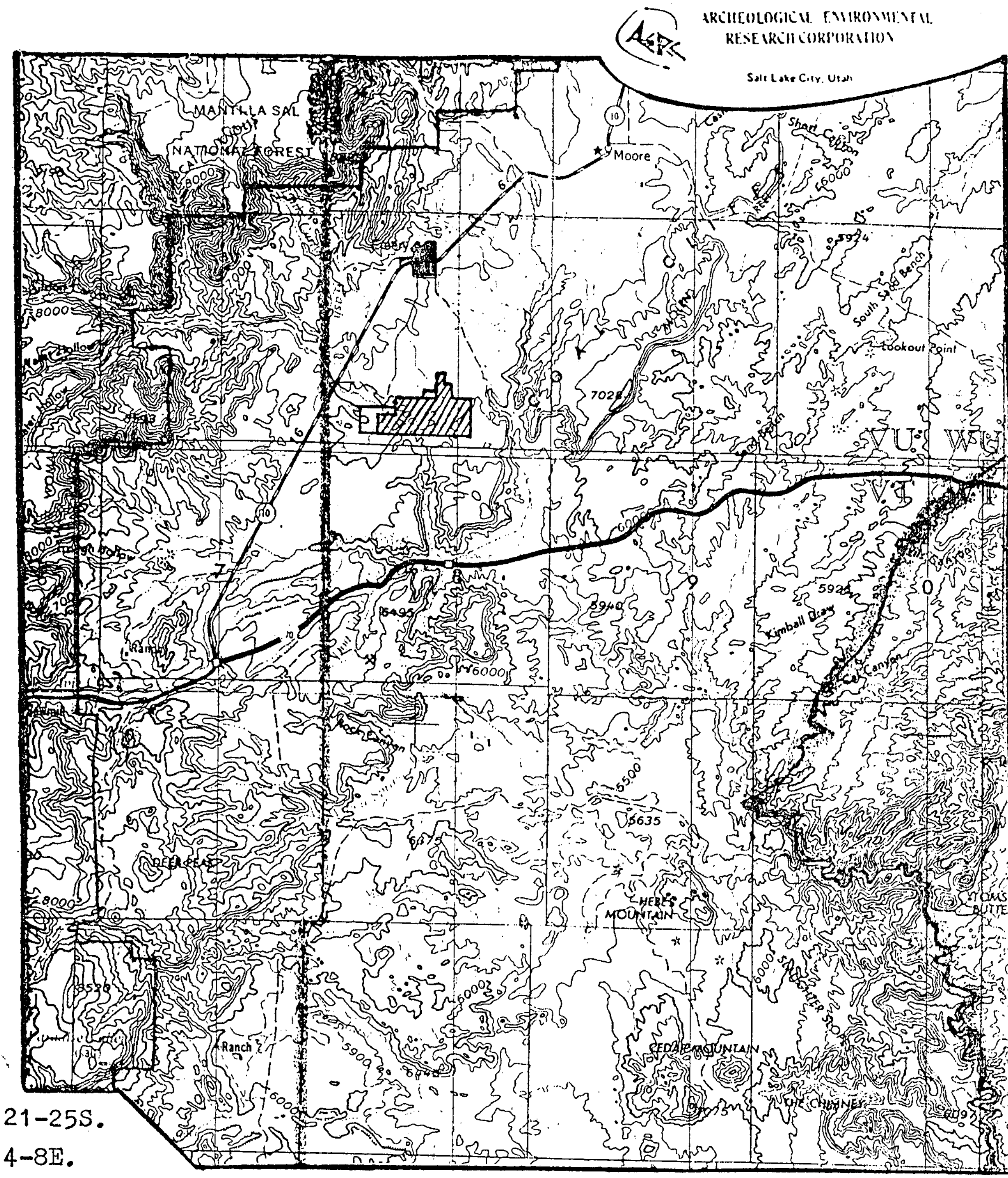
Archeological-Environmental Research Corporation (AERC) of Bountiful, Utah, was contracted by Consolidation Coal Company (CONSOL) to conduct an intensive archeological surface survey on a 400 acre extension to the existing Emery Mine project area. This survey was conducted by AERC from June 24-26, 1981. In accordance with a mining plan application for submission to federal and state authorities, CONSOL requested that cultural resource evaluations be conducted which would comply with pertinent governmental legislation, i.e., Executive Order 11593 "Protection and Enhancement of the Cultural Environment" (Federal Register, Vol. 36, No. 95, May 17, 1971) and "The Archeological and Historical Data Conservation Act of 1974," which is an amendment of "The Reservoir Salvage Act of 1960 (Stat. 220)." For additional information on the development, refer to the mine plan application prepared by CONSOL.

Previous AERC field evaluations for CONSOL in the general central Utah region began in 1976 with an intensive evaluation of proposed well locations and access roads in the Dog Valley locality which is situated six miles south of the Emery Mine project (see Hauck 1976). During the 1977, 1978, 1979, and 1980 field seasons, AERC personnel conducted numerous cultural resource surveys in the general area for CONSOL's coal exploration unit. In 1980, three separate consulting projects were initiated by AERC for CONSOL in this general locality. Two of these projects (CCC-80-2 and 80-3) were conducted within the Emery Mine project area with the latter being the intensive survey related to the permitting of the Emery Mine (see Hauck 1980a-c). AERC has recorded 12 cultural resource sites within the Emery Mine project area, including nine reported in AERC Paper No. 24 (Hauck and Weder 1980) and three reported in the current 1981 project extension. These sites include the Browning Mine site, 42Em1312, 1313, 1314, 1316, 1317, 1318, 1319, 1321, 1385, 1386, and 1387 (AERC temporary site numbers: 488N/2-4, 488N/6-10, and 488N/12). Three other sites lie outside the permit area and include a segment of the Spanish Trail (488N/11) and sites 42Em1371 and 42Em1315. All of the aforementioned sites are situated on private land.

Archeologists attached to the Antiquities Division of the Utah State Historic Preservation Office (SHPO) and to the Bureau of Land Management have also conducted investigations in the Emery Mine project area in 1974 and 1975. Their evaluations resulted in the recording of four sites, 42Em611, 625, 626, and 627, which are all along Christiansen Wash. Thus, a total of 19 known prehistoric and historic cultural resource sites is situated within, or near, the Emery Mine project area as defined on Figure 1.

The 1981 archeological survey was initiated by AERC under U.S. Department of Interior Antiquities Permit No. 81-Ut-179 (expires June 9, 1983). The field investigations on the 1981 extension of the Emery Mine permit area extended from June 24-29, 1981.

The 1981 cultural resource inventory involved one 320 acre land parcel located in Sections 29 and 32 of Township 22 South, Range 6 East; and a smaller parcel of 80 acres in Section 28 of Township 22 South, Range 6 East. Together the 1981 extension of the Emery Mine project area includes 400 acres (see Figure 2).



T. 21-25S.

R. 4-8E.

Meridian: Salt Lake B. & M.

Quad: Salina, Utah

Project: CCC-81-1

Series: Central Utah

Date: 7-6-81

Figure 1

General Project Area

Scale: 1:250,000

Legend:

Permit area boundary

Emery Mine project area 1980

1" = 4 miles

Scale

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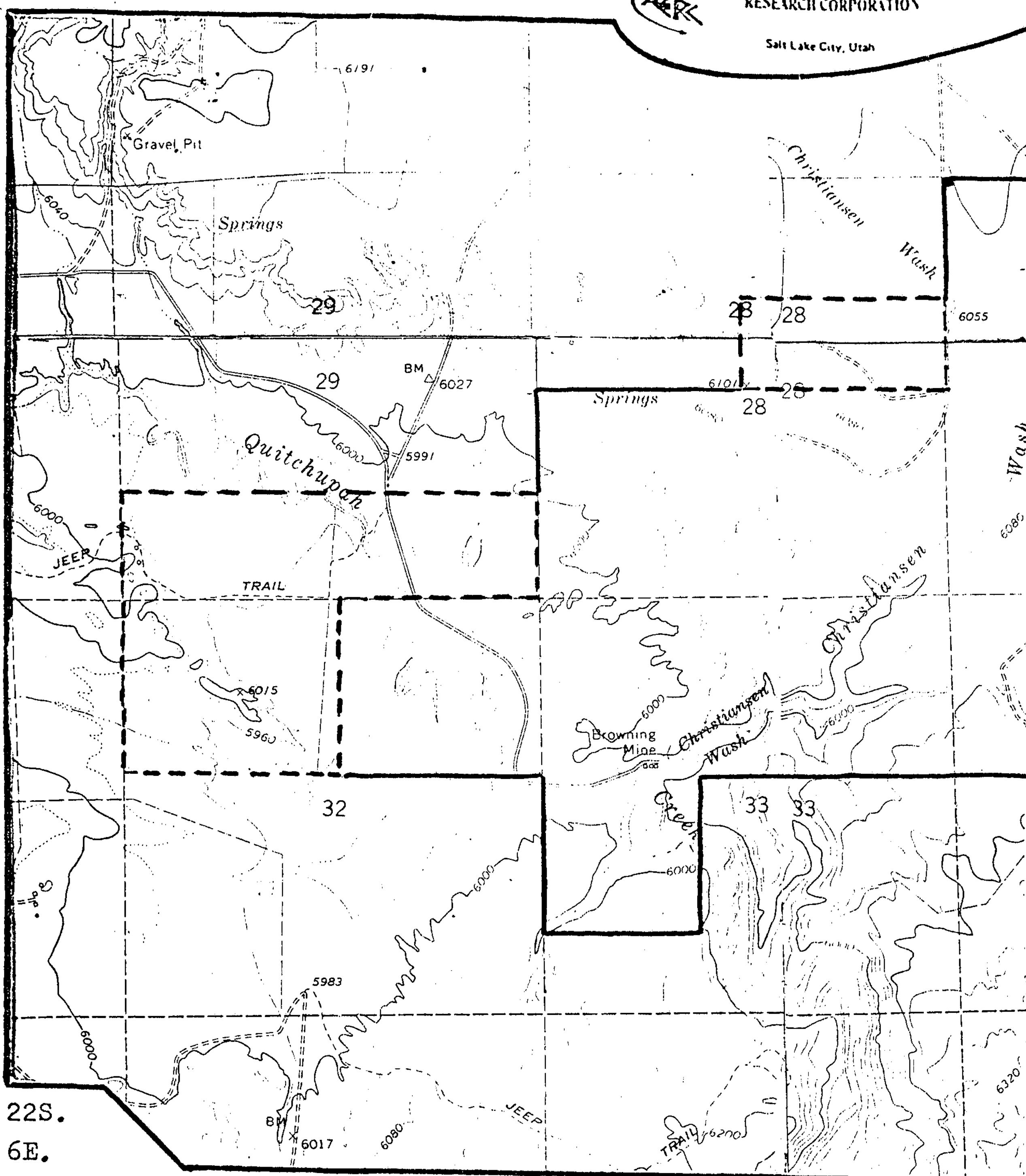
Salt Lake City, Utah



T. 22S.

R. 6E.

Meridian: Salt Lake B. & M.

Project: CCC-81-1 **Series:** Central Utah **Date:** 7-6-81	Figure 2 Intensive Survey Areas	**Quad:** Walker Flat, Utah Composite Map 7.5 Minute USGS

Legend:

1981 project boundary

Previously surveyed project area

0 .5 1 mi

.5 0 .5 1Km

Scale

N

The project area is situated approximately four miles south of Emery, Utah. U.S.G.S. 7.5 minute topographic quads include Emery East, Walker Flat, and Mesa Butte, Utah.

Surfaces within the 1981 extension of the Emery Mine project area are all privately owned. The subsurface within the original project area is primarily privately owned; however, federal land administered by the Bureau of Land Management is situated in the southwest quarter of Section 33.

Field notes and site data are on file at AERC headquarters in Bountiful, Utah. In addition, site reports are being submitted to the State Historic Preservation Office and to all relevant governmental agencies as an appendix to this final report.

B. Environment and Locality

The 1981 extension to the Emery Mine project is adjacent to the original project area located in the northern portion of the Walker Flats segment of Castle Valley. These flats are flanked on the west and east, respectively, by the high Wasatch Plateau piedmonts and the lower elevation coal cliffs. The elevations within the mine project range from 5880 feet to 6100 feet ASL.

The general locality is situated in the Desert Shrub and Pinyon-Juniper ecozones with sparse juniper communities and greasewood communities extending along drainages within the Desert Shrub zone. The vegetation is the Desert Shrub ecozone and consists primarily of scattered pockets of sagebrush Artemisia tridentata, Plains prickly pear Opuntia polyacantha, fishhook cactus Sclerocactus whipplei, rabbitbrush Chrysothamnus nauseosus, and shadscale Atriplex canescens.

The lower elevations of the Pinyon-Juniper ecozone extend into the project area and are primarily associated with the Ferron Sandstone outcrops with their attendant stony soils and drainages. Here Juniperus is the most apparent vegetation with sagebrush, rabbitbrush, and shadscale communities interspersed among the junipers.

Stream channels along the Quitchupah primarily support greasewood Sarcobatus vermiculatus and Tamarix ramosissima communities, while the junipers form the more abrupt and rocky tributaries which have a northern or western aspect.

The surface geology of the Emery Mine project extension area is predominantly composed of Quaternary period alluvial deposits which originated in the Wasatch Plateau piedmonts to the northwest. Two Cretaceous period members of the Mancos Shale Formation are also found in the vicinity of the Quitchupah channel. These include the gray clay flats which make up the Blue Gate Shale Member and the Ferron Sandstone Member.

Precipitation rates within the mine permit area include eight inches of rainfall or snow per annum with four inches occurring between the months of May and September. The freeze-free season for the year is relatively long averaging from 120 to 140 days per annum, which is sufficient for horticultural demands.

Prior to the beginning of the Holocene Epoch (ca. 10,000 years B.P.), the pluvial conditions of the Pleistocene in the eastern Great Basin and in the Wasatch Range began to decrease. The gradual heating and drying trend of the Anathermal (ca. 10,000 to 7500 B.P.) was accelerated until ca. 4000 B.P., although this occurrence varied in different localities throughout the West relative to local conditions. The ecosystems of the project area were, undoubtedly, influenced by these climatic changes from cool and wet through a period of increasing desiccation. After ca. 4000 B.P., the climate in the Intermountain West became cooler and wetter than at the present with a subsequent remigration of floral and faunal species from the upper elevations back into the lower basins. These fluctuations in climate affected prehistoric human occupation patterns in the West as shall be noted in a later section.

Land-use techniques employed in the project area have ranged from hunting-gathering activities, which began during the Pleistocene, to primitive farming technology practiced along the river bottoms by the Fremont peoples as early as 1500 B.P. With the introduction of the Euro-American settlers in the 19th Century, modern farming technology, including horticulture and livestock production, became established in the Castle Valley area. During the Historic period until the present, the general project area has been utilized as rangeland for livestock grazing as well as for minor horticultural purposes.

During the early 20th Century, alfalfa seed was a highly productive crop along the alluvial creek bottoms which extended between the Wasatch cliffs and the coal cliffs. Around 1920, the coal mining industry was established at the junction of Quitchupah Creek and Christiansen Wash at the site of the Browning Mine.

C. Prehistory and History of the Region

The variety of human cultures which have inhabited the project region can be examined from several perspectives. The temporal continuum extending over a range of 12,000 years involves such diverse groups as the early prehistoric big game hunters, the archaic hunter-gatherers, the semi-horticultural Fremont, the Shoshonean bands, the early historic explorers and fur trappers, the Mormon colonists, the coal and cattle barons, the final influx of farmers, small town settlers, and merchants. Man's social and technological variations mirror the complexity of his changing ecological system.

The Prehistoric Period

The Prehistoric period within the project region can be subdivided into four main temporal phases: Paleo Indian, Archaic, Fremont and Shoshonean.

PALEO INDIAN PHASE

The Paleo Indian phase began at approximately 12,000 B.P. and terminated by about 7000 B.P., and is generally divided into three subphases which are known as the Llano, Folsom and Plano cultures (Jennings 1974:81).

The Llano culture was characterized by the hunting of mammoth during a time period between 12,000 B.P. and 10,000 B.P. Since the Llano culture has been defined primarily from the excavation of mammoth kill sites, very little is known about the overall subsistence activities of this culture.

Evidence of the Llano culture has been found over a widespread area in the Intermountain West and Southwest. The Clovis point, a large, lanceolate, fluted spear point is the only artifact which can be used confidently to infer the presence of the Llano hunters. Clovis points, in association with mammoth remains, have been found in New Mexico, Oklahoma, Colorado, Arizona and Wyoming.

Based on these sites, which are characterized by mammoth-Clovis point association, the core area of the Llano culture is limited to eastern Colorado, most of New Mexico, and eastern Arizona. However, the Clovis point by itself has a much larger distribution. Clovis points, or very similar fluted points, have been found throughout the entire United States.

Within the project region of Utah, no characteristic Llano sites have been found, although several isolated Clovis points and one fluted point site have been reported. An isolated Clovis point was reported from Sevier County, Utah (Tripp 1966). Gunnerson (1956) performed a test excavation on a small rockshelter in Emery County (42Em8) from which a local collector had obtained a Clovis point. The test excavation did not, however, recover any additional Clovis points. An unusual fluted point very closely resembling the Cumberland fluted points commonly found east of the Mississippi River was found by an amateur collector in the San Rafael Swell and reported by Hauck 1979 (see 42Em677).

The Folsom culture (ca. 11,000 B.P. to 9000 B.P.) immediately followed the Llano culture, but several differences in subsistence and artifacts allow a clear distinction to be drawn. Although the primary evidence of the Folsom culture is also from kill sites, the fauna hunted and the projectile points used are different from the Llano culture. The Folsom point is a lanceolate, fluted and usually eared projectile point generally smaller and thinner than the Clovis point. In addition, the Folsom point is associated at kill sites with the extinct Bison antiquus.

Folsom kill sites occur predominantly within the same region as the Llano core area but isolated Folsom points are not as widely distributed as Clovis points. Isolated Folsom points are almost entirely limited to the High Plains immediately east of the Rocky Mountain. A total of 11 Folsom points has been found in Utah but only one of these, found by an amateur collector somewhere in the San Rafael Swell, is known from the project region (Tripp 1967).

The Plano subphase of the Paleo Indian phase extends from ca. 9000 B.P. to 7000 B.P. The Plano culture, like the Llano and Folsom cultures before it, was economically partially dependent on large game, bison in particular. However, the Plano culture is characterized by a great diversity of projectile point types. Plano culture projectile points are typically lanceolate, precisely flaked, and non-fluted.

A new hunting technique also became widespread during the Plano subphase, the jump-kill. The jump-kill hunting technique entailed the driving of a herd of bison over the edge of a cliff or arroyo in order to injure or kill the bison.

Evidence of Plano culture inhabitation is predominantly limited to the High Plains east of the Rocky Mountains. The presence of Plano culture hunters in Utah is becoming substantiated by isolated finds.

The presence of Paleo Indian cultures within Utah was minimal even during the Llano subphase, and tended to decrease with time. The slight Paleo Indian utilization of Utah can possibly be tied to the relative scarcity of the large game species in Utah compared to the Great Plains east of the Rocky Mountains. The widespread increase in aridity following the end of the Pleistocene was more acute west of the Rocky Mountains than on the eastern side, and as a result, the large herbivorous animals utilized by the Paleo Indian cultures were present on the Great Plains in considerably greater numbers.

ARCHAIC PHASE

Because of the relatively arid conditions of Utah and the Great Basin, large mammal hunting was not a viable subsistence technique in that area. The Great Basin and adjacent Colorado Plateau of eastern Utah were occupied at an early date by Indian groups who were engaged in a subsistence pattern dependent on smaller game animals and the gathering of wild plant foods.

The utilization of caves and rockshelters by Archaic cultures in Utah has resulted in good temporal sequences for the entire Archaic phase. Radiocarbon dates from Danger Cave (Jennings 1957) verify human inhabitation of the Great Basin as early as 10,000 B.P., but the artifacts retrieved from the lowest levels of Danger Cave are not diagnostic of any recognized culture group.

In addition to Danger Cave, Hogup Cave (Aikens 1970) in the Great Basin, Sudden Shelter (Jennings et al. 1980a) in the southern Wasatch Mountains, and Cowboy Cave (Jennings et al. 1980b) in southeastern Utah have all supplied important data pertinent to the development of a cultural sequence for the Archaic inhabitants of Utah. The Archaic has been divided into three phases based on changes in projectile point types.

The Early Archaic period begins at approximately 8500 B.P. and continues until about 6000 B.P. Subsistence during this period was based on generalized gathering and hunting techniques. A large variety of plant, animal and insect resources was utilized. Hunting was primarily limited to deer and mountain sheep, although antelope and bison were also utilized. The trapping of rabbits and small rodents was also an important source of protein.

The prevalent utilization of caves and rockshelters as habitations in conjunction with the aridity of the area has resulted in conditions suited to the preservation of normally perishable materials. Due to the excellent preservation, it is known that the spear thrower (atlatl) was the implement used for hunting. The atlatl was used with a two- or three-component shaft and stone dart point throughout the Archaic phase. The

Early Archaic period was characterized by four types of dart points, the Pinto, Humboldt, Elko and the Northern Side-notch (Holmer 1978). During this time period, the Elko point type had a limited areal extent confined primarily to the northeastern Great Basin and the northern Colorado Plateau. The Pinto and Humboldt points, generally found in close association in archeological contexts, had the same distribution as the Elko points, but are also found in sites in southern and central Idaho at this time period. The Northern Side-notch point had a very wide distribution during the Early Archaic period encompassing the northern Great Basin, Columbia Plateau, Northern Colorado Plateau and Great Plains.

The Middle Archaic period began about 6000 B.P. and ended about 4500 B.P. Subsistence techniques and the utilization of caves were the same as during the Early Archaic but dart point styles changed and also diversified. Dart points such as the Rocker Side-notched, Sudden Side-notched, McKean Lanceolate, and San Rafael Side-notched were characteristic of this period (Holmer 1978). The Elko point continued to be used during this period in the same areas as it had been during the Early Archaic period. Although the Rocker Side-notched and Sudden Side-notched points were limited in their distribution to central Utah, the McKean Lanceolate and San Rafael Side-notched styles had wider distributions including the Great Plains at this time. Another point style made its appearance during the Middle Archaic, the Gypsum point (Holmer 1978). This point style was very common in the southern Great Basin and northern Colorado Plateau and continued to be utilized through the end of the Late Archaic period.

The Late Archaic period began about 4500 B.P. and ended at roughly 1700 B.P. Subsistence techniques were essentially unchanged from the earlier Archaic periods and the utilization of the Elko and Gypsum point styles was continued although the latter style is generally limited in its occurrence to the southern half of Utah. At the end of the Late Archaic period, two new technological developments occurred which mark a significant change in prehistoric subsistence patterns: the introduction of corn and the bow and arrow.

Evidence of corn horticulture in the latter part of the Late Archaic period has been found at several locations: Cowboy Cave (Jennings et al. 1980b), Cottonwood Cave in western Colorado (Hurst 1948), and Clyde's Cavern in central Utah (Winter 1973, Winter and Wylie 1974). At all three locations, corn caches were found which dated generally between 1600 B.P. and 2000 B.P. The very late portion of the Late Archaic period also witnessed the advent of the bow and arrow. At Cowboy Cave (Jennings et al. 1980b), Rose Spring arrowheads were recovered from the uppermost level and were dated about 1700 B.P.

The entire Archaic phase is characterized by a gathering and hunting subsistence mode and a sequence of dart point styles which have been defined through the analysis of excavated cave and rock shelter sites. Transient habitation of these caves during the annual migratory round is the most widely accepted interpretation of the Archaic subsistence pattern.

The atlatl was the universal Archaic hunting implement until the very last centuries of the Late Archaic period. However, the advent of the bow and arrow around 1700 B.P. does not seem to have eliminated the utilization of the atlatl during the Late Archaic. Gypsum dart points continued to be manufactured even after the appearance of Rose Spring arrowheads at Cowboy Cave (Holmer in Jennings et al. 1980b).

FREMONT PERIOD

The Fremont culture of Utah has traditionally been divided into five regional variants: Parowan, Sevier, Great Salt Lake, Uintah, and San Rafael. However, a recent re-evaluation has resulted in a three-fold division. The Sevier culture now includes the Sevier, Great Salt Lake, and Parowan variants; the Uintah variant is replaced by an, as yet, unnamed northeastern Utah culture, and the San Rafael variant is designated as the Fremont culture. No cultural entity has been defined that can take into account the variation present between these three groups or areas. The differences are ascribed to separate origins (Madsen and Lindsay 1977).

All of these Utah cultures are characterized by the utilization of permanent dwelling, ceramics, and some degree of corn horticulture. According to Madsen, the Sevier culture (ca. 1300-650 B.P.) can be distinguished from the Fremont culture because of the former's primary dependence on wild foods collected from marshland environments west of the Wasatch Plateau. Madsen notes that Sevier villages are normally located near marshland or riverine biomes and consist of deep semi-subterranean dwellings which are frequently clay lined. In addition, adobe surface storage structures are prevalent.

The Fremont culture is found east of the Wasatch Plateau and north of the Colorado River and dates from between 1500 to 700 B.P. The Fremont culture relied heavily on corn horticulture and is characterized by a settlement pattern which is also distinctly different from the Sevier culture (Madsen and Lindsay 1977). Fremont culture villages are relatively small and are located adjacent to permanent streams such as Ivie Creek, Muddy Creek, Ferron Creek, Cottonwood Creek, and Huntington Creek. Fremont culture architecture also differs from that of the Sevier; rock-lined semi-subterranean dwellings and coursed masonry surface storage structures predominate. In addition, Anasazi tradewares are considerably more prevalent in the Fremont culture sites than in the Sevier culture sites.

The unnamed plains-derived culture of northern and northeastern Utah existed from about 1300 to 650 B.P. (Madsen and Lindsay 1977). This culture was dependent upon hunting of bison and the collecting of wild plants. The dwellings are normally shallow basin structures without any clear evidence of the type of superstructure utilized. Unlike the coiled pottery of the Sevier, Fremont, and Anasazi cultures, the unnamed culture produced pottery by the paddle and anvil techniques. It is important to note that there is a considerable spatial overlap of the unnamed culture and the Fremont culture traits in the northern portion of the latter's distribution. There is insufficient data at the present to determine whether the spatial trait overlap is due to alternate occupation, simultaneous occupation by the two cultures or a combination of these two possibilities.

Hunting activities among the Sevier, Fremont, and unnamed cultures are evident from the many varieties of small arrowheads which have been recovered from excavations. Small, stemmed corner-notched (Rose Spring) arrowpoints are present in the earlier phases of all three cultures, but after about 1100 B.P., numerous regional variants developed. Side notch arrowpoint styles (Bear River Side-notched and Uinta Side-notched) were common in the northern part of Utah while Parowan Basal-notched and Bull Creek arrowpoint styles were common in the southwestern and south-central portions of Utah respectively. The Bull Creek points are of particular interest because they are found in high frequencies at both Kayenta Anasazi sites in southern Utah and Fremont sites along the east side of the Wasatch Mountains (Coombs Village, Bull Creek sites, Snake Rock Village, Old Woman, and Poplar Knob) and probably indicate the reciprocal exchange of males for matrimonial purposes (Holmer and Weder 1980).

Dart points, the Elko series and Gypsum, in particular, are also found in association with Fremont sites. This association has been used by Schroedl (1976) to verify the indigenous development of the Fremont culture from Archaic antecedents. Dart points, during the Archaic, were used as both projectile points and knives (Weder in Jennings et al n.d.) but their function in the Fremont context has not yet been evaluated.

In reference to Utah, the Mesa Verde and Kayenta variants of the Anasazi culture are of particular importance. The San Juan Anasazi culture was centered around the Four Corners area where Colorado, New Mexico, Arizona, and Utah meet. The Kayenta Anasazi inhabited the extreme southern periphery of Utah from the San Juan River west to central Utah. As has already been noted, Kayenta influence is particularly evident in a narrow band of sites running from Coombs Village northwards past the Henry Mountains to the Snake Rock Village site adjacent to Interstate 70 on the east side of the Wasatch Plateau.

SHOSHONEAN PHASE

The Shoshonean populations, who were the sole inhabitants of Utah at the time of Euro-American contact, have been in the northeastern Great Basin region since approximately 650 B.P. Their origin has been the subject of considerable controversy, however. Several hypotheses have been expressed.

One hypothesis maintains that the Shoshoneans came from the southwest of the Great Basin at about the time of the dispersal of the Sevier, Fremont, and Anasazi agriculturalists (Madsen 1975b and Lamb 1958). Gunnerson's hypothesis (1962) states that the Fremont, Sevier, and Virgin cultures were Shoshonean peoples who had taken up horticultural and ceramic techniques diffused from the Anasazi, but later reverted to an Archaic subsistence style after a climatic change which made agricultural subsistence techniques unproductive.

Regardless of which hypothesis is correct, Shoshonean groups (Ute, Paiute, Shoshone and Bannock) were inhabiting the Great Basin into eastern Utah at ca. A.D. 1300, roughly coincident with the disappearance of the Fremont and Sevier cultures.

The Shoshonean subsistence pattern was quite similar to the Archaic adaptation. Small familial bands were engaged in a gathering and hunting subsistence utilizing a wide variety of non-domesticated plant, mammal and insect species.

Very little archeological evidence is available for this time period. Two characteristic artifact types can generally be associated with the Shoshonean occupation of Utah. The bow and arrow was utilized for hunting and a type of arrowhead, the Desert Side-notch point, has been correlated with the Shoshonean occupation (Holmer and Weder 1980). The Shoshoneans also utilized ceramics to a small degree. Shoshonean ceramics are easily distinguished from Sevier, Fremont, and Anasazi wares by the former's relative crudeness. Shoshonean ceramics are typically thick-walled, have large temper particles, are poorly smoothed, exhibit little decoration and have been fired in an uncontrolled or oxidizing atmosphere.

The Protohistoric Period

The prehistoric Shoshonean occupation of the Intermountain West continued up to and through the period of Euro-American contact. The Indian groups inhabiting the area of eastern Utah within which the project locality is situated came to be called the Utes.

PRECONTACT

The Utes are a group belonging to the Shoshonean (Uto-Aztecan) linguistic family of which there are three branches: Ute-Chemehuevi, Shoshoni, and Mono-Paviotso. The Ute-Chemehuevi branch includes those groups which came to be known as the Utes, Southern Paiutes, and Chemehuevi. Although there is little archeological evidence, the Utes probably were characterized by a social organization and subsistence mode quite similar to all of the other aboriginal groups in the Great Basin and Colorado Plateau. The Utes were pedestrian gatherers and hunters who utilized a relatively large area of western Colorado and eastern Utah (Steward 1974).

The Utes were grouped into loosely organized bands consisting of extended families. Leadership was present only for subsistence task groups. The Utes could be reliably distinguished from the other contemporary aboriginal groups only in terms of linguistic differences.

Group territoriality was developed only in a statistical sense. A particular Ute band might consider a certain area as a home, but the seasonal round of each band was highly variable from year to year. The area with which any band was most familiar was not exclusively utilized by that band. Intermarriage among the various Ute bands tended to maintain linguistic unity but blur the definition of a territorial homeland for any particular band. Except for those Utes who were utilizing the aquatic resources around Utah Lake, local populations were small and mobile (Steward 1974).

EARLY CONTACT

The presence of the Spanish colony at Santa Fe by 1598 resulted in the first contact between the Utes and Euro-American groups. The relationship which developed between the Utes and the Spaniards was consistently friendly and resulted in the spread of the horse among the Ute bands. When the Utes obtained the horse, a change in their subsistence occurred. The equestrian Ute was able to travel more widely and more effectively and concentrate on bison hunting (O'Neill 1973).

The utility of the horse was strongly mitigated by environmental factors, however. The maintenance of an extensive horse herd required substantial supplies of grass which generally limited the advantage of the horse to those areas where grass was plentiful such as western Colorado, the Uintah Basin, and along the western slopes of the Wasatch Mountains. The supply of grass also determined the distribution of the bison. The horse was, therefore, not equally valuable to all of the Ute bands. The bands in Colorado were able to support their horses whereas those bands in Utah, eastern Utah, in particular, were unable to utilize the horse effectively and were more likely to eat a horse than to ride it.

Considerable trading activity with the Utes was occurring during the 17th and 18th Centuries. Of particular importance was slave trade (O'Neill 1973). The Utes were able to conduct slave raids on neighboring tribes (especially the Navajo) because of their equestrian status. They then exchanged their slaves for horses and other Spanish goods. Whether the slaves were exchanged with traders travelling into Ute territory, or were driven by the Utes to Spanish settlements, is unknown because of the lack of documented evidence. Until the 1770s, there was little official Spanish interest in the territory of the Utes. However, at that time, King Charles III of Spain decided that an exploration of the areas north of Santa Fe would be beneficial to Spanish control. His developing interest was a reaction to the growing influence and explorations by the British and French in the West.

The Adams-Onis treaty of 1819, which gave Mexico its independence, resulted in an influx of Americans to Santa Fe. Most of the Americans came to engage in trapping. The newly arrived trappers caused a considerable increase in traffic along the Spanish Trail and an increase in competition for the available fur resources. This competition was not welcomed by the Utes, who were no longer consistently friendly with the Euro-Americans.

Although there were a large number of independent trappers operating in Utah, their activities have not been well documented. Antoine Robidoux was an important trapper, who by 1824, was operating primarily in the Uinta Mountains William Ashley and Peter Skene Ogden were trapping in the northern Ute territory during the summer of 1824 and, at about the same time, Jedediah Smith was exploring eastern Ute territories to evaluate their trapping potential (O'Neill 1973).

The growing traffic along the Spanish Trail had an important effect on the local Ute bands. Wakara, a Tumpanuwache leader, became quite powerful in the 1820s by conducting horse raids in southern California and returning to Utah by way of the Spanish Trail (Lyman and Denver 1970). He enhanced his power and wealth by exacting tribute from travelers along the trail and by the trading of stolen horses and Pahvant and Paiute slaves (O'Neill 1973). In addition, Wakara and his band actively engaged in fur trapping.

By the late 1830s, there was considerable competition for the fur resources of Utah and western Colorado. Robidoux established a permanent fort and trading center in 1837 near White Rocks in the Uinta Basin to capitalize on the beaver-laden streams of the Uinta Mountains.

The prosperity of the fur trade was not destined to last very long, however. The fierce competition over trapping areas led to widespread disruptive conflicts and, most importantly, the demand for furs used to make the beaver skin hats which were fashionable in Europe and the eastern United States declined rapidly about 1840 as the fashions changed. Fort Robidoux was burned in 1844 by the Utes, who apparently blamed the trappers for the declining value of their furs (O'Neill 1973; Lyman and Denver 1970).

The decline of the fur trade had a serious impact on the Ute bands of Utah. The entire economic base of the Utes began to disintegrate after 1840. The trading activities with Santa Fe began to dwindle with the decline in the horse and slave trade. The termination of Mexican control of the area in 1846 and the subsequent loss of contact for slave trade into Mexico (Lyman and Denver 1970) was very disruptive to the relationships existing between Utah and Santa Fe.

During the declining years of the fur trade, the largest invasion of Ute territory occurred. Beginning in 1847, Mormon pioneers began to move into Utah and rapidly swelled their numbers through immigration. At first, there was little conflict with the Utes because the major Mormon settlement, Salt Lake City, was on the periphery of the Ute territory and the earliest Mormon expansion was to the north. In 1849, Fort Utah (later to become the town of Provo) was founded near Utah Lake on the traditional campsite of the Tumpanuwache band. Since the Tumpanuwache band, still under the leadership of Wakara, had been forced to revert to their earlier mode of subsistence due to the decline of the fur trade, their utilization of the resources around Utah Lake became of vital importance. The conflicting interests in the Utah Lake vicinity escalated into a series of raids and counterraids during the 1850s which became known as the Walker War. In the end, the Utes were forced to leave the valley and moved east across the Wasatch Mountains (O'Neill 1973).

The next few years were difficult for the Utes, who were being gradually forced to split up into small bands and resume a subsistence mode similar to the precontact period. Some of the bands, however, chose to raid Mormon settlements and farms to obtain cattle so that they could avoid starvation. These raids became more prevalent during the 1860s. Raids were conducted on the Mormon settlers west of the Wasatch and the Utes returned to the unsettled areas east of the Wasatch with the stolen cattle (O'Neill 1973). Although several bands were responsible for these raids, one man by the name of Black Hawk became the focus of the blame for all the raiding.

The areas east of the Wasatch Mountains remained under Ute domination for several years. A Mormon attempt to colonize at Moab was undertaken in 1855, but the Mormon settlers were harassed by the Utes and forced to return to Salt Lake City. It was not until 1877, by which time the Utes had been removed to the Uintah Reservations, that Mormon colonists were able to safely settle east of the Wasatch Mountains (O'Neill 1973).

The Historic Period

The history of the east-central coal areas of Utah begins with the exploration and colonization efforts of the Spanish during the last quarter of the 18th Century. East-central Utah was first explored and mapped by the Dominguez-Escalante Expedition of the 1776-1777, in its efforts to establish a line of communication between the Spanish settlements of New Mexico and Monterey, California (Miller 1968).

Though the Dominguez-Escalante Expedition failed to achieve this end, subsequent attempts from the New Mexico settlements and the travelings of Spanish and American fur trappers, traders and frontiersmen resulted in a connecting route known as the Old Spanish Trail (Miller 1968:Map 20). Along this route, which came up from Santa Fe through the San Juan country, across the Colorado River at Moab, over the Green River at the present site of Green River, across the San Rafael Desert into Castle Valley, then south through

Salina Canyon to southwestern Utah and southern California, passed thousands of horses and numerous trading, trapping and Indian slave trade expeditions (Miller 1968).

By the 1830s, the trail was well established, portions of its route being followed in 1853 by explorer, John C. Fremont and government surveyor, John W. Gunnison, who reported several sets of well-worn tracks near Green River where Interstate 70 presently runs. Other sections of the trail still remain near the Big Hole Wash in Emery County. The primary route of the Old Spanish Trail, plus divergent trails to Utah Lake, Fort Robidoux and Fort Kit Carson, brought the first extended contact into the project area (Miller 1968: Map 20).

Though forts and trading posts were scattered sparsely through southern and central Utah, the first attempts at organized settlement were undertaken by the Mormon Church. In 1855, the Elk Mountain Mission passed southward through Castle Valley to the area of Moab intending to establish a permanent settlement, but Indian hostility forced a quick retreat. The combination of hostile Indians, the desolate appearance of the region, the hardships involved in securing sufficient water for irrigation and doubts about the quality of the soil caused further attempts at colonization of the eastern area of what was then Sanpete County to be dropped for over 20 years (McElprang et al 1949:16).

At a priesthood meeting at Mt. Pleasant on September 22, 1877, encouragement was given to settle Castle Valley; soon after, 75 men from Sanpete Stake were called with Christian G. Larsen as leader. Very few responded, however, because of the aforementioned reasons. Orange Seely was subsequently given the responsibility of superintending the founding of settlements and another call for colonizers was issued by the Church in the fall of 1878. Some of the earliest settlers of the area who dwelt in dugouts in hills or washes until log houses could be erected were Elias and John Cox, Ben Jones, William Avery and Anthony Humbel. By the fall of 1878, the crops were sufficient and the situation stable enough for the families of these men to join them, a sure sign of an intent to remain (McElprang et al 1949).

Work progressed on the agricultural settlements of Castle Valley and roads were built through the Wasatch Mountains to the more stable areas of western Sanpete County. Additionally, in the fall of 1878, the "Star-Mail Route" was opened between Salina and Ouray, Colorado; it followed the paths of the Old Spanish Trail and the "Gunnison" Trail of years before (McElprang et al 1949:19-21). In just three years the towns of Castle Dale, Wilsonville, Ferron, Green-river (Blake), Huntington, Lawrence, Molen, and Orangeville had been established and the Legislative Assembly in February, 1880, created Emery County, which embraced all of present-day Carbon, Emery, and Grand Counties (Lever 1898:593).

Though the project region was settled for its agricultural and grazing possibilities, it was the area that inspired active settlement and set the mining-dominated industrial base that central and eastern Utah retains to the present.

The first recorded discovery of coal in eastern Utah was by the Gunnison Expedition of 1853 (Powell 1976:13) when they located deposits of coal approximately three miles east of present-day Emery. The isolated location of the Gunnison find, coupled with the hope that the deposits already discovered at Coalville and Wales would prove sufficient for the territory's needs, caused Gunnison's discovery to be forgotten. The subsequent failure of the efforts at Wales to produce good coking coal, and the Union Pacific Railroad's monopolization and price-fixing on the deposits at Coalville, caused a re-evaluation of the potential coal producing areas east of the Sanpete settlements (Powell 1976:13).

As a result, the first effort to exploit the newly found eastern coal deposits was undertaken in 1875 at Connellsville in the upper reaches of Huntington Canyon. The Fairview Coal Mining and Coke Company was organized by men from New York, Salt Lake City, and Fairview. Eleven coke ovens were constructed and the coke was hauled by wagon into Springville. The expense involved with the hauling and the questionable quality of the coke produced caused the failure and abandonment of Connellsville by 1878 after only three years of operation (Powell 1976:13).

The next development of coal resources was begun in the Pleasant Valley area, also in 1875. The Pleasant Valley Coal Company, headed by Milan O. Packard, constructed a wagon road from Springville up Spanish Fork Canyon to Pleasant Valley coal lands in 1876; 1877 saw the opening of the Number 1 Mine in Winter Quarters Canyon (Powell 1976:14). A narrow gauge rail line was completed from Springville through Spanish Fork Canyon in October of 1879 by the Pleasant Valley Railroad Company as the haul to Springville by the wagon road occupied four days in good weather while in winter the road was impassable. This Pleasant Valley area proved to be extremely productive. The first three large scale mines in eastern Utah were established in this area when the Mud Creek Mine was reopened in 1882 followed by the 1884 opening of the Union Pacific Mine at Scofield just east of Winter Quarters (Powell 1976:15).

From the earliest times, the railroads sought to control the supply of coal in the territory, e.g., the Coalville resources and Union Pacific Railroad's control over that source. During the early 1880s, the Denver and Rio Grande Railroad was extending its lines from Colorado through Utah. Though originally graded through Castle Valley and Salina Canyon, the route of the railroad was altered, going through Price and Spanish Fork Canyon and thus taking in the rich coal areas of what was to become Carbon County (McElprang et al 1949:22).

Further expressing its interest in eastern Utah coal, the Denver and Rio Grande Western (Denver and Rio Grande's Utah holdings) purchased the independently owned Pleasant Valley Railroad Company and Pleasant Valley Coal Company in 1882. Shortly thereafter, Union Pacific Railroad Company (UPRR) penetrated the Pleasant Valley area in order to protect its threatened monopoly on Utah coal (Powell 1976:16). The UPRR formed the Utah Central Coal Company in 1882 and opened the Union Pacific Mine near Scofield in 1884. With the Denver and Rio Grande's Pleasant Valley Coal development (1882), the establishment of Utah Fuel Company in 1887 and the creation of Utah Central Coal of Union Pacific, the railroad companies almost totally dominated the ownership and production of the Utah mines until the early 1900s (Reynolds et al 1948:195).

In 1888, a mine was opened at Castle Gate on the Price River near the mouth of Price Canyon. In about 1899, a new mine began operations at Sunnyside just 24 miles east of present-day Price at the base of the Book Cliffs. The Sunnyside Number 2 Mine also began its production in 1899 with the coal obtained at Sunnyside and at Castle Gate was utilized for coking purposes (Powell 1976:17-18).

In 1906, the first of the coal operations which would remain free from railroad control began production at Kenilworth, three miles east of Helper. This enterprise was financially backed by James Wade and F. A. Sweet and was called the Independent Coal and Coke Company because of its unique ownership status. Sweet, one of Utah's most prominent coal authorities, also opened a mine on the middle fork of Miller Creek in 1908 and named the camp Hiawatha (Reynolds et al. 1948:213). This locality at the foot of Gentry Mountain, about 18 miles southeast of Price, was the scene of further coal mining development in 1911 when Black Hawk mine was opened by Brown and Eccles. Just a few miles to the south in northern Emery County, a small wagon mine was purchased by the Castle Valley Fuel Company and the town, Mohrland, named from the initials of the company's four major figures--Mays, Orem, Heiner and Rice--was begun. Mr. W. H. Wattis undertook the last development in this area in 1916 at Wattis, several miles north of Hiawatha on the flank of Castle Valley Mountain.

The decade from 1911-1920 saw an increase in activity in the coal regions of east-central Utah with many new mines being opened in hitherto undeveloped areas within the Utah coal producing regions. In 1911, Frank Cameron prospected the region around Panther Canyon on the Price River, and in 1914, the first coal was shipped out by the Utah Fuel Company which had leased the properties to Cameron for development. Cameron also developed and opened a small camp at the base of Castle Rock, about five miles northwest of Helper. Located directly on the main line of the Denver and Rio Grande Western Railroad, the camp's name was changed many times as was its ownership. Originally known as Bear Canyon, it soon was called Cameron for its developer, then Rolapp, and finally, Royal (Reynolds et al. 1948:244).

In 1912, Jesse Knight, one of the most prominent men in Utah mining history, bought 1600 acres of coal land west of Helper to provide coal for his smelting operations in the Tintic District. His mine, at what eventually became known as Spring Canyon, began production in 1913 and was the first of many mines in the Spring Canyon District, one of the most prolific coal producing areas in eastern Utah. Soon after the establishment of Storrs (Spring Canyon), F. A. Sweet opened another mine in Spring Canyon at Standardville, so called because it was considered to be the standard for the development of future mining camps. The year 1914 saw the opening of the Latuda Mine and camp by Liberty Fuel Company, while mines were opened in 1916 at Peerless and Rains. The last mining development undertaken in the Spring Canyon District was Mutual Coal Company's Mutual and Little Standard operations, begun in 1921 and 1925, respectively.

The final major coal producing area to be opened in east-central Utah was the Gordon Creek District. This region had first been prospected in 1908, but was really brought to prominence in 1920 by A. E. Gibson, the superintendent of the Spring Canyon Mine. Mines were developed in this area up until 1925 by Consumers Mutual Coal Company, National Coal Company, and Sweet Coal Company. The operations of all three companies ceased by 1950 (Carr 1972:81).

After the development of the Gordon Creek area, further work on the coal regions was undertaken in areas that had been opened previously. In 1922, Columbia Steel Company opened a mine at Columbia near the location of Sunnyside in order to further exploit the excellent coking coal obtainable from that region. One very late development of the same coal veins that supported the Columbia operation was initiated in Horse Canyon in 1942 by the United States government to aid steel production at its Geneva plant (Reynolds et al. 1948:252). Both mine and steel plant were taken over by U.S. Steel after WWII and continue in operation to the present.

Most of the mines in east-central Utah continued production through the heavy demand years of WWI and the years of prosperity that followed, but a combination of overdevelopment, the increased use of other natural fuels, rising costs associated with expensive underground haulage, and the Depression of the late 1920s and early 1930s caused several camps to be abandoned. Among the first mines to succumb were the long exploited Pleasant Valley mines. Winter Quarters, near Scofield, was closed down in 1928 while Scofield and Clearcreek experienced reductions of operations during the early 1920s and 1930s, respectively. Rains was also forced to cut back on operations in 1930. Despite these setbacks, as of

1929, there were 22 coal mines operating in Carbon, Emery, and Grand Counties, the production of these mines providing 98% of the state's output (Sutton 1949:852).

Economic and production difficulties continued to plague Utah's coal industry during the decade of the 1930s, forcing the closure of the Mutual and Mohrland Mines in 1938. World War II brought a temporary respite to the general downward trend with many mines achieving their highest production levels during the war years and immediately thereafter.

The decade of the 1950s signalled the end for a great number of the eastern Utah coal mining operations as the adaptation of coal for new uses was insufficient to keep pace with this fuel's replacement in many of its traditional roles. The increasing use of natural gas for heating homes and heavy industry use, and the railroad's switch to diesel power were among the developments which severely hurt the coal industry. This bleak picture has drastically changed with the advent of America's "energy shortage," and new technologies for coal use in the future have caused an upswing in coal production in east-central Utah. Mines which were closed, or kept running with skeleton crews, have begun to increase operations during the last decade and the possibility of a new sustained burst of coal mining activity definitely exists (Alexander 1963:244-247).

D. Previous Investigations in the Region

Archeological research in the Castle Valley locality began with the Claflin Emerson Expedition. In 1929, Noel Morss and Henry Roberts conducted explorations and limited test excavations under the auspices of this expedition along the Fremont River and as far north as the Muddy River in Emery County. Morss' work resulted in the original definition of the Fremont cultural entity (Morss 1931, Gunnerson 1969). Morss' description of Fremont sites north of the Colorado River was an important contribution to the understanding of the prehistoric horticultural adaptation in the American Southwest.

With the exception of Reagan's description of the large petroglyph panel in Buckhorn Draw (Reagan 1935), there were no archeological investigations in the Castle Valley region for the next 15 years. Between 1952 and 1957, the University of Utah conducted a series of surveys in order to better define the nature of the Fremont occupation in Utah. A large number of Fremont sites was located along the east side of the Wasatch Plateau and several of the sites were subjected to limited test excavations, including 42Em5, the Emery Site (42Em47), and Snake Rock Village (42Sv5). Each of these three sites was a Fremont habitation (Gunnerson 1957). In addition to these Fremont sites, Gunnerson also tested a shallow rock shelter on Silverhorn Wash (42Em8) as a result of a local collector's report that a fluted projectile point resembling the Clovis style had been found eroding from the shelter deposits. Little additional information was obtained by the excavation, however (Gunnerson 1956).

In the 1970s, there was a significant upsurge in archeological activity in the Castle Valley region. In 1970, three sites endangered by vandalism were excavated by the University of Utah. These sites, Windy Ridge Village (42Em73), Crescent Ridge (42Em74), and Power Pole Knoll (42Em75) all proved to be Fremont habitation sites (Madsen 1975a) dating between about 980 B.P. and 1260 B.P.

During the following year, the University of Utah conducted excavations at Clyde's Cavern (42Em177). Clyde's cavern was a locus of summer plant gathering activities during the Late Archaic period, but the majority of the cultural deposits was shown to be the result of summer maize cultivation and wild plant harvesting activities during the subsequent Fremont period (Wylie 1972, Winter and Wylie 1974).

The next site to be excavated in the study area was Joe's Valley Alcove (42Em693). During the summer of 1974, the United States Forest Service excavated this site which had cultural strata, dated by both radiocarbon and typological means, from the Early Archaic, Late Archaic and Fremont periods (E. DeBloois, personal communication). That same summer, a University of Utah field school excavated the Innocents Ridge site, which proved to be yet another Fremont habitation locus (Schroedl and Hogan 1975).

During the early fall of 1975, the Antiquities Section, Division of State History (Utah) conducted an excavation of a small rockshelter as a part of the cultural resource mitigation program for Consolidation Coal Company of Denver, Colorado. This site, known as Pint Size Shelter (42Em625), had two main cultural strata, one dated to the Late Archaic and the other dated to the early Fremont period. Both of these occupations were evidently the result of wild plant procurement activities (Lindsay and Lund 1976).

Other Fremont habitation sites, located farther to the south, have been excavated. These sites include Snake Rock Village (Aikens 1967), Old Woman and Poplar Knob (Taylor 1957), and the Old Road Site and Ivie Ridge Site (Wilson and Smith 1976). These five sites were all Fremont period habitations although Kayenta and Mesa Verde Anasazi ceramics were recovered at low frequencies indicating that there was contact with other cultural groups located farther south.

In addition to these Fremont sites, a deeply stratified rockshelter (Sudden Shelter, 42Sv6) was found to contain occupational strata spanning the entire Archaic period, ca. 8000 B.P. to 3000 B.P. (Jennings et al. 1980a). The original site report indicated that Fremont diagnostics were present on the site when it was originally documented, but these artifacts were no longer present when the excavations were begun. The Sudden Shelter site is of particular importance to the local prehistory and the prehistory of the eastern Great Basin and northern Colorado Plateau because of its numerous well-defined occupational strata which has allowed a fine-grain correlation between certain diagnostic projectile point types and the temporal phases of the Archaic period.

A test excavation of two heavily vandalized rockshelter sites (42Em959 and 42Em960) in Cottonwood Canyon conducted by AERC in 1979 seem to mirror the results of the excavations at the nearby Joe's Valley Alcove. Radiocarbon dates for the two shelters range from 4350 B.P. to 1896 B.P. depicting Late Middle Archaic occupation into the Fremont occupation of the region. Projectile point correlations indicate that these sites were occupied during the Early Archaic period, Late Archaic and, most heavily, during the Fremont period (Weder and Hauck 1981).

Since 1970, the level of survey intensity has increased drastically, The various cultural resource inventories conducted during the 1970s have generally been the result of natural resource development programs and are too numerous to summarize in the present context. Summaries of these inventories performed before 1978 can be found in Sargent (1977) and Hauck (1979a). The combined inventory results as of 1977 indicate that the majority of the culturally identifiable sites in the general area are Fremont although Archaic sites are also well represented. Protohistoric Numic sites are present but rare (Hauck 1979a:110).

Several cultural resource inventories have been conducted in the general project locality. In 1974, LaMar W. Lindsay, an archeologist temporarily attached to the Bureau of Land Management, recorded site 42Em611, a sparse lithic scatter located on the north bank of Christiansen Wash (see Lindsay 1974). In 1975, an intensive evaluation by Michael S. Berry, an archeologist with the Antiquities Section of the Utah State Historic Preservation Office, involved about 880 acres in the project area. This survey, commissioned by CONSOL, included parts of Sections 27, 28, and 33 (see Figure 2). In his report (Berry 1975), the archeologist noted the presence of sites 42Em625, 626, and 627, all of which were evaluated as not being of National Register status. These sites consist of one lithic scatter and two small rockshelter sites associated with sandstone outcroppings. Pint Size Shelter, or site 625, was subsequently excavated by SHPO personnel in 1975 and reported (see Lindsay and Lund 1976).

AERC began conducting cultural resource evaluations for CONSOL in the Dog Valley area in 1976 (Hauck 1976). During this surface survey, twenty prehistoric sites were located, ranging from Paleo-Indian to Fremont cultural periods.

Additional consulting projects were conducted by AERC for CONSOL from 1978 through 1980 in both Emery and Sevier Counties (Hauck 1978a, 1978b, 1979a, 1979b, 1980a-c).

Investigations by AERC in the Emery Mine project area began in 1980 with CCC-80-2, in which no cultural resources were reported in the project area (Norman and Hauck 1980). In September, 1980, AERC initiated an intensive cultural resource surface survey in the Quitchupah Creek locality (Hauck and Weder 1980). Within the Emery Mine project area, eleven cultural resources were recorded, the majority being prehistoric lithic scatters and rockshelters with the exception of Browning Mine, an early 20th Century coal mine. The prehistoric artifacts collected from the 1980 survey area indicated a cultural range of Early Archaic through the Fremont period, dating from about 8300 B.P. until 950 B.P.

The National Register of Historic Places has been consulted and no registered sites lie within the project boundaries, nor will any registered sites be affected by the Emery Mine development. The closest National Register site, the Rochester-Muddy Creek Petroglyph Site, is situated about 3.25 miles to the northeast of the Emery Mine project area and will not be affected.

E. Research Design

AERC's research design, which has been developed for the general central Utah region consists of the following:

1. The determination of presence or absence of a continual sequence of Paleo-Indian, Archaic, Fremont, and Shoshonean utilization of the project area and the local manifestations of these cultural phases when present;
2. the determination of presence or absence of cultural materials which demonstrate the utilization patterns of the Castle Valley locality;
3. the determination of which types of prehistoric cultural activity were conducted in the project area based upon patterns in artifact associations or predominance of particular types of sites;
4. the determination of presence or absence of early historic Euro-American habitation, trapping, trade or travel within the project area; and
5. the determination, on a regional level, of whether the sites in the project area contained any remains demonstrating local interaction between the Sevier and San Rafael variants of the Fremont culture.

Based upon the preceding research conducted in the general area, AERC has hypothesized that the high density cultural resource zone is associated with the pinyon-juniper ecozone, the Ferron Sandstone Member of the Mancos Shale Formation, the proximity of permanent water sources, and the sub-7500 foot elevations. Surfaces within the Castle Valley lowlands contain a variety of historic and prehistoric cultural resource sites including limited activity sites, e.g., lithic scatters, surface quarries, and ceramic scatters; and occupation sites, i.e., rockshelters, temporary and extended campsites, and habitation (village) sites. (The minimal definition of a limited activity site is an association of four or more flakes and/or lithic tools and/or ceramic sherds observed within the original context of deposition.)

Chapter II
Methodology

A. Field Research

A cultural resource survey on surface areas was conducted between June 24-26, 1981, by AERC personnel for CONSOL on the 400 acre extension of the Emery Mine project area in the Quitchupah Creek locality of Emery County, Utah.

The AERC personnel involved in the field operation included Jacki Montgomery, Keith Montgomery, and Dan Braithwaite with F. R. Hauck as the principal investigator.

The cultural resource inventory consisted of an intensive surface survey of the following areas: a 160 acre parcel in the south half of Section 29, Township 22 South, Range 6 East; a 160 acre track in the northwest corner of Section 32, Township 22 South, Range 6 East; and a smaller 80 acre parcel in the northeast corner of Township 22 South, Range 6 East. All the above described land parcels lie on privately owned lands.

The purpose of the intensive evaluation of the aforementioned survey areas was to assess the probability of cultural resource presence in the previously unevaluated segments of the mine permit area, specifically along the Quitchupah drainage channels and Christiansen Wash.

During the field survey, all examined surfaces were evaluated by personnel walking a series of parallel transects with individual spacing ranging between 15 and 25 meters. When evidences of cultural resources were observed, the field crew altered their survey pattern and examined the spatial extent and cultural significance of potential archeological sites. Cultural resources were evaluated, recorded, sketched, photographed, and the locations plotted on a standard U.S.G.S. topographic map, and an Emery Mine cultural resource map. In the case of historic sites, e.g., 42Em1385 and 42Em1387, follow-up research was conducted using county courthouse records of land ownership. In addition, local informants were contacted for additional historic information.

The surface area of the survey has been obscured by a century of modern land use. In Section 29, more than 50 percent of the surface was impacted by livestock grazing and mechanized horticultural operations. During the cultural resource evaluations, several fields of alfalfa in the west half of Section 29 were being harvested, limiting surface visibility and, in turn, partially hampering the detection of on-surface cultural resources. In the east half of Sections 28 and 32, ground visibility was fairly good except for the occurrences of dense greasewood thickets.

The AERC 1981 intensive survey resulted in the location of three cultural resource sites (Figure 3). Two of these were historical structures situated in Sections 28 and 29, tentatively dating before the 1920s. Only one prehistoric site was recorded during the field investigations.

TABLE 1

Site No.	Location	Type
42Em1385	T22S., R6E., Sec. 28	Historic
42Em1386	T22S., R6E., Sec. 28	Prehistoric
42Em1387	T22S., R6E., Sec. 29	Historic

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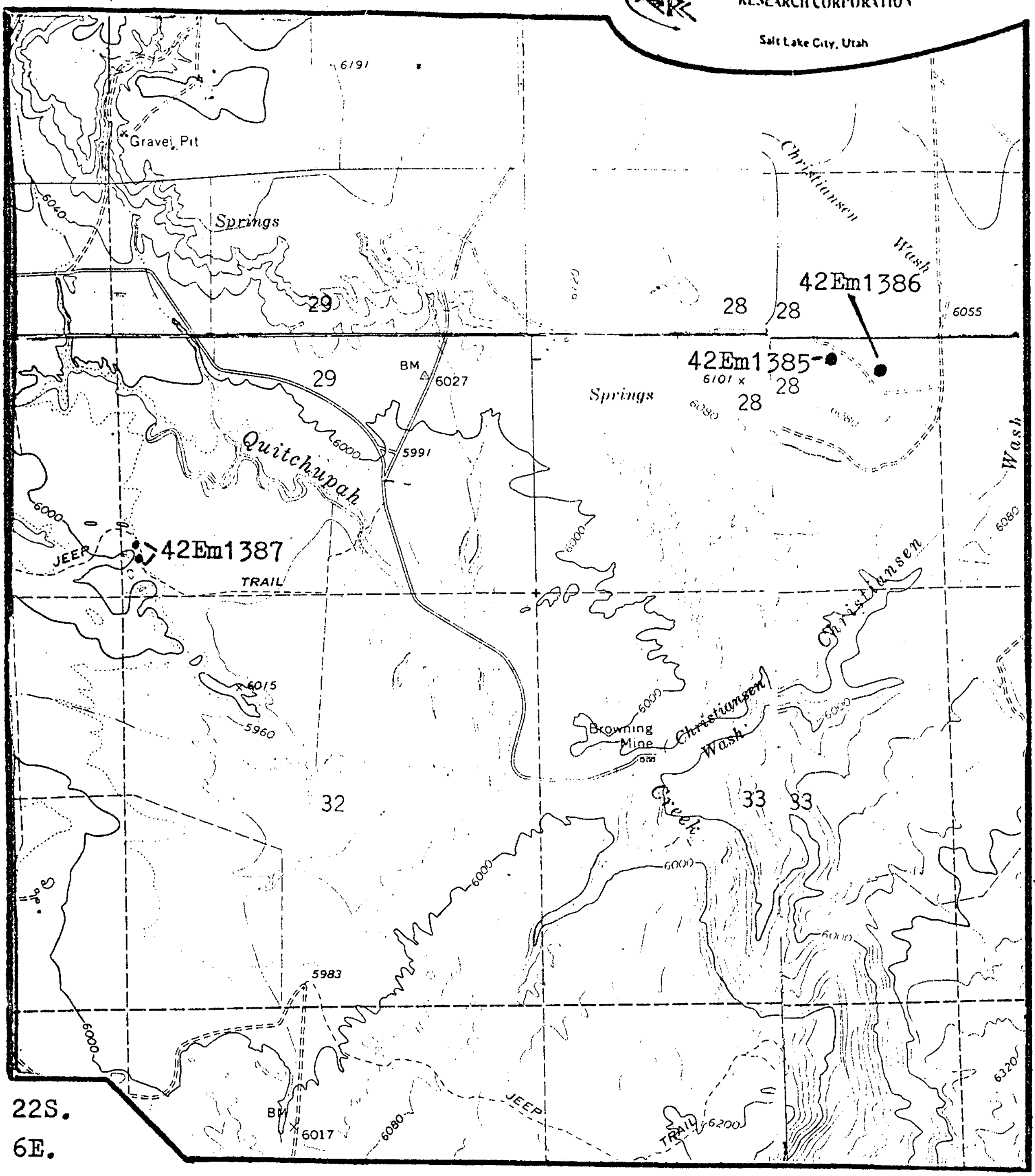

T. 22S.

R. 6E.

Meridian: Salt Lake B. & M.

Project: CCC-81-1

Series: Central Utah

Date: 7-6-81

Figure 3

Cultural Resources in the General Locality

Quad:

Walker Flat Composite Map

7.5 Minute USGS

Legend:

Archeological site ●

0 .5 1 mi

.5 0 .5 1Km

Scale

B. Laboratory Research and Methods

Only one artifact was collected during the 1981 survey. This consists of a small "medicine" bottle which was taken from an historic structure at 42Em1387, and has been included in the AERC historic bottle typological collection. Otherwise, no other cultural artifacts were collected that would warrant laboratory research or curation at the AERC repository, the Museum of Peoples and Cultures at Brigham Young University.

The bottle collected is a small brown glass medicine container with "Franklin Products 1845" embossed on the rounded base. It is characteristic of automatic bottle machine with molded seams running up over and around the top of the bottle; and it has a patent lip and measurements embossed on the body. The bottle dates after 1903 based on the manufacturing characteristics.

Chapter III
CULTURAL RESOURCE DESCRIPTIONS

A. Site Descriptions and Analysis

A total of three cultural resource sites was located and recorded during the survey of the Emery Mine extension area (Table I).

42Em1386 (AERC 596J/1)

This is a small prehistoric lithic scatter located in the SW¼, SE¼, NW¼ of Section 28, Township 22 South, Range 6 East. The site is situated on a secondary terrace approximately .5 kilometers south of Christiansen Wash. The site is about four by four meters and is partially buried by downslope surface erosion. The artifact inventory consisted of about a dozen primary chert flakes and a small core. Trowel testing of 42Em1386 yielded no subsurface artifacts, indications of stratigraphy, or cultural features such as fire hearths. The low density of cultural material and undiagnostic artifacts indicates a limited activity site of low significance.

42Em1385 (AERC 596J/2)

This site, 42Em1385, is an historic farmstead/ ranch house located in the SE¼, SW¼, NE¼ of Section 28, Township 22 South, Range 6 East. Standing structures include a log shed, loafing shed, and several corrals. Two delapidated structures are situated to the east along with water ponds and irrigation ditches.

Land records for the section show that John Lewis purchased the property in 1902 and passed it to Mr. Browning in 1907, at which time it was patented. According to local informant, A. Olson, (Emery, Utah), the farmstead/ranch was probably standing prior to the 1920s. The hand-hewn log structure has been remodeled inside and was probably re-roofed more than once since its original construction. Site 42Em1385 is structurally in good condition and is used presently for storing grains, and for sheltering cattle.

<u>42Em1387</u> (AERC 596J/3)

This is a larger historic farmstead/ranch located in the W½, SW¼, SW¼ of Section 29, Township 22 South, Range 6 East. It is situated adjacent to an artificial pond and is approximately .4 kilometers south of Quitchupah drainage. The farmstead features a three room, hand-hewn log house, a hand-hewn tack shed, two rectangular cellars, an outhouse, and several corrals. The house has been renovated some years ago with a front porch and kitchen added to the east face. This was probably renovated during the 1930s when the last tenants occupied the farmstead.

According to land records, the property was purchased by E. Larsen in 1902, however, the SW¼, SW¼ was not patented until 1908. Local informant, A. Olson, recalls that 42Em1387 was standing in 1914 when he lived at the farmstead to the west of the project area. He further states that, at that date, it was already an "old place," hence the log house was probably built around 1900 or earlier. The most recent occupation of the farmstead occurred between 1930 and 1940, and most of the artifacts in the house and shed are dated to this period. The only artifact collected for identification was a medicine bottle (Frankline-Products) recovered from the cabin and is machine-finished with patent lip dating post-1920.

42Em1387 is structurally in good condition. Since its original construction, both the house and tack shed have been renovated and probably reroofed.

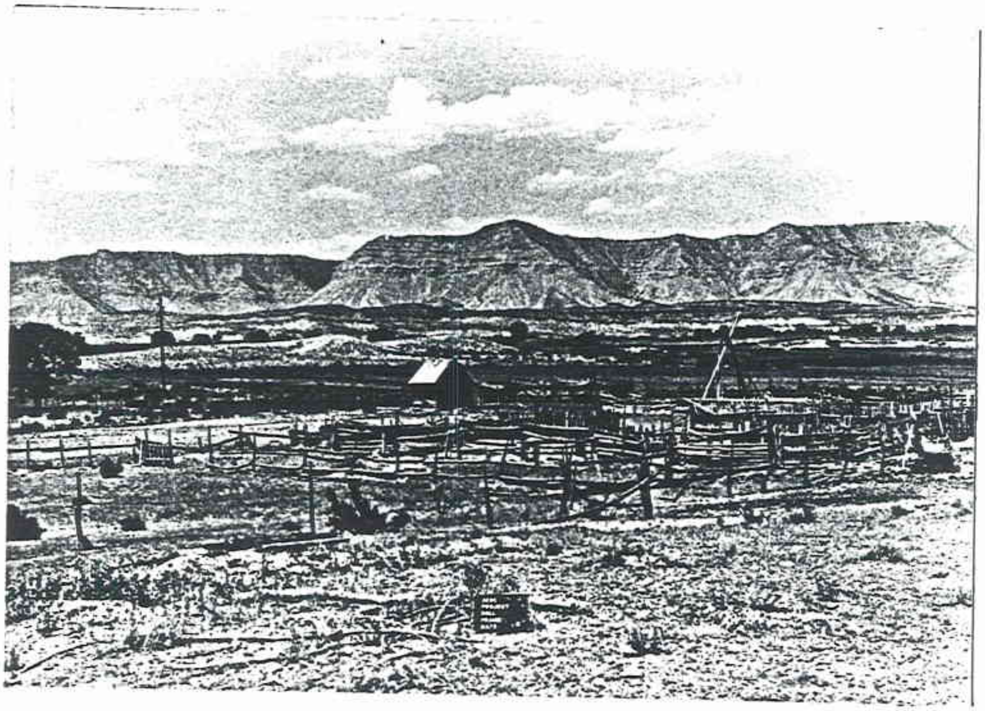

Figure 4 - Photographs of 42Em1385
looking to the northwest

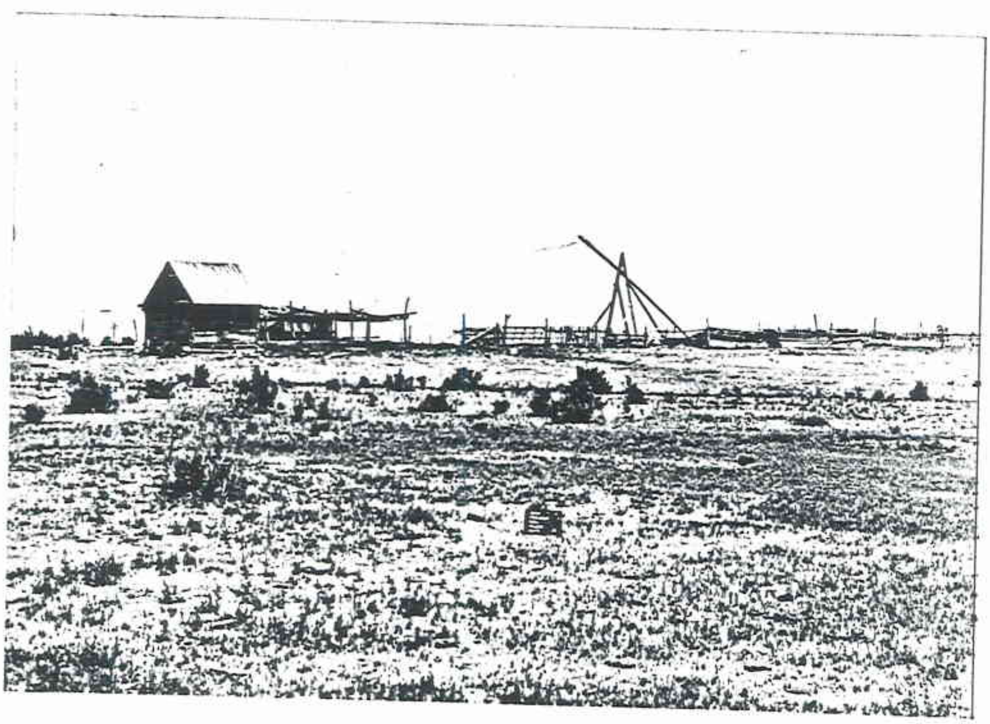

Figure 5 - Photograph of 42Em1385
looking to the northeast

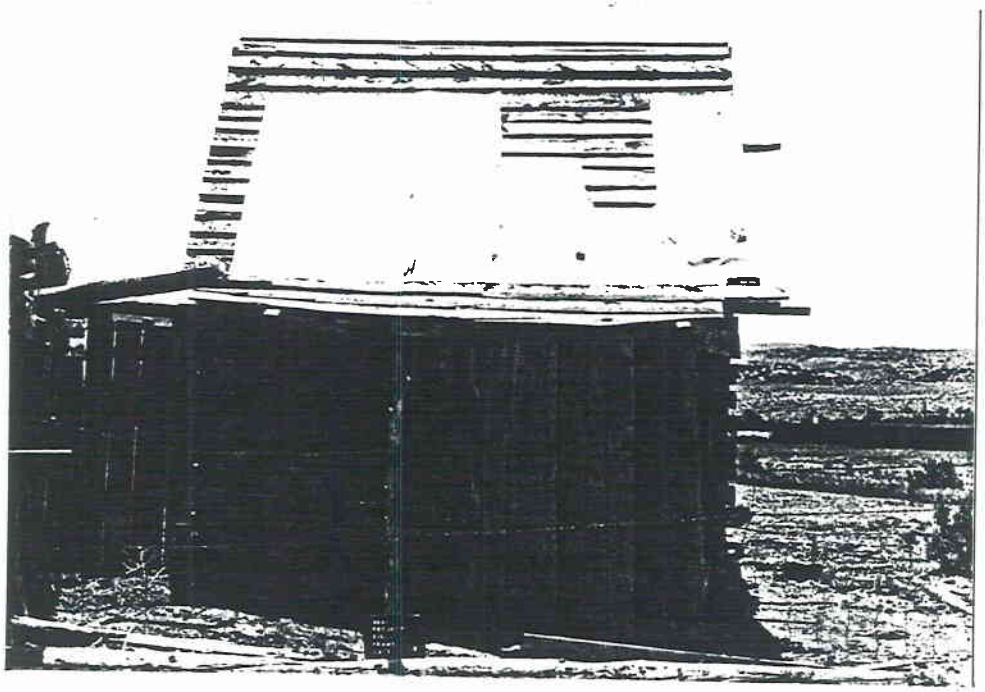

Figure 6 - North wall of 42Em1385

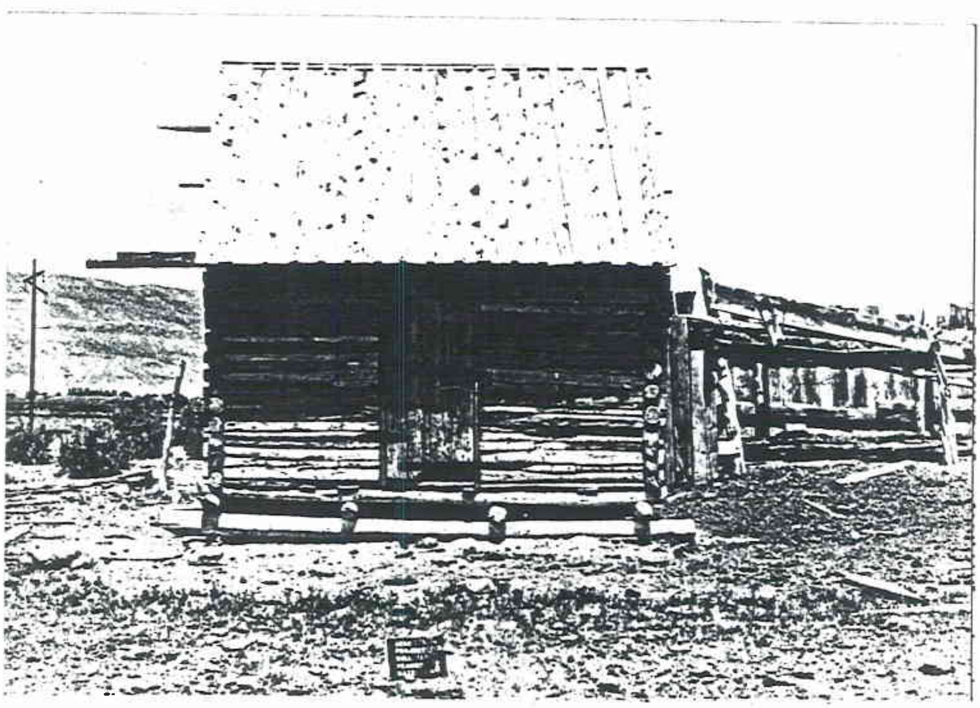

Figure 7 - South wall of 42Em1385

Figure 8 - West wall of 42Em1385

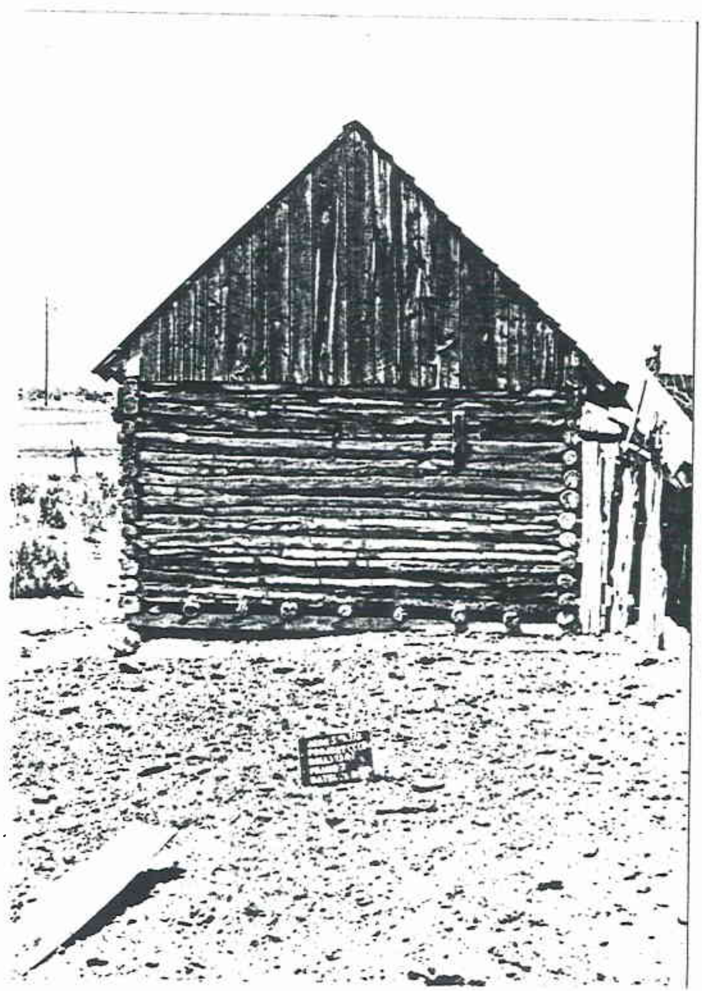

Figure 9 -
East wall of 42Em1385

Figure 10 - Photograph of 42Em1387
looking northwest

Figure 11 - Entrance and east wall
of 42Em1387

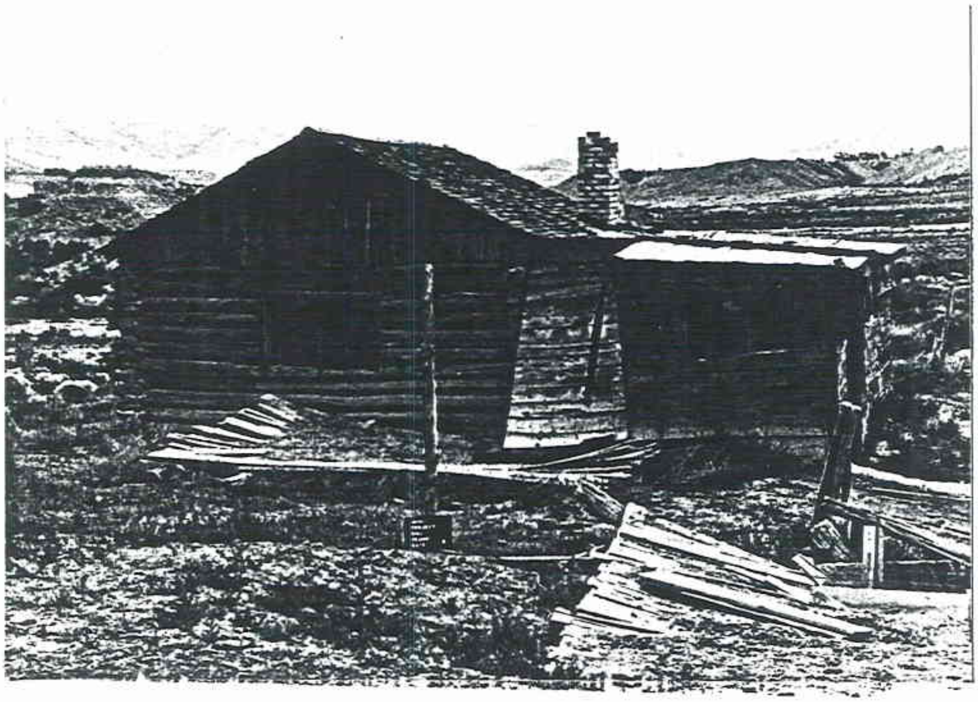

Figure 12 - South wall of 42Em1387

Figure 13 - Rear and west wall
of 42Em1387

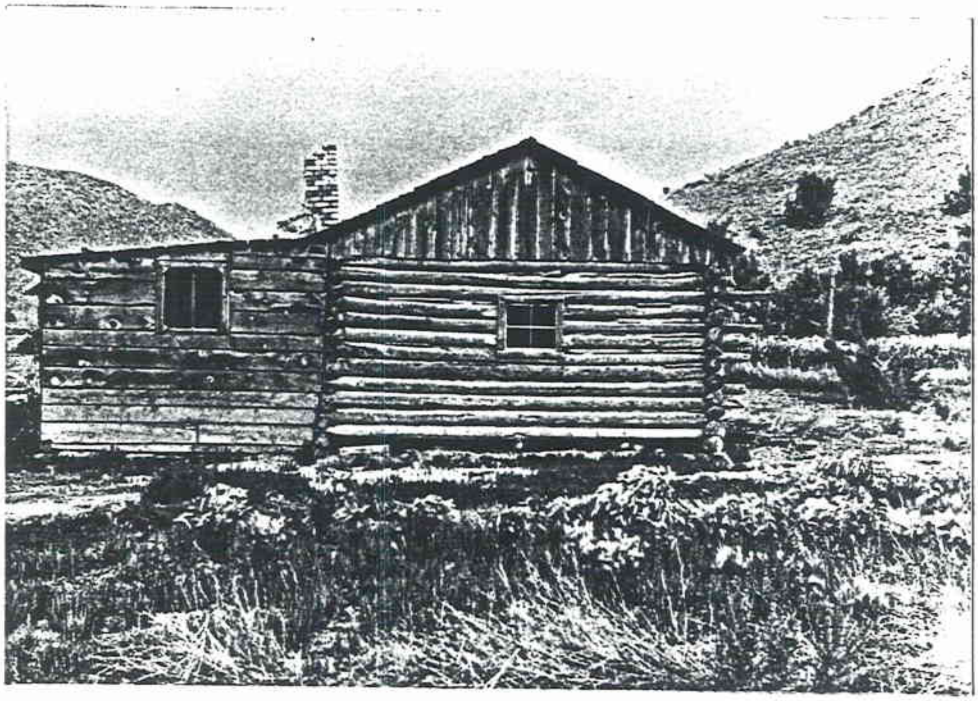

Figure 14 - North wall of 42Em1387
showing earlier log construction
contrasted with more recent addition

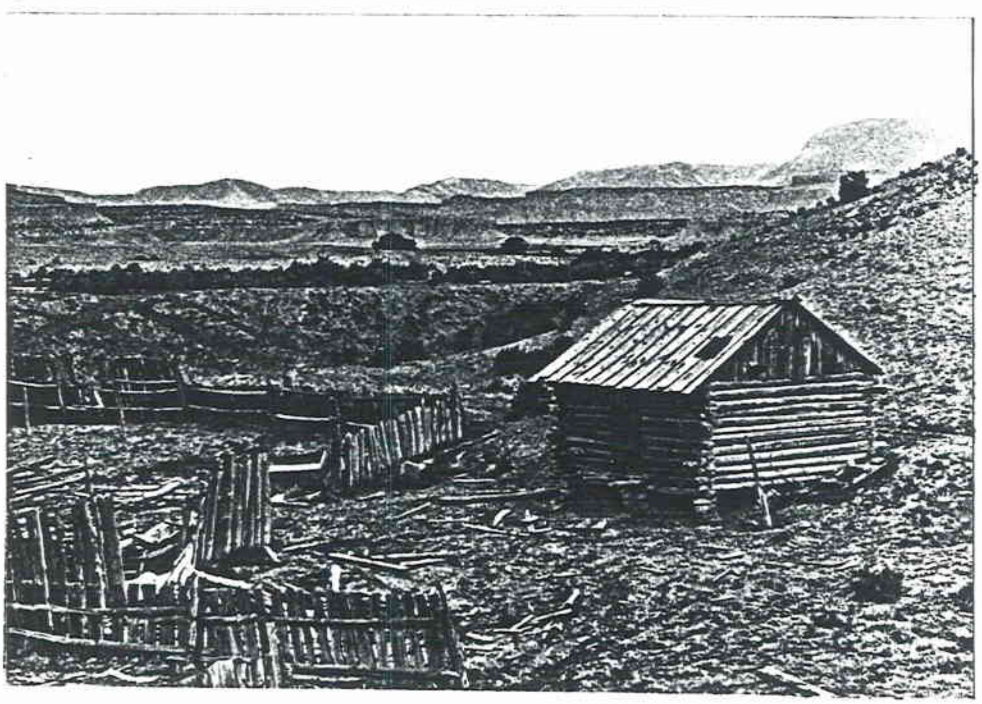

Figure 15 - View of storage shed on 42Em1387

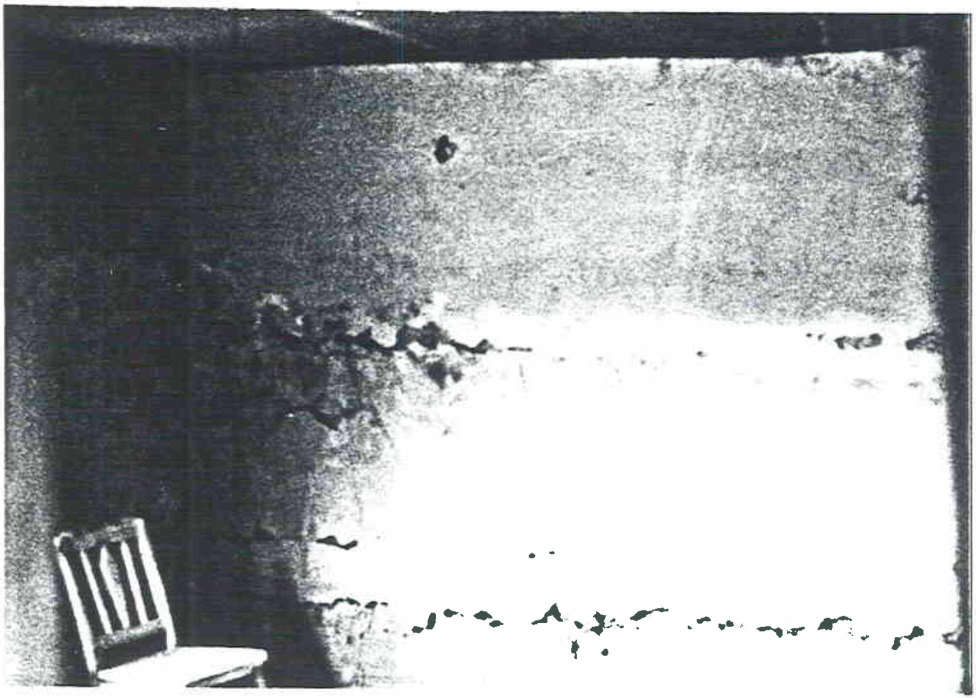

Figure 16 - Living room plaster wall
in 42Em1387

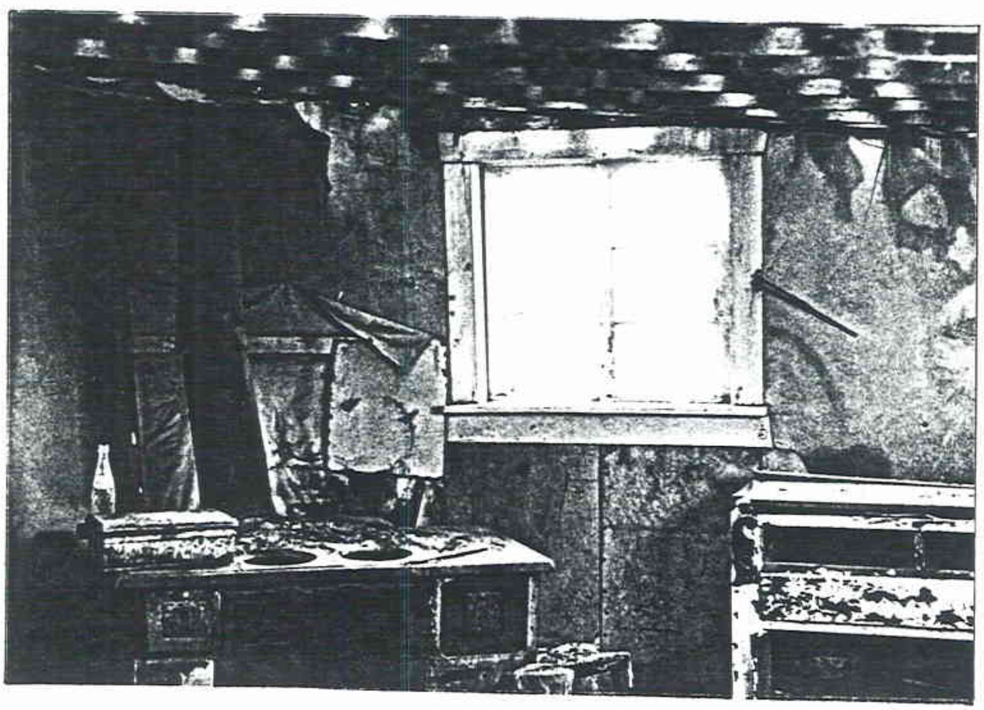

Figure 17 - Kitchen in eastern recent
extension of 42Em1387

B. Application of Research Design Guidelines

Cultural resource investigations in the Castle Valley area have revealed certain prehistoric and historic settlement patterns. Previous surveys and excavations have located Paleo-Indian, Archaic, and Fremont sites, and artifacts; however, few Shoshonean sites or habitations have been documented.

In accordance with the AERC research design guidelines of the Castle Valley locality (see Chapter I E), certain correlations between prehistoric site density and environmental locality have been documented. To the south of the present study area, prehistoric sites have been primarily located in the pinyon-juniper biome. Archeological sites located by Hauck (1976) indicated a predominance of Archaic habitation in the pinyon-juniper zone associated with sandstone outcrops. In addition, these habitations showed a high frequency of chert unifacially worked tools. Sites correlated with the pinyon-juniper biome have also been located along canyon rims in Ivie Creek Canyon (Rauch 1980). Both rock shelter sites associated with Archaic and Fremont cultural periods were found along with pictograph panels.

The Castle Valley lowlands where the 1981 Emery Project area survey was located is characterized by greasewood, shadscale, and sagebrush communities. Previous cultural resource investigations have located archeological sites along the two major drainages, Quitchupah Creek and Christiansen Wash. Several lithic scatters, including stratified Pint Size Shelter, were recorded on terraces of Christiansen Wash by Berry (1975). These sites were temporary occupation sites like many of those found in higher elevations, and were situated near sandstone outcrops, primarily associated with the sagebrush ecozone. Similarly, during the 1980 survey of the Emery Mine project area occupations ranging from early Archaic to Fremont were recorded along the gravel terraces of Christiansen Wash (Hauck and Weder 1980). The majority of the prehistoric occupations have been found in shallow rock shelters exhibiting both lithic and lithic-ceramic scatters.

In view of the variety of previous cultural resource surveys conducted in this general locality, certain correlations can be made between the absence or presence of archeological sites within the 1981 project area of Emery Mine. The following environmental factors seem to directly or indirectly attribute to the low density of prehistoric sites located within the present study area:

1) project area is outside of the optimal pinyon-juniper ecozone;
2) lack of sandstone formation, thus, no shelters for habitation.

In addition to the above, other factors, such as poorly drained flood plains (Quitchupah Creek), deep arroyo cutting and erosional occurrences, alkali soils, and current impact from farming and ranching practices have had a negative influence upon the surface partially affecting the low density of prehistoric sites in the area.

In Section 28 where sage brush communities predominate, 42Em1386 was located on a well-drained terrace of Christiansen Wash. As previously mentioned, other lithic scatters and lithic-ceramic sites have been recorded, primarily adjacent to sandstone outcrops (Berry 1975; Hauck and Weder 1980). The artifact inventory recorded at 42Em1386 consisted of all chert which is congruent with other artifact assemblages recorded in the area (Hauck 1976; Berry 1975; Hauck and Weder 1980).

In reference to the basic research design provided in Chapter I, and based upon the results of this present project, very little can be stated regarding Fremont occupation in the 1981 Emery Mine project area. Fremont habitations are commonly located on rises overlooking arable lands and along perennial streams. Additionally, Fremont habitations are frequently located in the same environmental zones and geological formation as Paleo-Indian and Archaic cultures. For instance, along Christiansen Wash and to the south, evidence of Fremont occupation has been recorded, stratified above Archaic cultural components, especially in rock shelters.

Consequently, the absence of Fremont sites along Quitchupah drainage could be attributed to the historic development of horticulture in areas where Fremont habitations may have existed in the past.

Early Euro-American presence near the study area has been documented along the Spanish Trail which was used by trappers, traders, and settlers during the 1800s when crossing the Wasatch. In the Quitchupah Creek lowlands, cultural resource sites 42Em1385 and 42Em1387 reflect the early farming communities which were established during the early 20th Century when the alkali alluvial bottomlands were farmed for alfalfa seed crops to be distributed throughout Utah.

In response to the research design guidelines described in Chapter I, the following statements are applicable to the 1981 Emery Project cultural resource survey.

1) A very low density of prehistoric sites was located within the 1981 project area. The site recorded (42Em1386) lacked diagnostic artifacts and no depth potential. A continual sequence of Paleo-Indian, Archaic, and Fremont utilization has been documented for adjacent areas to the south; however, the lack of datable sites within the 1981 project failed to add further information concerning prehistoric settlement and subsistence patterns of the Castle Valley lowlands.

2) Early Euro-American settlement and land-use patterns have been documented for areas adjacent to the 1981 Emery Mine project investigation. The additional historic habitations recorded in the study area, i.e., 42Em1385 and 42Em1387, contribute to the overall historical picture of the Castle Valley locality.

3) Although no Fremont sites were recorded within the present study area, others are noted both in the Castle Valley lowlands and upper localities. Further research and excavation are needed to define the local and regional manifestations of Fremont culture and its local variants within Castle Valley.

Chapter IV
EVALUATIONS AND RECOMMENDATIONS

A. National Register Criteria of Eligibility

Application of the National Register Criteria of Eligibility, as defined under 36 CFR 60.6, to each of the three sites that are situated in the Emery Mine project extension area, provides the following information:

a) None of the three sites is associated with events that have made a significant contribution to the broad patterns of our history; or

b) none of the three sites is associated with the lives of persons significant in our past; or

c) none of the three sites embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components may lack individual distinction; or

d) all three sites evaluated in this report yield commonly available information of marginal value on prehistoric and historic land-use and settlement patterns; however, very little specific data is obtainable on these cultural resources in terms of research potential. Hence, the prehistoric site (42Em1386) is not considered as capable of yielding prehistoric or historic information of value relative to criteria d. The two historic sites (42Em1385 and 42Em1387) appear to be capable of furnishing some historic information of value based upon application of criteria d, Title 36 CFR 60.6.

In accordance to the definitions of the National Register Criteria of Eligibility (36 CFR 60.6), two of the three cultural resource sites recorded are superficially eligible under criteria d for National Register of Historic Places (NRHP) consideration. Both of the historic sites (42Em1385 and 42Em1387) represent an architectural construction used in late 19th and early 20th Century Utah farming communities, and also demonstrate historic land-use patterns. These structures are not unique in themselves, according to an application of NRHP criteria a, b, and c (36 CFR 60.6).

Site 42Em1386 is a small lithic scatter lacking depth and diagnostic artifacts and is not significant in terms of the National Register Criteria of Eligibility.

B. Recommendations

All of the cultural resource sites reported herein are currently on private land. The two historic sites (42Em1385 and 42Em1387) are presently owned and maintained by John Lewis III, a local property owner.

At the present, it is uncertain which, if any, of the recorded sites are susceptible to adverse impact by expansion of the Emery Mine project. 42Em1386 is not considered eligible under NRHP standards, and avoidance measures cannot, therefore, be advocated as a means of mitigating disturbance. Sites 42Em1385 and 42Em1387 are fairly well preserved and may offer further information to the local historical record in Utah's early farming communities. These structures are susceptible to vandalism, and therefore more detailed photographic records may be warranted to insure their documentation.

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App 5-2

October 10, 1988

Subject: CULTURAL RESOURCE EVALUATION OF A PROPOSED SETTLEMENT POND LOCATION IN THE QUITCHUPAH CREEK LOCALITY OF EMERY COUNTY, UTAH

Project: Consolidation Coal Company

Project No.: CCC-88-1

Permit No.: Department of Interior -- Ut-88-54937
Utah State Project No. -- Ut-88-AF-511p

To: Mr. Chris Jones, Consolidation Coal Company, P.O. Box 527, Emery, Utah 84522

Info: Antiquities Section, Division of State History, 300 Rio Grande, Salt Lake City, Utah 84101

GENERAL INFORMATION:

On October 5, 1988, F.R. Hauck of AERC conducted a cultural resource reconnaissance evaluation of a proposed settlement pond and pipeline corridor location situated in the Quitchupah Creek locality of Emery County, Utah. This project was initiated for the Consolidation Coal Company of Emery, Utah. The project area is situated in the northeast quarter of Section 30, Township 22 South, Range 6 East (see attached map).

The project location is on private land.

The project area is situated on the valley floor between the 6000 and 6080 foot elevations. The settlement pond area covers ca. five acres to the south of Consolidation's haul road to the Browning Mine to the east. The pipeline corridor extends in a north-south orientation between the proposed pond and the subterranean pipeline connection situated to the north of the haul road. Soils in the construction areas associated with the settlement pond and pipeline consist of hardpan clays which have developed through years of alluvial deposition related to the gradual erosion of the Mancos Shale terrace to the north of the project area. Several low clay knolls situated on the western periphery of the settlement pond are remnants of this extensive clay terrace formation. Existing ground cover in the project area ranges from the barren conditions within the clay beds where the pipeline is situated, to a sparse, dwarf saltbush, rabbitbush, and greasewood community associated with the settlement pond location. Top soil formation in the project area has been highly restricted.

FILE SEARCH:

A records search of the site files and maps at the Antiquities Section of the State Historic Preservation Office was conducted on October 6, 1988. The National Register of Historic Places has been consulted and no registered historic or prehistoric properties will be affected by the proposed development.

FIELD METHODOLOGY:

The archaeologist conducted a intensive evaluation of the settlement pond and pipeline corridor areas by walking a series of 15 meter wide transects. Cultural materials identified during these transects were carefully evaluated and the immediate localities searched for the presence of cultural activity loci. Cultural resoures identified during the survey were recorded on the standard IMACS site form, sketched, and photographed.

RESULTS:

One large historic-prehistoric cultural resource activity locus was identified and recorded during the evaluation. This site consists of a historic homestead occupation and corral which dates between A.D. 1875 and 1920. In addition, a significant prehistoric multiple occupation site was recorded in the same location as the historic site. This prehistoric component consists of Fremont pithouses located on the tops of the two clay knolls which are situated just outside and to the west of the settlement pond's western periphery. Ceramic and lithic debris from the pithouses litter the slopes of these knolls and intrude into the original construction area. In addition, several concentrations of detritus which may or may not be contemporaneous with the Fremont occupation are situated on the flats to the east of these knolls within the construction zone.

The prehistoric component on this site was partially identified by James H. Gunnerson during his June 1955 reconnaissance. This site was originally identified as 42EM 43. That designation has been retained and expanded in the site report to include both the historic and prehistoric components of the site which actually overlap along the western portion of the settlement pond development area.

This site can be rated over-all as highly significant. Its various units and components have varying levels of cultural value, however. The Fremont occupation area is most significant as a cultural resource. The sparse detritus concentrations on the surface to the east of that occupation are not considered to be culturally valuable due to lack of material, lack of depth, and marginal research potential. The historic occupation contains some research potential and therefore is considered to have moderate cultural value.

The moderate to high cultural significance of the western portion of the site, which is both within and outside the western periphery of the original settlement pond area, results in a request that the pond development and future maintanance be moved to the east with a 10 to 15 foot buffer zone between the pond's western boundary and the historic occupation area. A red and yellow flagline was placed along the eastern edge of this buffer zone to facilitate the identification and avoidance of this historic resource. This avoidance will insure the preservation of the significant units on this site through avoidance of the historic occupation area and avoidance of the prehistoric occupation area which is located even farther to the west of the revised settlement pond boundaries.

In addition to this avoidance proposal, AERC recommends that the period of blading and surface disruption be monitored by an authorized archaeologist.

CONCLUSION AND RECOMMENDATIONS:

AERC recommends that a cultural resource clearance be granted to Consolidation Coal Company relative to this project based upon adherence to the following stipulations:

1. All vehicular traffic, personnel movement, and construction should be confined to the location examined as referenced in this report, and to the existing roadway and/or evaluated access route;

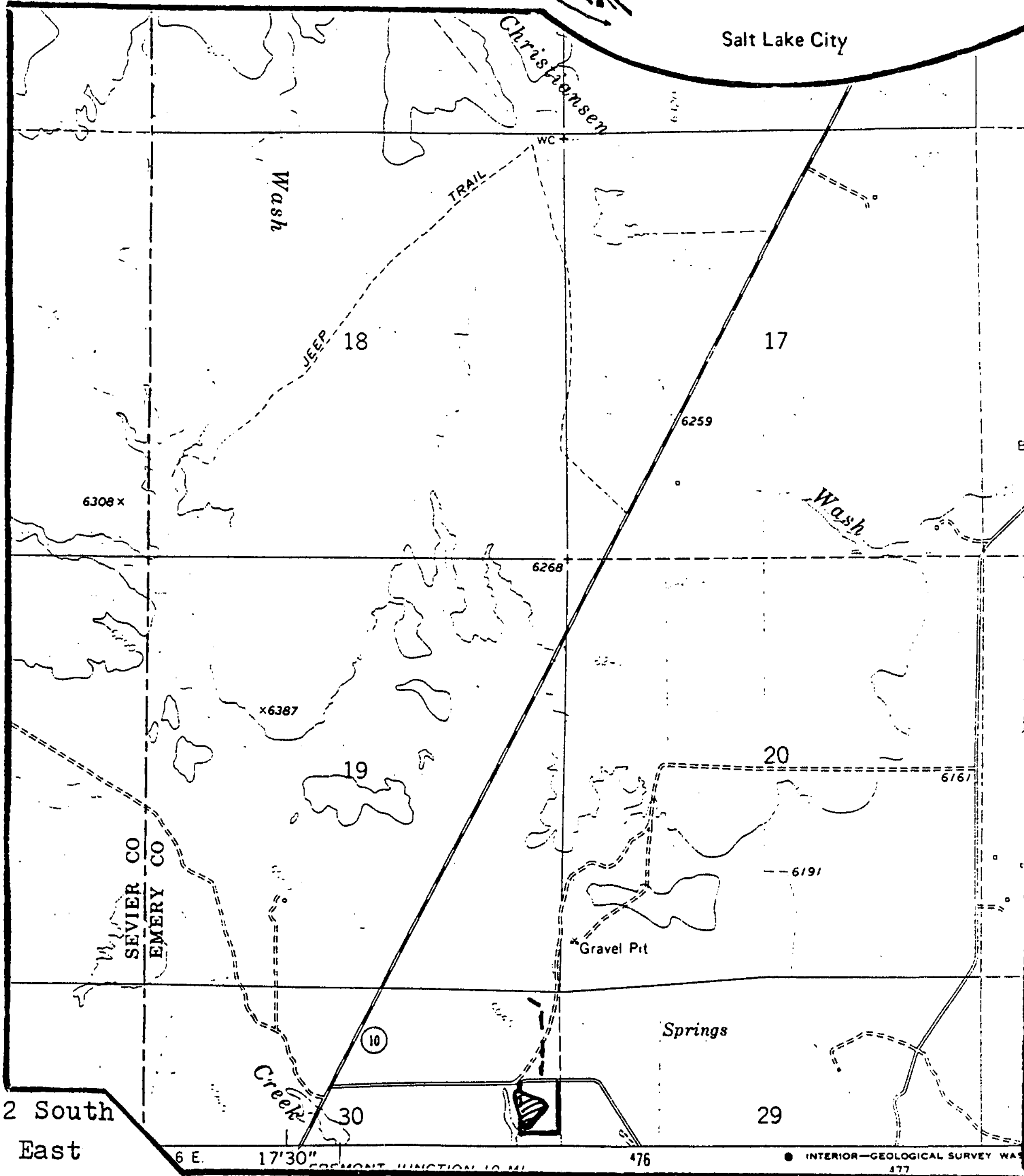
2. all personnel should refrain from collecting artifacts and from disturbing any cultural resources in the area; and

3. the appropriate state officials should be consulted should cultural remains from subsurface deposits be exposed during construction work or if the need arises to relocate or otherwise alter the location of the construction area.

F. Richard Hauck, Ph.D.
President and Principal
Investigator

ARCHEOLOGICAL-ENVIRONMENTAL RESEARCH CORPORATION

Salt Lake City



T. 22 South

R. 6 East

Meridian: Salt Lake B. & M.

Project: CCC-88-1

Series: Central Utah

Date: 10-10-88

Cultural Resource Survey of a Proposed Settlement Pond in the Quitchupah Creek Area of Emery Co.

Quad: Emery West, Ut. 7.5 minute-USGS

Legend:

Project Area

Site 42EM 43

Pipeline Route

N

2.64" = 1 mile

Scale

CHAPTER 6.0

GEOLOGY

EMERY MINE

CONSOLIDATION COAL COMPANY

MARCH 23, 1981

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

6.0 GEOLOGY

6.1 Scope

The following sections of this chapter describe the general regional geology of the project area and the coal bearing units, with particular emphasis upon the I zone where mining is currently taking place. Included in this chapter are reserve estimates and information on strata near the minable seams.

6.2 Methodology

During the past several years Consol has been gathering information on the project area through exploratory drilling. Within the past year information has also been collected on the chemistry of the coal seams and the overlying strata. The purpose of this section is to inform the regulatory authorities of Consol's most recent findings and knowledge of the Emery coal field.

6.3 General Geologic Framework

Figure 6-1 shows the formations and members in the region of the study area. In the permit area three geologic units are important: Quaternary colluvium and alluvium, the Bluegate Shale member of the Mancos Shale, and the upper portion of the Ferron Sandstone member of the Mancos Shale.

Quaternary colluvium and alluvium occurs on toe slopes, along the drainages, and on the high terraces. The colluvium is a bouldery, loamy sand below sandstone outcrops and a silty clay below shale hills. The Quaternary alluvium and terrace deposits are crudely stratified, poorly sorted sands and gravels.

The Bluegate Shale outcrops west of Christiansen Wash and west of Quitchupah Creek south of the mine office. It is a saline, bluish gray, silty mudstone or siltstone. It is nodular and irregularly bedded. Thin sandstone beds occur within the Bluegate Shale. Where the Bluegate Shale is exposed at the surface it forms barren shale hills.

The Ferron Sandstone outcrops along Quitchupah and Christiansen Wash. The Ferron Sandstone averages 400 feet in thickness and consists of an upper and lower unit. The upper Ferron comprises lenticular beds of fine to coarse sandstone, and lenses and intercalated beds of shale, siltstone, and coal. The lithologies indicate fluctuations of a nonmarine coastal swamp environment at the edge of the Cretaceous Sea. The coal seam now being mined (I zone) occurs in the Upper Ferron. The lower unit of the Ferron is a calcareous, yellow-gray, medium- to fine-grained, locally cross-bedded marine sandstone. A minor amount of erosion after Ferron deposition is indicated by the disconformable contact between the Ferron Sandstone and the Bluegate Shale.

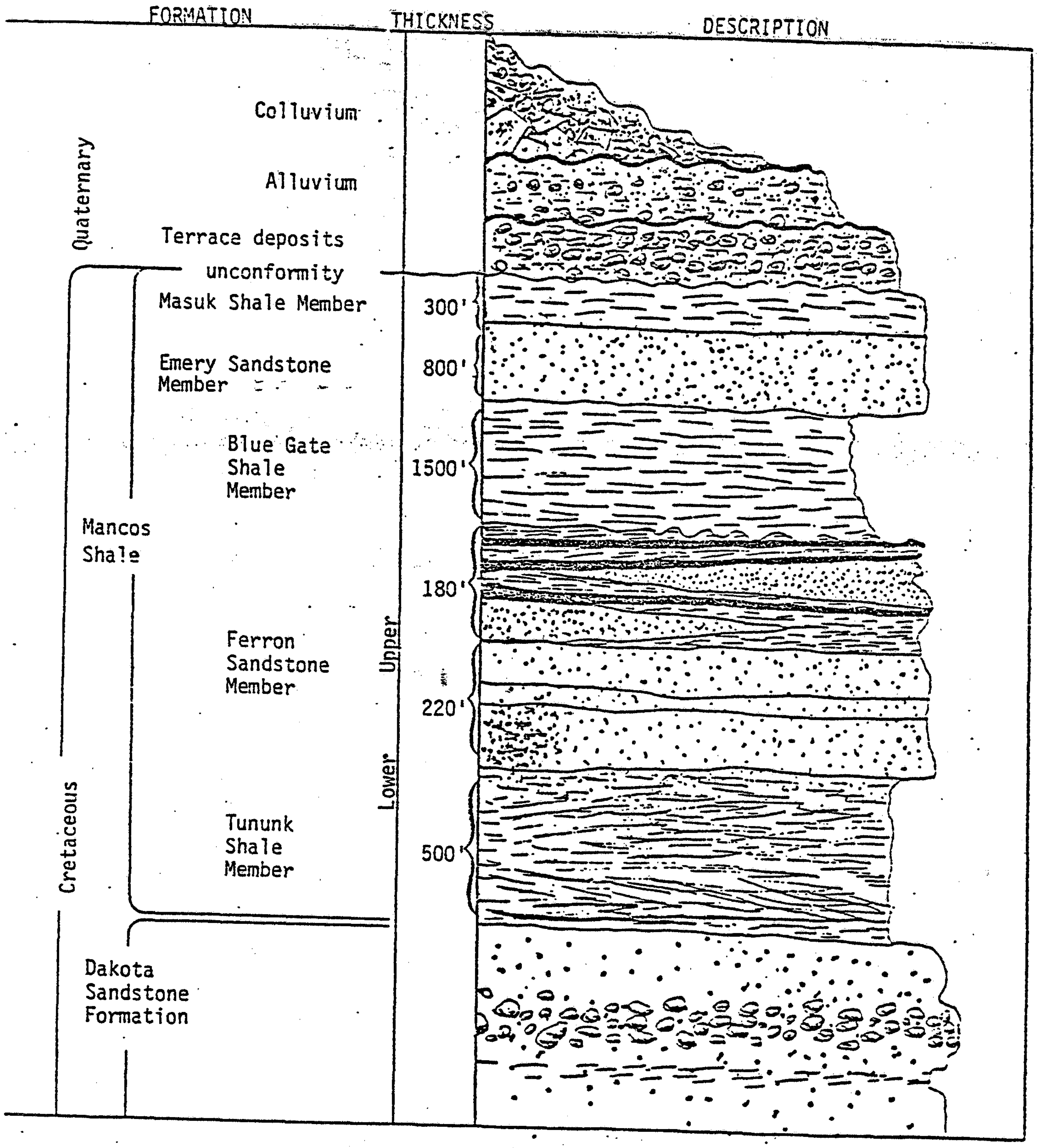


FIGURE 6-1

GENERALIZED STRATIGRAPHIC COLUMN

6.4 Geology of Project Vicinity

6.4.1 Stratigraphy

6.4.1.1 Quaternary Alluvium

Alluvium occurs as unconsolidated deposits of partly stratified silt, sand, and gravel deposits in and adjacent to Quitchupah Creek and Christiansen Wash. South of Quitchupah, this material grades into fine silty surficial material which is probably older alluvium. It is difficult to distinguish this older material from weathered Bluegate Shale. A maximum thickness of 75 feet of this unconsolidated material was recorded in drill hole FC-560 in SW¼, SW¼ Section 29, T22S, R6E. Part of that thickness may have been weathered shale.

6.4.1.2 Gravel Deposits

Sand and gravel deposits are present on benches (either terraces or pediment surfaces) north of Quitchupah Creek. Maximum thickness in Section 29, T22S, R6E, is about 40 feet. A small gravel pit in NW¼NW¼ Section 29, T22S, R6E produces gravel for local use.

6.4.1.3 Cretaceous Bluegate Shale Formation

The Bluegate is a soft, blue-gray shale unit of marine origin composed of irregularly bedded mudstone and siltstone with rare thin sandstone lenses. Maximum reported thickness is 1500 to 2000 feet. In the Emery area, the upper portion is truncated by the Joe's Valley fault zone so that a maximum of only 700 feet is exposed.

6.4.1.4 Ferron Sandstone Formation

The Ferron Sandstone is the coal bearing unit of the Emery field. The coal beds are described in Section 6.5. The Ferron averages about 400 feet thick and is composed of interbedded, lenticular layers of sandstone, siltstone, shale, clay, and coal. The upper contact is sharp and usually can be easily detected on electric logs. The lower contact is transitional over a thickness of about 60-70 feet. Because the base of the Ferron occurs below the economic coal beds, Consol seldom drills to that depth.

6.4.1.5 Tununk Shale Formation

The Tununk Shale unit is lithologically similar to the Bluegate. It conformably underlies the Ferron and crops at the base of the coal cliffs. Regional thickness is reported to range from 500 to 800 feet.

6.4.2 Structure

The Emery coal field is located at the western side of the San Rafael swell. The bedrock dips to the west-northwest at angles of 3-4 degrees. No other major folds are known.

The field is bounded on the west by the Joe's Valley fault zone, a regional graben structure. Published information indicates that the eastern-most edge of the graben is located ½ to ¼ mile west of Utah Highway 10. Consol has no information indicating the precise location of this zone. No other faults are known.

6.5 Geology of Coal Beds and Adjacent Units

6.5.1 Exploration and Drilling

The present owners began their exploration activity in the Emery coal field in the mid 1960s. At the end of 1980, 833 holes had been drilled in the Emery field; about 150 of these are within the present permit limits. All holes, except the first 100, have been electrically logged.

The major target for the holes within the permit area has been the I zone. The seams of this zone were cored at most of the drill sites.

6.5.2 Stratigraphy of Coal Beds

6.5.2.1 K Seam

The K seam is the uppermost of the defined coal seams within the permit application area. The seam averages about 6 feet thick, and a maximum detected thickness of 8.5 feet was penetrated in drill hole FC-80 (Section 29, T22S, R6E). Generally, the K seam is one fairly solid seam with a few shale partings. The seam splits into progressively thinner coal layers separated by shaley partings toward the edges of its extent.

In the southwestern part of the permit area the K seam is about 100 feet below the top of the Ferron. In the northwestern part of the permit area the K seam is at or near the top of the Ferron (the Ferron thins northward). This K-Ferron top interval contains thick sandstones toward the southwest. These thin and disappear northward so that the K seam in the northwestern part is overlain by shales and siltstones of the Bluegate.

6.5.2.2 The K-I Zone Interval

The interval between the K seam and the seams of the I zone below ranges from about 10 feet in Section 31, T22S, R6E, to 57 feet in drill hole FC-275 (NW¼ Section 29, T22S, R6E).

The thin part of the interval is composed of shale. The thicker part to the north contains 20-30 foot layers of sandstone. The increase in thickness to the north is sudden, occurring along a northwest-southwest trending line running through the southern part of Section 29, T22S, R6E.

6.5.2.3 The I Zone

The I zone is the targeted commercial horizon for the present permit application area. Various coal layers of this zone will be extracted during the permit life.

In the present mine area, the zone consists, from base upwards, of an 8-10 foot layer of coal (Lower I-5), a 0.1-0.2 foot clay parting (First Slip), a 3-4 foot layer of coal (Lower I-1), another thin clayey layer (Second Slip), a third layer of coal 3-4 feet thick (Upper I), and topped off by a 3-4 foot layer of interbedded coal and shale (J). The clayey material corresponding to the Second Slip can be recognized readily in E-logs from holes away from the mine area. The First Slip commonly cannot be recognized in the absence of a detailed core description; in such cases, the combined LI1-LI5 is referred to as the Lower I.

A distance away from the presently active mine, the First Slip (or a shale layer in similar stratigraphic position) thickens rapidly as the coal below the interval (the LI5) begins to thin and become shaley. Present plans are to ramp upward from the LI5 and to begin mining the combined UI and LI1.

About ¼ to ½ miles southwest of the present mine works, the LI1-LI5 interval again thins and becomes undetectable allowing the presence of a thick mass of Lower I in and around Section 31, T22S, R6E. Plans are to ramp back down from the UI-LI1 mining interval into the Lower I once this region is reached.

Present information shows that the LI5 commonly becomes thin and shaley once the LI1-LI5 parting becomes thicker than about 2 feet. While there are areas where the LI5 could produce high quality coal, these areas are much smaller than the extent of the planned UI-LI1 mining interval. The two potential coal layers are too close stratigraphically for multiple seam mining. Therefore, there are no plans at present for mining the LI5 where the LI1-LI5 parting becomes thick.

The parting between the UI and LI1 has a fairly constant thickness of 1-2 feet over most of the permit application area. This interval rapidly increases to more than 20 feet along a line trending through the southern part of Sections 31 and 32, T22S, R6E. Mining of the combined UI-LI1 will end where the interval is more than 2 feet.

6.5.2.4 The I-G Interval

The material immediately beneath the I zone generally is a soft clayey or silty material about 6 inches to 1 foot thick underlain by sandy siltstone or sandstone. Standard mining practice is to leave a foot or so of coal in the floor to avoid mining the machinery in that material.

The I-G interval has an average thickness of about 70-80 feet but attains a maximum measured thickness of near 100 feet along a rather diffuse trend extending north-south through the central part of the permit area.

Generally, the thinner parts of this interval are composed predominantly of shale and siltstone. The thicker parts contain one or more thick sandstone beds.

6.5.2.5 The G Seam

The G seam is a thin (5-foot average, 7-foot maximum) high sulfur, moderately extensive seam lying between the I zone above and the CD zone below.

Thin outcrops of the G seam are present in cliff walls bounding Muddy and Quitchupah Creeks to the east. The seam is only 2-3 feet thick along these canyons; drill hole data indicate that the seam thickens to the west and is about 5-6 feet thick over most of the permit area.

No mining of the G seam is contemplated because of the generally high sulfur and ash content and rather close stratigraphic distance from the preferred I zone.

6.5.2.6 The G-CD Interval

This interval has quite a variable thickness. Two lobes of near 60 feet thickness extend north from the southern border of the permit area. These are separated and bounded by areas where the thickness averages about 20 feet. The thin areas are approximately in the same location as the thick areas of the I-G interval.

As is common, the thinner areas are composed mainly of siltstone and shale while the thick areas contain one or more massive sandstone bodies.

6.2.5.7 The CD Zone

The CD coal bearing zone is a complex of interbedded lenticular coal beds, shale, clay siltstone and thin sandstone. Thickness of the zone averages about 12-13 feet. Commonly two coaly benches 3-5 feet thick separated by a 2-3 foot shale parting can be recognized. Average ash content of the full zone is about 30% and ash content of the more coaly parts ranges from 15-25%.

No mining of the CD zone is contemplated because of the very high ash content and because of the rather thin interval between the CD and the underlying A seam.

6.5.2.8 The CD-A Interval

This interval, as presently defined, ranges from 20-65 feet along the southern border of the permit area, but increases rapidly to over 100 feet a short distance north of there. This rapid thickening is associated with the northward thinning and disappearance of the A seam.

6.5.2.9 The A Seam

The main body of the A seam extends from Quitchupah Creek to just south of Ivie Creek. A single seam up to 13 feet thick exists in that region. Within the permit area, this lens of the A seam ranges in thickness of 0 feet along the Quitchupah to about 12 feet in the southwestern corner.

This lens of the A seam will be developed through a portal located along Ivie Creek, about 2½ miles south of the permit area. Mining of the A seam is not part of this application.

6.5.2.10 Strata Below the A Seam

The A seam is the lowest minable seam in the Emery project. Therefore, very few drill holes have penetrated more than 15-20 feet below this seam. The available information indicates that the interval between the base of the A seam and the bottom of the Ferron is about 60-70 feet thick and is composed mainly of sandstone and sandy siltstone.

6.5.3 Structure

The coal bearing strata dips gently to the west-northwest at about 7%. Departures of the coal beds from the regional structure are the result of differential compaction over lower sandstone units. The coal field is bounded on the west by the Joe's Valley fault zone.

6.5.4 Project Area Reserves

The following tables summarize the reserve calculations within the project area. All calculations were performed as per the USGS General Mining Order and as outlined in Section 6.5.5.1.

TABLE 6-1

COAL RESERVE BASE

Parameters:
1. All seams
2. 500 ft. deep, min. thickness is 2.33 ft.
3. 500 ft. deep, min. thickness is 4 ft.

(All values are x 1000 tons.)

Seam	Federal	State	Fee	Seam Total
K	3,461	3,225	16,230	22,916
J	3,298	1,056	17,372	21,726
I Zone	164,495	29,773	148,211	342,479
G	17,275	2,658	46,066	65,999
D	61,965	7,829	33,167	102,961
C	60,061	13,467	120,305	193,833
A	215,985	21,351	33,799	271,135
		Grand Total		1,021,049

TABLE 6-2

ECONOMICALLY MINABLE COAL RESERVES

Parameters: 1. I Zone & A Seam only.
2. Coal is sufficiently thick and of high enough quality to be presently enonomic to mine.

(All values are x 1000 tons.)

Seam	Federal	State	Fee	Seam Total
I Zone	27,587	7,027	54,978	89,592
A	108,842	5,753	11,485	126,080
		Grand Total		215,672

TABLE 6-3

ECONOMICALLY RECOVERABLE COAL RESERVES

Parameters: 1. I Zone and A Seam
2. Recovery factors appropriate for the proposed mining methods applied to the economically minable reserves.

(All values are x 1000 tons.)

Seam	Federal	State	Fee	Seam Total
I Zone	18,397	3,873	32,266	54,536
A	58,171	3,509	7,006	68,686
		Grand Total		123,222

TABLE 6-4

PHYSICALLY MINABLE COAL RESERVES

Parameters: 1. I Zone and A Seam
2. Minimum mining thickness 5 ft.
3. Maximum mining thickness 12 ft.

(All values are x 1000 tons.)

Seam	Federal	State	Fee	Seam Total
I Zone	41,619	8,194	70,886	120,799
A	194,690	14,015	24,725	233,430
		Grand Total		354,209

TABLE 6-5

PHYSICALLY RECOVERABLE COAL RESERVES

Parameters: 1. I Zone and A Seam
2. 50% underground recovery, 85% surface recovery applied to the physically minable reserves.

(All values are x 1000 tons.)

Seam	Federal	State	Fee	Seam Total
I Zone	25,857	4,617	41,344	71,837
A	97,345	7,008	12,363	116,715
		Grand Total		188,552

6.5.4.1 Method of Reserve Calculation

All reserve calculations were done according to the USGS General Mining Order. The calculations were performed using a computer to correlate all of the drill holes on the Emery property (Table 6-6). The seam thickness from each drill hole was first extrapolated onto a 200-foot grid with a thickness assigned to each intersection point. Each seam occurring in the property was then given an "Area of Extent," which was defined by outcrops, fault zones and the 2-foot thickness line.

The computer then integrated the grid data inside each area of extent, segregating the reserves into measured, indicated, and inferred, based on the distance from drill holes or outcrops (reserve figures shown in Section 6.5.4 have been totaled). At depths below 500 feet from the lowest surface elevation, the computer used a 4-foot minimum thickness cutoff, and for depths less than 500 feet it used a 2.33-foot cutoff. The results of these calculations were reported as the coal reserve base.

Minable reserves were calculated using both physical and economical constraints. "Physically minable" reserves were determined by the parameters of seam thickness (greater than 5 feet but less than 12 feet), seam quality, and interburden between seams. Using these constraints, only the I zone and the A seam were determined to be "physically minable."

Given the physically minable reserves contained in the I zone and the A seam (as calculated between 5' and 12'), second order economic constraints, as outlined in Section 3.3.3.2, were applied to determine "economically minable" reserves. The constraints used were based upon the financial position of the Emery Mine as of January 1, 1981. It is important to note that the economically minable reserves will change with time depending upon market conditions, productivity, and the overall economic and competitive atmosphere. In principle, as the intrinsic value of the inplace coal increases and productivity increases through increased recovery, the economically minable reserve should eventually become equal to the physically minable reserve.

TABLE 6-6 PERMIT AREA DRILL HOLE LOCATION AND IDENTIFICATION

ID#	X	Y	ELEV.
FC 1	2067750	194100	5969.30
FC 2	2065517	196537	6015.70
FC 3	2062690	199170	6075.40
FC 9	2057959	191914	6032.90
FC 29	2068180	200460	6152.00
FC 40	2063500	193800	5972.00
FC 41	2073597	199267	6090.64
FC 48	2066688	194226	5955.33
FC 49	2065380	193310	5945.25
FC 50	2065280	189110	5975.70
FC 52	2059992	196541	6009.60
FC 53	2069366	196768	6103.66
FC 55	2074520	194040	6102.05
FC 58	2065826	199418	6170.28
FC 59	2061369	201190	6083.51
FC 61	2063979	202014	6216.92
FC 62	2067368	202023	6187.92
FC 63	2065680	190580	5950.32
FC 64	2073495	201694	6124.40
FC 66	2070950	202229	6129.82
FC 68	2061340	191010	6023.18
FC 76	2067150	193504	5943.85
FC 77	2067080	194650	5963.86
FC 78	2066474	195191	5973.58
FC 79	2065728	195537	5972.72
FC 80	2063895	197134	6003.40
FC 82	2067317	190119	6018.92
FC 83	2066807	191325	5938.08
FC 84	2073950	193890	6103.60
FC 85	2074419	194712	6090.96
FC 88	2073674	196371	6055.04
FC 89	2072748	195496	6044.94
FC 90	2074140	198489	6080.33
FC 91	2064814	189252	5975.96
FC 94	2073766	195636	6031.87
FC 95	2074470	196130	6030.40
FC 96	2074775	196711	6036.96
FC 133A	2074147	189766	6235.32
FC 133B	2074155	189723	6236.46
FC 142	2067737	190836	6006.73
FC 144	2069067	189097	6115.32
FC 158	2075545	196275	6082.56

ID#	X	Y	ELEV.
FC 158B	2075527	196281	6082.63
FC 159	2075194	195899	6072.91
FC 159A	2075306	195767	6080.44
FC 159B	2075215	195901	6073.52
FC 167	2075381	197714	6054.67
FC 167A	2075294	197757	6051.28
FC 180	2074870	191569	6206.63
FC 187	2072610	190710	6163.00
FC 187A	2072480	190860	6157.00
FC 188	2071476	192085	6049.92
FC 189	2067592	190585	6008.67
FC 190	2064961	189595	5969.44
FC 194	2068479	189775	6066.22
FC 194A	2068540	189770	6055.00
FC 195	2068620	189265	6093.49
FC 195A	2068757	189370	6092.79
FC 245	2075848	199829	6084.84
FC 247	2075995	198085	6059.38
FC 248	2074455	198029	6063.33
FC 249	2075140	196998	6050.93
FC 250	2073524	196808	6055.87
FC 251	2072910	194929	6036.68
FC 259A	2075635	196665	6078.47
FC 259B	2075753	196438	6078.91
FC 259C	2075792	196298	6085.07
FC 260A	2075252	196118	6078.18
FC 260B	2075353	195950	6076.52
FC 260C	2075450	195805	6081.95
FC 261A	2074890	195674	6070.85
FC 261B	2075071	195557	6083.24
FC 261C	2075270	195415	6087.23
FC 262A	2074579	195216	6070.32
FC 262B	2074622	195002	6085.20
FC 262C	2074697	194869	6085.74
FC 263A	2074246	195355	6056.53
FC 263B	2074272	194873	6078.26
FC 263C	2074294	194718	6081.44
FC 263F	2074332	194520	6081.67
FC 264A	2074166	194625	6072.53
FC 264B	2073986	194792	6062.69
FC 264C	2073944	194902	6057.01
FC 265A	2073944	194903	6056.92

TABLE 6-6

ID#	X	Y	ELEV.
FC 265B	2073898	194665	6059.67
FC 266A	2073722	194653	6065.96
FC 266B	2073704	194581	6071.46
FC 267A	2072449	195593	6052.80
FC 267B	2072298	195614	6058.08
FC 267C	2072183	195674	6066.06
FC 267D	2072082	195715	6072.93
FC 268A	2072108	195310	6029.06
FC 268B	2071921	195193	6035.45
FC 268C	2071735	195188	6044.34
FC 269A	2071741	194913	6038.21
FC 269B	2071610	194824	6036.94
FC 269C	2071233	194713	6075.06
FC 269D	2071228	194455	6075.97
FC 270A	2071791	194515	6020.89
FC 270B	2071684	194488	6028.27
FC 270C	2071563	194327	6067.11
FC 271	2071963	194198	6051.13
FC 272A	2072237	194363	6024.44
FC 272B	2072215	194266	6037.06
FC 272C	2072149	194141	6046.77
FC 273	2072400	194167	6037.34
FC 274	2060780	199430	6035.06
FC 275A	2063524	198031	6031.44
FC 275B	2063498	198053	6031.66
FC 275P	2063760	198915	6165.28
FC 276	2062389	197138	6002.48
FC 277	2063645	196234	5984.04
FC 278	2068348	195491	6008.49
FC 279	2066589	198826	6152.22
FC 280	2066570	196790	6014.36
FC 281	2069065	191840	6034.21
FC 282	2068940	191803	6034.39
FC 283	2068848	191770	6033.50
FC 284	2065033	190274	5959.12
FC 285	2064073	190010	5960.82
FC 286	2063371	189373	5974.92
FC 287	2063356	191048	5974.84
FC 288	2065345	191614	5941.06
FC 289	2065967	191509	5940.43
FC 291	2061761	192107	5991.83
FC 292	2061951	195158	5994.29
FC 293	2063821	192780	5965.11
FC 294	2065364	192473	5944.15
FC 296	2066716	189563	6009.08
FC 298	2065945	190283	5954.25
FC 300A	2068603	189861	6063.74
FC 301A	2068650	189607	6079.22
FC 301B	2068522	189545	6077.00
FC 302A	2068841	189436	6090.35
FC 303A	2068916	189058	6103.90
FC 303B	2068993	189193	6109.67
FC 334	2059299	191105	6038.36
FC 336	2058546	195711	6040.28
FC 337	2056955	190802	6062.54
FC 340	2059177	194152	6018.98
FC 341P	2066290	189965	5978.66
FC 342P	2072844	196296	6062.83
FC 343P	2072537	196510	6086.13
FC 347	2066838	192374	5929.96
FC 348	2066203	192479	5932.31
FC 353	2072716	193588	6058.46
FC 354	2073094	193878	6073.37
FC 355	2074604	194650	6088.61
FC 355A	2074875	194695	6088.96
FC 355B	2074449	194706	6090.76
FC 355C	2074509	194682	6087.63
FC 355D	2074396	194712	6090.24
FC 355E	2074439	194703	6091.14
FC 355F	2074458	194694	6090.06
FC 356	2074663	195444	6063.58
FC 357	2074100	194860	6063.86
FC 358	2073789	194648	6067.24
FC 358B	2073733	194696	6063.23
FC 358C	2073709	194716	6062.59
FC 359	2072350	197501	6077.12
FC 360	2072637	198348	6070.44
FC 361	2070850	197424	6091.54
FC 362	2074274	197370	6053.16
FC 363	2074166	196400	6043.99
FC 365	2071590	193279	6064.50
FC 366	2071977	194944	6039.06
FC 367	2072075	194166	6049.92
FC 368	2072477	194057	6028.33

TABLE 6-6

ID#	X	Y	ELEV.
FC 369	2072945	194492	6046.92
FC 370	2073217	194756	6045.74
FC 371	2072236	193853	6043.37
FC 372	2071980	193458	6035.50
FC 373A	2073259	194677	6013.07
FC 373B	2073270	194660	6010.59
FC 373C	2073292	194620	6007.65
FC 373D	2073308	194601	6007.92
FC 374A	2073039	194396	6008.63
FC 374B	2073050	194380	6005.11
FC 374C	2073064	194361	6004.42
FC 374D	2073075	194342	6003.48
FC 374E	2073084	194325	6003.19
FC 374F	2073094	194305	6003.50
FC 375A	2072749	194164	5996.12
FC 375B	2072719	194193	5996.24
FC 375C	2072687	194235	5997.18
FC 375D	2072792	194132	5996.35
FC 376A	2072365	193845	5988.13
FC 376B	2072364	193807	5986.97
FC 377A	2072050	193579	5993.16
FC 377B	2072029	193589	5990.22
FC 377C	2071963	193642	5991.97
FC 377D	2072091	193562	5985.27
FC 377E	2072127	193520	5983.81
FC 377F	2072110	193540	5984.81
FC 378	2066392	197497	6049.66
FC 379	2068854	196475	6114.34
FC 380	2066491	196295	6005.01
FC 381	2067648	197919	6130.64
FC 382	2065383	197533	6065.58
FC 383	2064932	195965	5980.58
FC 384	2065430	195268	5964.96
FC 385	2068185	196269	6036.29
FC 386	2068065	197156	6051.96
FC 387	2066224	198466	6144.55
FC 434	2073300	195450	6040.00
FC 442	2068249	197597	6111.30
FC 443	2070452	198056	6104.30
FC 444A	2070848	197400	6092.10
FC 445	2072241	197122	6093.80
FC 446	2071321	196180	6090.30
FC 447	2064781	192204	5964.00
FC 447A	2064751	192194	5965.10
FC 448A	2070570	200009	6107.30
FC 451	2059158	200557	6066.10
FC 452	2062397	201159	6195.50
FC 453	2064796	199479	6162.30
FC 454	2065634	201230	6192.10
FC 455	2065232	202642	6214.90
FC 456	2068338	190358	6045.50
FC 458	2066675	191436	5934.30
FC 459	2064383	189070	5974.90
FC 460B	2068530	190382	6051.00
FC 471	2061505	190086	6002.60
FC 473	2062451	189730	5984.10
FC 475	2058089	189872	6069.30
FC 476	2057829	191391	6045.90
FC 497	2075344	196759	6063.00
FC 498	2074914	195754	6071.00
MC 1	2071560	193640	6060.00
MC 2	2072090	195190	6066.00
MC 3	2073940	196480	6050.00
MC 4	2075860	197820	6055.00
74FC350	2071766	194017	6026.00
74FC351	2071745	193205	6060.00
74FC352	2071506	193043	6049.00
79FC499	2073568	198010	6058.00
79FC500	2065462	194021	5950.00
79FC501	2072042	198689	6080.00
79FC502	2071060	199138	6095.00
79FC503	2073369	199077	6084.00
79FC504	2064398	194097	5960.00
79FC505	2063997	191269	5961.30
79FC506	2074225	200027	6096.60
79FC508	2064359	189698	5965.60
79FC510	2073044	201004	6142.00
79FC511	2064310	193596	5957.40
80FC142	2067693	190815	6012.00
80FC514	2073571	200708	6117.00
80FC515	2074662	200719	6101.00
80FC522	2059130	198900	6037.00
80FC523	2068623	199494	6138.00
80FC529	2075661	192155	6200.00

TABLE 6-6

ID#	X	Y	ELEV.
80FC536	2068791	191081	6024.00
80FC541	2068439	190959	6098.00
80FC544	2066965	190971	5959.00
80FC545	2065379	193186	5946.00
80FC547	2059982	191361	6028.00
80FC552	2057567	194030	6032.00
80FC553	2060000	194068	6008.00
80FC560	2063597	195495	5976.00
80FC563	2061472	195810	5997.00
80FC564	2062828	196134	5984.00
80FC565	2062540	194099	5999.00
80FC566	2058858	193499	6017.00
80FC567	2060130	195340	6018.00
80FC568	2069720	198672	6113.00
80FC569	2063019	193818	5994.00
80FC570	2064370	194076	5960.00
80FC571	2062788	192852	5970.00
80FC572	2057519	192590	6047.00
80FC584	2068094	198267	6129.00
80FC617	2057754	198184	6069.00

The recoverable reserves were calculated by applying recovery factors to each area of physical and economic extent. The recovery factors were determined from the proposed mining method for each area. A figure consistent with partial extraction was used for the I zone underground mine. Other factors were used for the future A seam longwall operations and the proposed future strip mining areas.

6.5.4.2 Coal Characteristics of the I Zone

General coal quality for the minable portion of the I zone is as follows:

Raw Ash	8.8%
Raw Sulphur	0.7%
Raw BTU/lb.	12,300

Sulfur content of the coal in the operating I zone mine ranges from about 0.5 percent to 2.0 percent. Daily averages are usually less than 1.0 percent. Some small areas in and around the mine have larger numbers of sulfur balls that yield higher than average sulfur contents.

Sulfur content of coal from core samples in the mine area averages from 1.0 to 1.5 percent for a number of bore holes. Typically the sulfur contents are less than 1 percent. Values from 20 percent to 50 percent are found where the core intersects a concentration of sulfur balls.

Two samples of coal, categorized as vitrinite (sample 1) and exinite (sample 2), were analyzed for pyrite and marcasite by CSMRI. Sample 1 contains less than 0.5% of sulfide, all pyrite, in the 2-micron-diameter size range or less. Sample 2 contains more total sulfide content, 7 - 10% by volume. With the exception of a few rare isolated pyrite grains, all of the sulfide minerals are microscopic concretions. Under high magnification (1000x), it can be seen that the concentrations are composed of minute crystals of pyrite, marcasite, and the remainder, chalcopyrite. The crystals are much too fine grained to be certain of optical properties for marcasite.

Kaolinite is the dominant clay mineral in the four roof and floor samples tested. Illite varies from minor amounts to moderate amounts. Montmorillonite is either not present or present in moderate amounts. Total clay content is moderate to high for three samples.

6.5.5 Classification of Strata/Adjacent Units

Table 6.7 lists results of chemical analyses for various strata to be discussed below.

6.5.5.1 Roof and Floor Characteristics of the I Zone

Roof and floor materials of the I zone mine are interbedded sandstones and shales. The 10 feet of section immediately above the I zone coal generally contains several feet of irregularly laminated, light gray, fine-grained quartz sandstone. Dark gray shale is usually in contact with the coal. Pyrite is present occasionally in minor amounts. The floor material is generally dark olive gray, coaly, silty shale. Several

Table 6.7

Chemical Analyses of Deep Mine Core

CONSOLIDATION COAL / HOLE: #COLLUVIUM

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	0.0 TO 5.0	6.9	7.7	31.4	7.76	53.66	17.00	1.3	2.2	1.7	0.01	1	0.68	0.0	8.3	4.6				
2	5.0 TO 9.5	5.5	41.8	40.9	45.11	34.74	272.43	3.6	2.5	6.1	0.01	0	4.90	1.5	61.0	25.0	+25			

CONSOLIDATION COAL / HOLE: #ALLUVIUM

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	0.0 TO 3.0	6.4	12.0	32.4	19.30	34.07	45.21	3.0	5.9	2.4	0.01	0	1.20	0.0	5.3	2.7				
2	3.0 TO 6.0	6.9	5.9	29.7	8.20	27.28	13.47	1.8	4.6	1.4	0.01	1	0.54	0.0	3.3	5.3				
3	6.0 TO 12.0	7.1	5.1	28.7	8.48	24.92	9.29	2.1	4.3	2.8	0.01	1	0.66	0.0	2.7	3.2				

CONSOLIDATION COAL / HOLE: #2008

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	421.0 TO 431.0	6.2	12.4	28.5	28.10	33.84	56.20	4.2	3.0	0.5	0.00	0	1.05	0.0	59.0	21.0				

CONSOLIDATION COAL / HOLE: #338

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	736.0 TO 746.0	6.7	2.7	29.5	10.61	13.56	11.30	3.0	1.5	0.1	0.00	0	0.26	0.0	22.0	8.1	+1			
2	766.0 TO 776.0	8.9	2.6	27.6	24.78	2.15	8.96	2.6	1.2	0.6	0.00	16	0.21	0.0	13.0	0.8				

CONSOLIDATION COAL / HOLE: #340

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	680.0 TO 690.0	6.3	12.4	27.7	55.19	20.90	26.44	11.3	4.6	0.2	0.01	0	1.59	0.0	50.0	3.9		9.5	1.1	11.9
2	717.4 TO 730.0	5.9	4.9	30.5	45.60	10.49	6.55	15.6	0.2	0.2	0.00	0	0.55	0.0	54.0	2.8	+2	8.1	1.5	18.7

CONSOLIDATION COAL / HOLE: #454

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	831.0 TO 835.0	7.3	4.9	28.1	26.00	22.06	14.24	6.1	5.1	0.1	0.00	1	0.43	0.0	26.0	4.3				
2	838.0 TO 840.0	9.0	2.8	30.5	27.67	2.83	7.85	6.0	1.2	0.6	0.00	22	0.35	0.0	9.6	0.7				

CONSOLIDATION COAL / HOLE: #459

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	198.0 TO 206.0	9.2	1.6	65.6	16.54	0.64	2.48	3.3	0.7	0.8	0.00	9	0.15	3.2	17.0	0.4				

CONSOLIDATION COAL / HOLE: #460D

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	129.8 TO 136.5	8.9	2.0	28.2	18.13	2.03	3.14	9.4	3.5	0.6	0.00	5	0.15	0.0	11.0	1.1				
2	150.0 TO 158.0	9.1	1.7	42.4	16.79	0.71	3.09	1.6	1.0	0.6	0.00	12	0.13	1.4	12.0	0.6				

CONSOLIDATION COAL / HOLE: #460

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	520.0 TO 528.0	8.9	1.2	32.7	12.40	1.28	1.07	11.7	2.8	0.4	0.00	2	0.12	0.6	12.0	1.2		11.6	1.4	12.0
2a	533.4 TO 536.0	8.8	1.3	60.2	12.68	0.93	1.16	7.9	4.3	0.6	0.00	3	0.11	2.0	15.0	1.8				
2bc	536.0 TO 546.0	9.1	1.9	31.6	17.96	2.50	2.78	7.1	3.8	0.5	0.00	5	0.14	0.6	13.0	2.4				

CONSOLIDATION COAL / HOLE: #473

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	360.0 TO 367.2	9.1	1.9	32.1	19.72	3.22	1.34	6.4	8.2	0.3	0.00	6	0.24	0.0	38.0	3.0				
2	387.0 TO 390.0	9.0	3.1	28.2	32.08	5.40	9.00	8.6	1.9	0.8	0.00	10	0.37	0.0	15.0	1.5				

CONSOLIDATION COAL / HOLE: #480D

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1ab	550.0 TO 556.0	7.2	8.4	29.5	59.00	9.50	2.26	24.3	1.7	0.3	0.00	1	0.77	0.0	47.0	4.0		9.1	2.5	28.1
1cd	556.0 TO 560.5	5.0	10.4	31.9	38.21	24.79	35.57	7.0	0.3	0.1	0.02	0	1.10	0.0	65.0	8.3	+2			
2	566.5 TO 570.0	7.8	2.9	32.3	27.98	6.19	4.12	12.3	5.2	0.1	0.00	2	0.28	0.0	30.0	4.9		10.0	1.4	14.5

CONSOLIDATION COAL / HOLE: #484

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	620.0 TO 630.0	7.7	3.8	33.5	46.74	3.58	1.99	28.0	1.7	0.3	0.00	3	0.35	0.6	17.0	1.5		10.8	3.5	32.4

CONSOLIDATION COAL / HOLE: #486

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	260.2 TO 270.0	8.5	3.1	28.6	38.64	3.92	4.36	19.7	0.7	0.7	0.00	4	0.20	0.0	17.0	2.8		9.0	1.7	19.3
2	280.0 TO 288.0	9.2	2.8	29.0	27.53	3.52	7.34	3.7	2.1	0.3	0.00	7	0.36	0.0	17.0	7.1				

CONSOLIDATION COAL / HOLE: #487

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	550.0 TO 560.8	9.0	2.2	36.2	21.60	2.57	4.28	12.7	3.8	0.3	0.00	6	0.20	0.7	18.0	3.2		11.7	1.8	15.4
2	569.0 TO 570.0	9.2	2.3	49.9	23.42	1.25	5.57	1.8	1.1	0.5	0.00	7	0.18	1.4	14.0	1.2				

CONSOLIDATION COAL / HOLE: #488

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
2	583.0 TO 593.0	9.2	1.8	60.0	17.63	1.08	2.92	1.9	1.3	0.7	0.00	12	0.23	2.6	22.0	1.1				
3	593.0 TO 600.0	9.1	1.6	42.8	15.93	0.70	3.21	2.4	0.7	0.3	0.00	6	0.17	1.4	11.0	0.8				
1	580.0 TO 583.0	7.9	2.4	31.7	9.86	10.08	2.10	4.0	0.4	0.7	0.01	1	0.66	0.0	2.7	3.2				

CONSOLIDATION COAL / HOLE: #490

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	230.0 TO 242.8	8.3	3.2	30.5	39.88	7.86	2.18	17.8	4.2	0.4	0.00	2	0.26	0.0	20.0	5.9		19.3	3.6	18.8
2	252.0 TO 260.0	9.4	2.3	41.7	21.63	2.29	5.09	4.6	1.6	0.6	0.00	10	0.28	1.3	11.0	2.5				

CONSOLIDATION COAL / HOLE: #492

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	390.0 TO 401.2	9.1	2.7	27.5	29.50	6.40	3.55	10.0	1.5	0.4	0.00	4	0.20	0.0	12.0	1.9				
2	405.5 TO 407.9	9.2	2.4	56.3	26.56	2.35	3.92	10.4	1.3	0.6	0.00	11	0.30	1.9	23.0	1.3		18.1	2.4	13.1

CONSOLIDATION COAL / HOLE: #FC 499

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	240.0 TO 243.0	7.1	6.7	32.3	25.08	23.53	6.20	6.7	0.5	1.6	0.01	1	0.83	0.0	9.7	1.8				

CONSOLIDATION COAL / HOLE: NFC 500

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	312.0 TO 332.0	8.2	6.5	32.3	39.89	9.92	4.13	15.1	0.5	2.4	0.00	8	0.74	0.0	14.0	1.7		8.4	1.5	17.9
2	361.0 TO 376.0	8.6	8.2	47.3	26.56	90.20	40.69	3.7	0.1	3.0	0.01	12	1.05	1.4	19.0	1.0				

CONSOLIDATION COAL / HOLE: NFC 501

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	320.0 TO 330.0	6.3	4.4	29.7	10.53	28.55	4.49	2.6	0.5	0.9	0.01	0	0.31	0.0	18.0	4.3				

CONSOLIDATION COAL / HOLE: NFC 505

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	280.0 TO 290.0	7.9	4.1	28.7	27.91	6.98	1.86	13.3	5.5	1.6	0.00	3	0.52	0.0	35.0	4.1		9.5	1.4	15.0

CONSOLIDATION COAL / HOLE: NFC 536

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	0.0 TO 20.0	6.9	9.1	28.8	18.10	50.60	20.81	3.0	2.8	2.3	0.01	1	1.11	0.0	5.7	1.4				
2	20.0 TO 40.0	6.7	12.3	28.7	18.16	51.34	32.49	2.8	1.7	1.3	0.01	1	1.50	0.0	3.3	0.9				
3	40.0 TO 60.0	7.0	9.4	32.2	8.65	57.79	24.07	1.3	2.6	1.5	0.03	3	0.94	0.0	3.1	0.6				
4	60.0 TO 95.0	7.1	10.0	31.6	17.62	48.23	14.78	3.1	1.2	1.5	0.01	2	1.05	0.0	5.2	0.7				
5	95.0 TO 110.0	7.0	7.9	30.8	26.00	37.00	10.83	5.3	0.6	1.7	0.02	1	0.77	0.0	12.0	1.9				

CONSOLIDATION COAL / HOLE: NFC 142 OFFSET

SAMPLE #	DEPTH FT:	PH	EC	SAT%	NA	CA	MG	SAR	LM	B	SE	F	AS	MO	FE	MN	ABP	CEC	XNA	ESP
1	112.0 TO 120.6	8.6	8.2	41.6	20.19	47.44	91.78	2.9	4.6	4.6	0.01	7	1.02	1.2	12.0	3.2				
2	127.3 TO 132.8	8.7	5.8	47.0	6.42	22.65	78.17	2.0	1.2	4.4	0.01	12	0.60	1.9	28.0	1.6				
3	144.9 TO 148.0	9.0	3.6	52.1	4.64	12.70	42.33	1.6	0.6	3.2	0.01	15	0.45	2.1	14.0	0.8				

HOLE	SAMPLE #	DEPTH INTERVAL	Pb	Zn	Ni
280B	1	421.0 - 431.0	4.3	3.6	-.1
340	1	680.0 - 690.0	5.1	4.3	-1
	2	717.4 - 730.0	6.2	3.6	-1
459	1	198.0 - 206.0	1.6	0.8	-.1
473	1	360.0 - 367.2	3.7	1.2	-.1
	2	387.0 - 390.0	1.4	0.9	-.1
501	1	320.0 - 330.0	1.6	1.3	-.1
362	3	30.0 - 65.3	3.1	1.1	-.1
363	1	20.0 - 22.0	1.1	1.4	-.1
	2	22.0 - 30.0	1	.8	-.1
	3	30.0 - 38.0	.8	1.6	-.1
	4	38.0 - 41.3	.9	1.4	-.1
	5	41.3 - 58.0	1.9	2.1	-.1
	6	58.0 - 60.8	.9	1.8	-.1
	7	60.8 - 62.0	5.4	3.2	-.1
	8	62.0 - 77.4	1.8	2.8	-.1
	9	77.4 - 88.0	1.5	2.6	-.1
	10	88.0 - 100.0	6.3	4.3	-.1
	11	126.6 - 130.0	4.2	1.1	-.1
	12	130.0 - 133.0	8.6	5.2	-.1
365	1	20.0 - 52.0	3.7	4.7	-.1
	3	58.6 - 71.8	1.4	3.6	-.1
	4	71.8 - 73.6	8.9	3.1	-.1

Minus sign indicates less than reporting minimums.

feet of light gray fine-grained quartz sandstone with irregular shale lamina, burrow structures and coal fragments are typically present within the first 10 feet of section below the coal.

Values of pH in the roof and floor horizons range from 5.0 to 9.1. The acid materials have a net base potential. Most of the strata have alkaline pH. Floor pH is generally higher than that of the roof, with many values greater than 9.0. The high pH values indicate that elements mobile at high pH may be in solution.

Electrical conductivity values are typically below 4.0 mmhos/cm, except in holes nearest the outcrop. Roof materials are more generally sodic. Sodium adsorption ratios range from 1.8 to 28.0. Values exceed 10 in several holes, in both roof and floor intervals. Many ESP (exchangeable sodium percentage) values are above 15. Mine water might have sodium concentrations unsuitable for irrigation use.

Trace element analysis for boron, selenium, flouride, arsenic, molybdenum, iron, manganese, lead, zinc and nickel were conducted. Boron (hot-water extractable) concentrations are generally less than 1.0 ppm; but the salty strata have higher boron levels (1.6 to 4.6 ppm). These are near the outcrop of the Ferron and could produce boron in the mine discharge unsuitable for irrigation use. Selenium concentrations are low. Flouride is present in most holes, and therefore mine water might contain levels unsuitable for irrigation or for livestock. Arsenic (acid-soluble) concentrations exceed 0.1 ppm in all intervals and range to 1.59 ppm. Molybdenum is not a potential problem. Iron (DTPA extractable) concentrations range from 12 to 65 ppm.

Manganese (plant extractable) concentrations are below suspect levels for overburden. Lead is below the suspect level for overburden with pH greater than 6. Zinc (DTPA-extractable) is below the drinking water standards. Nickel (DTPA-extractable) concentrations are less than 0.1 ppm; no water standards for nickel have been established.

6.5.5.2 Proposed New Portal Area Strata

The strata to be affected in the proposed new portal area of the Emery Mine are colluvium, alluvium, sandstones (altered and unaltered) of the Ferron, and interbedded shales and coals. Colluvium has a bouldery, loamy sand texture. It is mostly a slightly calcareous medium sand. The alluvium is stratified sand, silt, and gravels up to 50 feet thick. It is mostly a medium sand with many thin (1 to 2 in.) intervals of silt.

The Ferron sandstone is a lenticular bedded, fine to coarse sandstone. It overlies burned coal. Unaltered sandstones are fairly competent but highly fractured, since subsidence occurred where the coal has burned.

Shales in the Ferron Sandstone are gray, gypsiferous, slightly hard, weathered, with nodules and veins of gypsum.

The colluvium is the primary material to be affected in the portal area. It is a fair reclamation material. It is saline (EC 7.7), non-sodic, and calcareous.

The alluvium is chemically similar to the colluvium. It too is saline, non-sodic, and calcareous. As a souce of reclamation material most of the alluvium would be rated fair. The strata with an EC between 8.0 and 16.0 would be rated marginally unsuitable.

The sandstones of the Ferron are similar to the colluvium and alluvium, which are derived from it. They are saline, non-sodic, and calcareous. As a root-zone material, most of the Ferron Sandstone tested would be rated fair to marginally unsuitable in strata with an EC between 8 and 16. A gray, gypsiferous, weathered shale overlying the coal bed in the portal area is unsuitable for use in reclamation. It is moderately acid, extremely salty, high in boron, high in arsenic, and high in iron. This material may need to be disposed with the coal waste in the portal area.

The principal strata to be affected in the portal area--colluvium, alluvium, and sandstones and shales of the Ferron--have generally suitable physical properties for engineering uses.

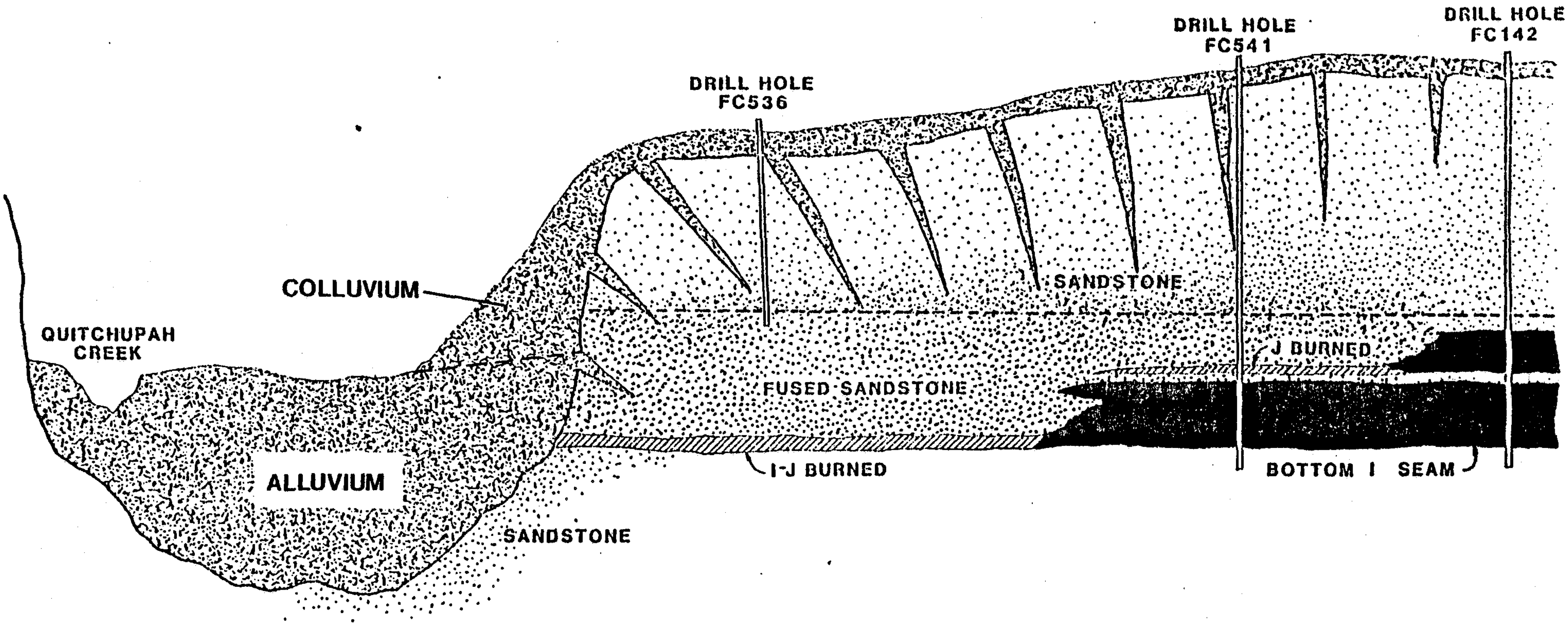
The colluvium is in Unified Class SM. It has fair workability as a construction material and has good compaction characteristics. It will be semi-pervious to impervious and will have good shear strength and low compressibility when compacted. The surface of the soil has about 5 percent gravels, 3 percent cobbles, 3 percent stones, and 15 percent boulders. The erodibility factor (K factor) is good for a source of reconstruction material.

The alluvium in the portal area is in Unified Class ML and AASHO group A - 4(3). It has fair workability as a construction material but may have poor compaction characteristics. It has fair shear strength, medium to high compressibility, and is semi-pervious to impervious when compacted. Under conditions of good drainage and thorough compaction, the supporting value as a sub-grade material should be fair.

In the portal area the unaltered sandstones are fairly competent; the sandstone forms massive ledges above the draws (Figure 6-2). Drilling indicated fairly competent but highly fractured sandstones in subsided areas. Testing of similar sandstones indicated high durability to weathering, moderate compressive strengths of 3912 to 8842 psi, and low tensile strengths of 238 to 684 psi. The erodibility of spoil material generated from the Ferron Sandstone is estimated to be low. Spoiled material from the sandstone will be competent, easily compacted, with good workability. The spoil should be semi-pervious to pervious when compacted.

The colluvium and alluvium will supply fair reclamation material. The principal deleterious characteristic is salinity; typically in the range of 4 to 8 mmhos/cm. Values of EC generally are less than 16.0. These saline levels are typical of many of the soils in the Emery Basin. Reclamation plans will have to include salt-tolerant species of plants.

Acid-forming, alkaline-producing or toxic-forming materials in the strata of the portal areas will not affect reclamation. There are no acid-forming or alkaline-producing strata, but toxic-forming strata do



6-23

FIGURE 6-2

CONCEPTUAL CROSS SECTION THROUGH AREAS OF PROPOSED PORTAL ENTRIES

occur and may require special handling. The strata are generally nonsodic. Values of pH are all less than 7.9. Values of SAR are less than 8.0. Shales associated with coals in the portal area may be very saline and high in some toxic elements.

6.5.5.3 Identification and Description of Potential Acid, Alkaline, or Toxic Material

The potential for water quality degradation due to underground coal mining results from the interaction between inimical materials in the roof and floor, groundwater seeps or drains in the mine, and the movement of mine water into an aquifer system or surface flow. Present coal mining techniques include using water to eliminate particulate matter from the air in the mine by putting it into aqueous suspension or dissolution. Total dissolved solids in mine water will be expected to be high from this source alone. Most samples of Browning mine discharge have a pH between 7.1 and 8.5 and an average TDS of 4000 ppm. The high TDS value is due to the addition of Mg, SO_4, Na, and Cl from rock and coal dust. Trace element analyses of the mine water have not been reported.

Baseline hydrologic data indicate that mine water will probably not degrade the confined aquifers. Present mine inflow comes almost entirely from the sandstone above the coal. It is unlikely that there is a hydrologic connection between the coal to be mined and the lower Ferron aquifer. Any potential geochemical hazard will be from the movement of water from the upper Ferron into the mine and then, via pumping, out to the surface drainage system.

Even before receiving discharge from the present deep mine, both Quitchupah Creek and Christiansen Wash contain highly saline, low- to medium-sodium waters that are unfit or, at best, marginal for most uses. Mine water will likely add to the dissolved solid load of the already naturally polluted Christiansen Wash and Quitchupah Creeks. Mine water might contain higher concentrations of sodium, boron, flouride, arsenic, and iron than are suitable for most uses. Selenium, molybdenum, manganese, lead, zinc and nickel do not appear to represent any toxic potential.

6.5.5.4 Reclamation Effects

Acid-forming, alkaline-producing, or toxic-forming materials in the strata to be affected in the portal areas are not expected to affect reclamation. In the proposed portal area there are not any acid-forming or alkaline-producing strata. Based on limited data, potentially toxic-forming strata do occur and may require special handling.

Acid-forming potential is not a problem in the portal area. Most pH values are greater than 6.0. There is abundant lime in all the strata to neutralize any acid-formers present. In the most acidic sample tested in the portal area, the acid-base potential was basic (+ 25).

There are no alkaline-producing strata in the portal area. The strata are generally nonsodic. Values of pH are all less than 7.9. The SAR values are less than 8.0.

The colluvium and alluvium will supply fair reclamation material. Its principal deleterious characteristic is salinity, typically in the range of 4 to 8 mmhos/cm. Values of EC generally are less than 16.0. These saline levels are typical of many of the soils in the Emery Basin. Reclamation plans will have to include salt-tolerant species of plants.

6.6 Geologic Effects of Mining

6.6.1 Mining Hazards

Although there has been intense geologic activity to the east and west of the Emery coal field, the seams in the area have been left reasonably intact. However, this activity has impacted the field by the creation of lineaments and highly jointed areas, which have posed roof control problems in the past.

Through the use of aerial photographs, Consol has been able to map structure patterns and predict areas of possible roof instability. This has proved to be an invaluable aid in the mining of the I zone, as preparations can now be made for adverse areas before they are encountered.

6.6.2 Surface Hazards

Since the mine facilities do lie in the bottom of a steep canyon, there have been minor problems with rock falls in the past, especially during the spring. However, potentially dangerous material has been removed from the canyon walls over the years so that they remain fairly stable at present.

6.6.3 Impacts of Mining

Consol does not predict any significant impacts on the area geology during the permit term.

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Appendix 6.1

Pyrite/Marcasite Report

Colorado School of Mines Research Institute

September 4, 1980

P.O. BOX 112 · GOLDEN, COLORADO 80401
PHONE (303) 279-2581 · TWX 310-934-0194 · CSM Res Gldn
CSMRI

CSMRI Project C00849

Mr. Don Wasson
James P. Walsh & Assoc.
465 Grape Ave.
Boulder, CO 80302

Dear Mr. Wasson:

We have completed our investigation of the relationship between marcasite and pyrite in the coal sample you submitted which was designated as being retrieved from hole FC-466.

The portions of core received were inspected and observed to be composed of widely differing lithologies (presumably differing maceral content). For this reason, two apparently different pieces of coal were selected for study. Each of these samples, designated herein as No. 1 and No. 2, was prepared as a polished section and examined with the aid of the ore microscope.

The two samples may, superficially at least, be categorized as vitrinite (No. 1) and exinite (No. 2). Sample No. 1 contains only a trace (less than 0.5%) of sulfide, all pyrite, in the 2μm diameter size range or less. Sample No. 2, contains more sporonite material and a total sulfide content of 7-10% by volume. With the exception of a few, rare isolated pyrite grains, all of the sulfide minerals are confined to irregular masses and nearly spherical, fine-grained concretions(?). The spheres average 18μm and the masses about 200μm. The spheres are found as isolated structures and within the larger, and irregular masses. Under high magnification (~1000x), the masses and spheres are observed to be composed of minute crystals of pyrite, marcasite(?)[1], and chalcopyrite. If this were a metallic ore specimen, these spheres would be termed "framboidal." The pyrite accounts for about one-half of the sulfide in spheres and masses as well. Approximately one-fourth is marcasite(?) and the remainder is chalcopyrite. Pyrite and marcasite occur as rounded to subrounded particles, generally 1μm diameter or less. Much of the chalcopyrite occurs as similarly sized triangular crystals.

The nature of the sulfide occurrences in sample No. 2 is suggestive of a former gel stage in its development. The original gel was most likely composed of melnikovite, an amorphous form of FeS_2. Melnikovite is highly unstable at atmospheric temperatures and pressures and quickly converts to the stable pyrite form or possibly marcasite under those conditions. The shape of chalcopyrite crystals is also suggestive of authigenic origin.

Mr. Don Wasson
James P. Walsh & Assoc.
September 4, 1980
page 2

I hope this information will prove useful to you. We thank you for the opportunity to be of service to you and James P. Walsh & Assoc. If you have any questions or would like us to return your polished sections and/or unused core, please let us know.

Sincerely,

Delbert E. Gann

Delbert E. Gann
Project Mineralogist
Exploration & Mining Division

/rms

[1] Crystals are much too fine-grained to be certain of optical properties for marcasite.