CONSOLIDATION COAL COMPANY
EMERY MINE

PERMIT ACT/015/015

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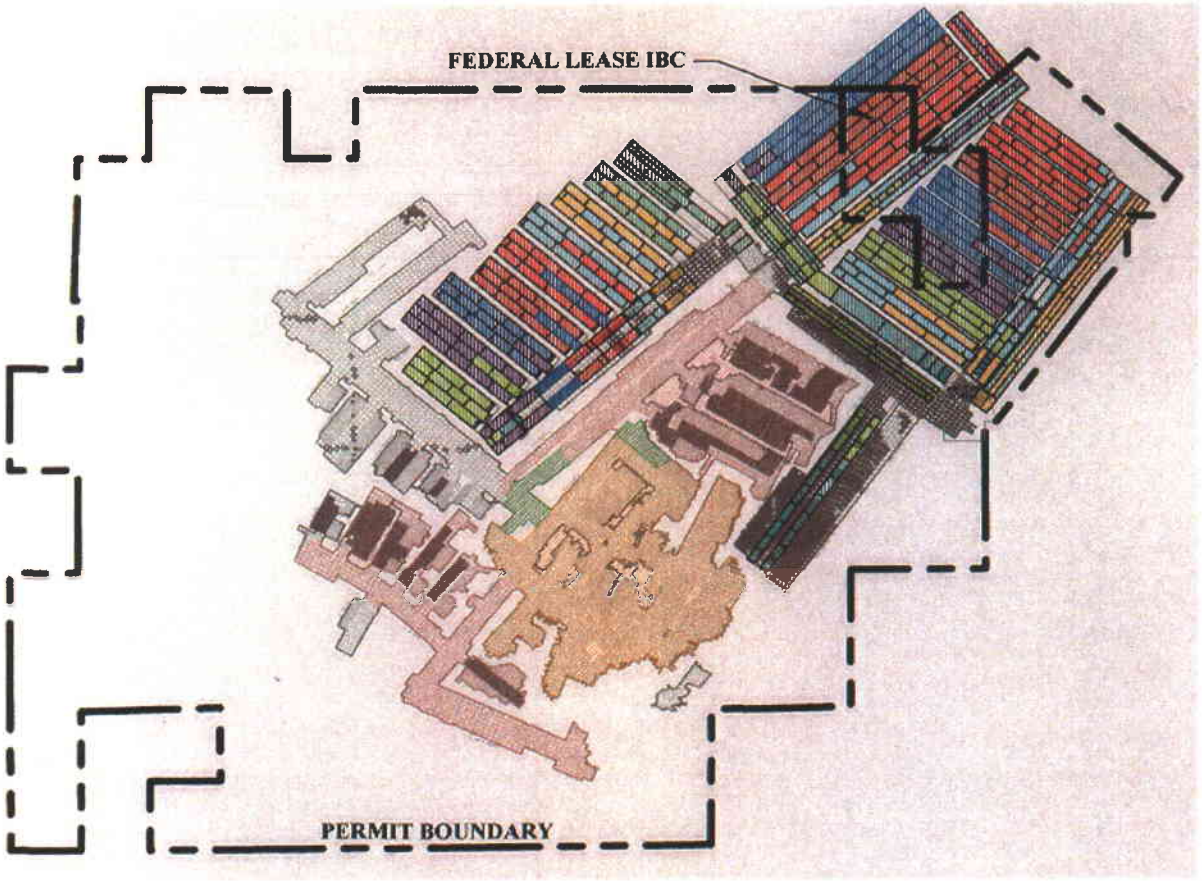
for additional information

CHAPTER XIII

FEDERAL LEASE AREA
INCIDENTAL BOUNDARY CHANGE
APPLICATION



CHAPTER XIII

EMERY MINE FEDERAL LEASE INCIDENTAL BOUNDARY CHANGE APPLICATION

EMERY MINE
CONSOLIDATION COAL COMPANY
EMERY COUNTY, UTAH

SUBMITTED TO

UTAH DIVISION OF OIL, GAS AND MINING

PREPARED BY

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SEPTEMBER 12, 2006
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CHAPTER XIII

EMERY MINE FEDERAL LEASE INCIDENTAL BOUNDARY CHANGE APPLICATION

XIII.A INTRODUCTION

This application for an incidental boundary change ("IBC") is submitted to the Utah Division of Oil, Gas and Mining ("UDOGM") by Consolidation Coal Company ("Consol") for the Emery Mine in Emery County Utah (UDOGM Permit No. ACT/015/015). The IBC area encompasses approximately 160 acres of private land and Federal coal adjacent to the northeast portion of the existing Emery Mine permit area (see Plate I-1 of the approved MRP). The IBC falls within the area of an existing Cumulative Hydrologic Impact Assessment and is within a drainage basin already authorized in the approved mining and reclamation plan ("MRP").

Approval of this IBC request will allow Consol to develop additional coal reserves in the northern portion of the permit area without the need for new surface disturbances. Coal will be extracted under this application from the IJ zone of the Ferron Sandstone using room and pillar methods with~~out~~ pillar extraction ~~(i.e., first mining only)~~ (i.e. planned subsidence).

XIII.B GENERAL CONTENTS

XIII.B.1 RIGHT OF ENTRY

The U.S. Government is the owner and Consol is the leaseholder (Lease No. U-50044) of all coal to be mined under this IBC application (see Plate I-1 of the approved MRP). Information regarding coal ownership within the IBC and adjacent areas is provided in Chapter I of the approved MRP.

All of the Federal Lease IBC surface land is owned by D.U. Company Inc. (see Plate I-1). Information regarding surface ownership within the IBC and adjacent areas is provided in Chapter I of the approved MRP. Consol knows of no pending litigation concerning their right to mine coal within the IBC area.

XIII.B.2 LEGAL DESCRIPTION AND STATUS OF UNSUITABILITY CLAIMS

The area affected by this IBC application is located in SW¼NW¼, NW¼SW¼, NE¼SW¼, and SE¼SW¼ of Section 22, T. 22 S., R. 6 E., SLBM. Consol knows of no portion of the Federal Lease IBC that is designated, or under study to be designated, as unsuitable for mining. Consol does not propose to conduct coal mining or reclamation operations in the IBC area within 300 feet of any occupied dwelling or within 100 feet of a public road.

XIII.C ENVIRONMENTAL RESOURCE INFORMATION

XIII.C.1 PERMIT AREA

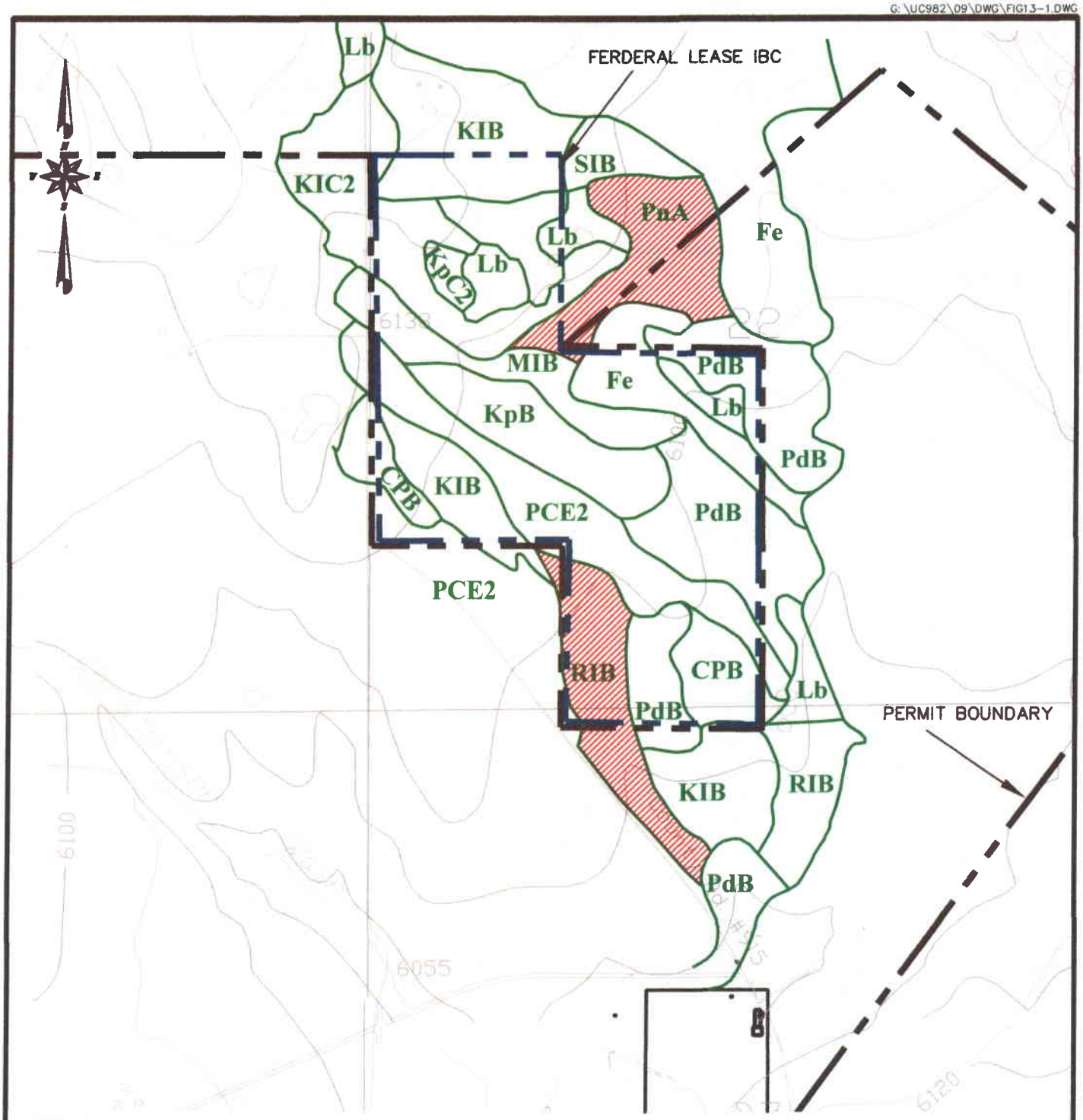
The lands subject to coal mining operations within the IBC area are noted on Plate I-1. It is not anticipated that individual permits will be sought for subareas within the IBC area. A discussion of cultural resources within the IBC area is provided in Appendix XII-3 of the approved MRP. This prior Class I survey, conducted in May 2005, included all of the area of the Federal Lease IBC and identified no cultural resources within that area. A class 3 survey was conducted in the area in January 2007. The results of that survey are provided in Appendix XIII-3. There are no cemeteries within 100 feet of the IBC boundary. There are no public parks located within the IBC area. There are no Historical or cultural resources eligible for listing in the National Register of Historic Place. There are no lands within the boundaries of the National System of Trails or Wild and Scenic Rivers System within the IBC area.

XIII.C.2 SOIL RESOURCE INFORMATION

Soil resources in the IBC area are depicted in Figure XIII-1(Published soil survey) and Figure XIII-1a (unpublished NRCS soil survey). Descriptions of these soils are provided in Appendix XIII-1. Soil series descriptions in the appendix were obtained from the U.S. Natural Resources Conservation Service (2006). Descriptions of individual map units on Figure XIII-1 were obtained from Swenson et al. (1970). Descriptions of individual map units on Figure XIII-1a were obtained from the NRCS field office in Price. The data depicted on the map and in the table on Figure XIII-1a are not approved or published, and as such are subject to change per the NRCS office. Soils within the IBC area tend to be fine grained, ranging generally from loam to silty clay loam. If irrigated, the soil supports alfalfa and similar crops. Otherwise, the soils mostly support rangeland plants such as shadscale, Indian ricegrass, greasewood, and/or saltgrass. Minchey loam, Penoyer loam, ~~and~~ Ravola loam, and Tusher loam are considered prime farmland when irrigated (Appendix XIII-1 and Figure XIII-1a). ~~About 2 acres of Penoyer Loam and 10 acres of Ravola Loam are irrigated and, therefore, may be prime farmland within the IBC area. Although s~~Subsidence-related ~~is not planned,~~ ground movement will be monitored and mitigated in accordance with Section V.B.1 of the MRP.

The vegetation map of the Federal IBC area found in Appendix XIII-2 and Plate VIII-1 shows the area that is irrigated pasture and areas of dry (not irrigated) pasture. These data were compiled from a field visit during the summer of 2006. The data available from the NRCS field office were compiled by looking at an aerial photo and talking to the land owners. According to the U.S. Farm Service Agency, this information is updated every few years and is subject to change. The land owner decides which fields to irrigate based on several factors, including drought conditions, pasture needs, availability of irrigation water, etc. Hence, boundaries between irrigated and non-irrigated pasture, as well as between pasture and rangeland, are likely to change on occasion.

Additional information regarding soil resources in the IBC and adjacent areas is provided in Chapter VII of the approved MRP. Impacts to soil resources are not anticipated as a result of mining under this application since no new surface disturbances are planned.



LEGEND

CPB	CHIPETA-PERSAYO ASSOCIATION, 1 TO 3 PERCENT SLOPES.
Fe	FERRON SILTY CLAY LOAM, HEAVY VARIANT.
KIB	KILLPACK CLAY LOAM, 1 TO 3 PERCENT SLOPES.
KIC2	KILLPACK CLAY LOAM, 3 TO 6 PERCENT SLOPES, ERODED.
KpB	KILLPACK LOAM, 1 TO 3 PERCENT SLOPES.
KpC2	KILLPACK LOAM, 3 TO 6 PERCENT SLOPES, ERODED.
Lb	LIBBINGS SILTY CLAY LOAM.
MIB	MINCHEY LOAM, 1 TO 3 PERCENT SLOPES.
	DESIGNATED PRIME FARMLAND
PCE2	PERSAYO-CHIPETA ASSOCIATION, 1 TO 20 PERCENT SLOPES, ERODED.
PdB	PALISADE VERY FINE SANDY LOAM, 1 TO 3 PERCENT SLOPES.
PnA	PENOYER LOAM, EXTENDED SEASON, 0 TO 1 PERCENT SLOPES.
RIB	RAVOLA LOAM, 1 TO 3 PERCENT SLOPES.
SIB	SANGETE SANDY CLAY LOAM, 1 TO 3 PERCENT SLOPES.

0' 1000'

FIGURE XIII-1. SOIL TYPES IN THE IBC AREA.

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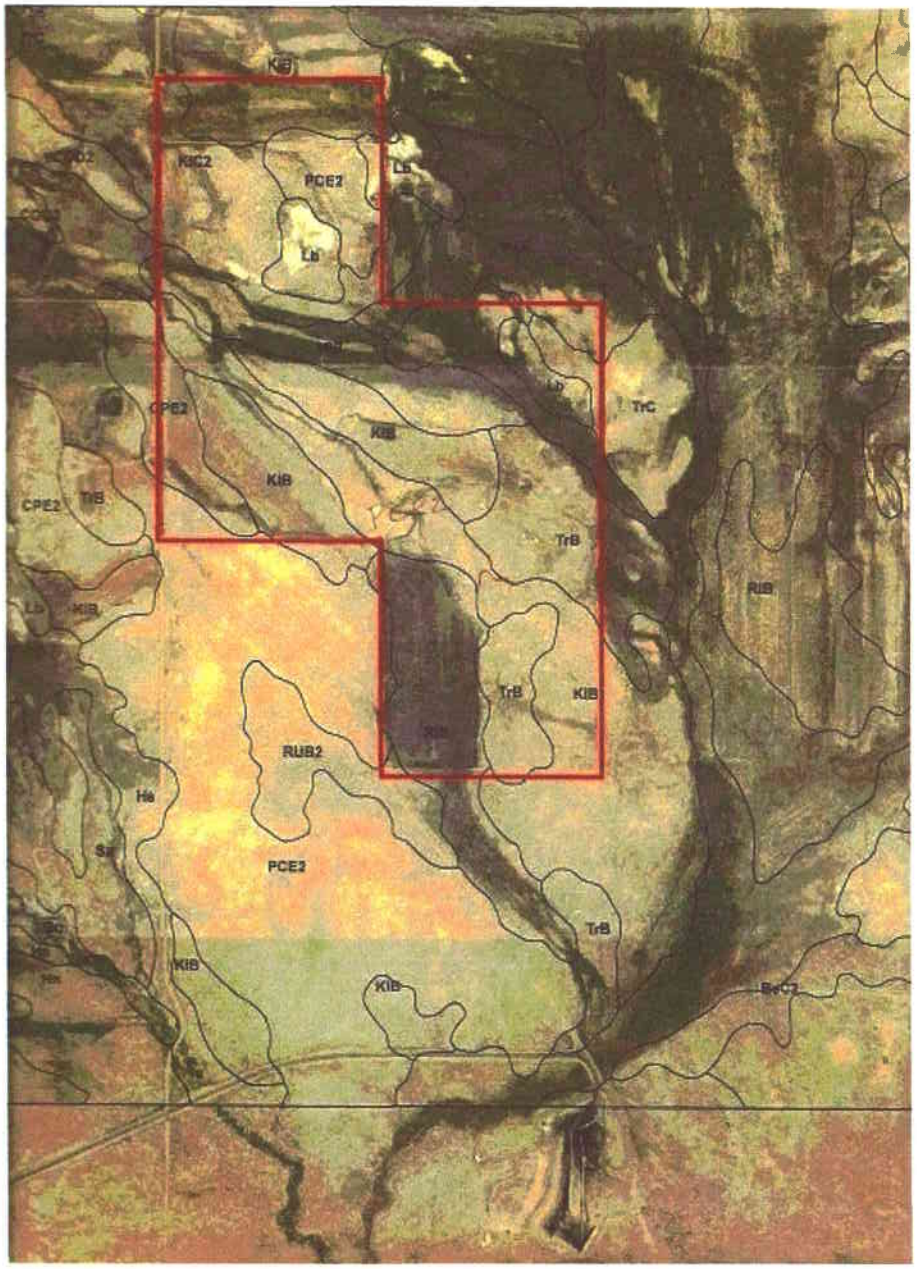
G:\UC982\09\ Federal IBC\FIG13-1.dwg, Layout3-Layout1, 2/12/2007 2:30:13 PM



Legend

SW/NW, NW/SW, NE/SW, SE/SW
Section 22, T. 22 S., R. 6 E., SLBM

Map[1] Symbol	Map Unit[2]	Prime Farm Land, If Irrigated[3]
BeC2	Beebe loamy fine sand, 3 to 6 percent slopes, eroded	No
CPE2	Chipeta-Persayo Association, 3 to 20 percent slopes, eroded	No
KIB	Killpack clay loam, 1 to 3 percent slopes	No
KIC2	Killpack clay loam, 3 to 6 percent slopes	No
LB	Libbings silty clay loam	No
MIB	Minchey loam, 1 to 3 percent slopes	Yes
PCE2	Persayo-Chipeta Association, 1 to 20 percent slopes eroded	No
PnA	Penoyer loam, extended season, 0 to 1 percent slopes	Yes
RIB	Ravola loam, 1 to 3 percent slopes	Yes
RUB2	Ravola-Bunderson complex, 1 to 3 percent slopes, eroded	No
TrB	Tusher fine sandy loam, 1 to 3 percent slopes	Yes
TrC	Tusher fine sandy loam, 3 to 6 percent slopes	No

1. Symbols in red have been changed or added since the Carbon-Emery Area, Utah Soil Survey (1970).
2. Data Source: NRCS, personal communication with Leland Sasser and Robert Fish (January 23-24, 2007). ***Information is from unpublished Emery County Soil Survey data and is subject to change.***
3. Personal communication with Leland Sasser, NRCS, Price, Utah Service Center, January 24, 2007.

Scale of map is not defined in this layout. Area outlined in red is approximately 160 acres.

FIGURE XIII-1a. PROVISIONAL SOILS MAP OF THE IBC AREA.

XIII.C.3 VEGETATION RESOURCE AND LAND USE INFORMATION

Information concerning vegetation resources within the IBC area is provided in Appendix XIII-2. Three plant communities are present in the IBC area, namely greasewood, shadscale/winterfat, and pasture (both irrigated and dry land). The vegetation map in Appendix XIII-2 and Plate VIII-1 depict pastureland (irrigated and dry), greasewood, and shadscale/ winterfat within the Federal IBC area. Defined land uses would be pastureland and undeveloped, as indicated on Figure XIII-1b. Chapter IX, Plate 10-1 shows wildlife use of the area. Information presented in Appendix XIII-2 indicates that federally-listed threatened or endangered plant species are not likely to exist in the IBC area. No impacts to vegetation are anticipated from mining in the IBC area due to the planned non-disturbance of the surface.

XIII.C.4 FISH AND WILDLIFE RESOURCE INFORMATION

Information regarding fish and wildlife resources within the IBC and adjacent areas is provided in Appendix XIII-2. Additional information regarding fish and wildlife resources in the IBC and adjacent areas is provided in Chapter IX of the approved MRP. The IBC area is located within a zone of high value winter habitat for elk.

It is unlikely that raptors occur within the IBC area. One prairie dog community is located with the IBC area (see Chapter IX of the approved MRP). Given the lack of ~~planned subsidence~~new surface disturbances, it is not anticipated that impacts will occur to these or other wildlife resources from coal mining in the IBC area. Although several Federally-listed threatened or endangered animal species are known to occur in Emery County, a lack of appropriate habitat greatly reduces the potential for any of these species to occur within the IBC area (see Appendix XIII-2).

XIII.C.5 GEOLOGIC RESOURCE INFORMATION

Information regarding geologic resources within the IBC and adjacent areas is provided in Chapter V of the approved MRP. The Bluegate Shale member of the Mancos Shale outcrops over the entire surface of the IBC area. This unit is a saline, blue-gray silty mudstone and siltstone with occasional, thin sandstone lenses. The Bluegate Shale abruptly overlies the Ferron Sandstone member of the Mancos Shale. The Ferron Sandstone consists of interbedded layers of sandstone, siltstone, shale, and coal, with the coal to be mined in the IBC area occurring in the upper portion of the Ferron Sandstone in a layer known as the IJ zone. The Tununk Shale member of the Mancos Shale underlies the Ferron Sandstone.

Based on data provided on Plate V-20 of the approved MRP, approximately 300 to 500 feet of overburden overlies the IJ zone within the IBC area. Roof and floor materials above and below the IJ zone within the IBC area are expected to be as indicated in Section V.A.4 of the approved MRP, consisting of interbedded sandstone and shale. Dark gray shale typically contacts the roof of the coal, with several feet of irregularly laminated, light gray, fine-grained quartz sandstone above the shale. The floor material is generally dark olive gray, coaly, silty shale interbedded with light gray, fine grained quartz sandstone.

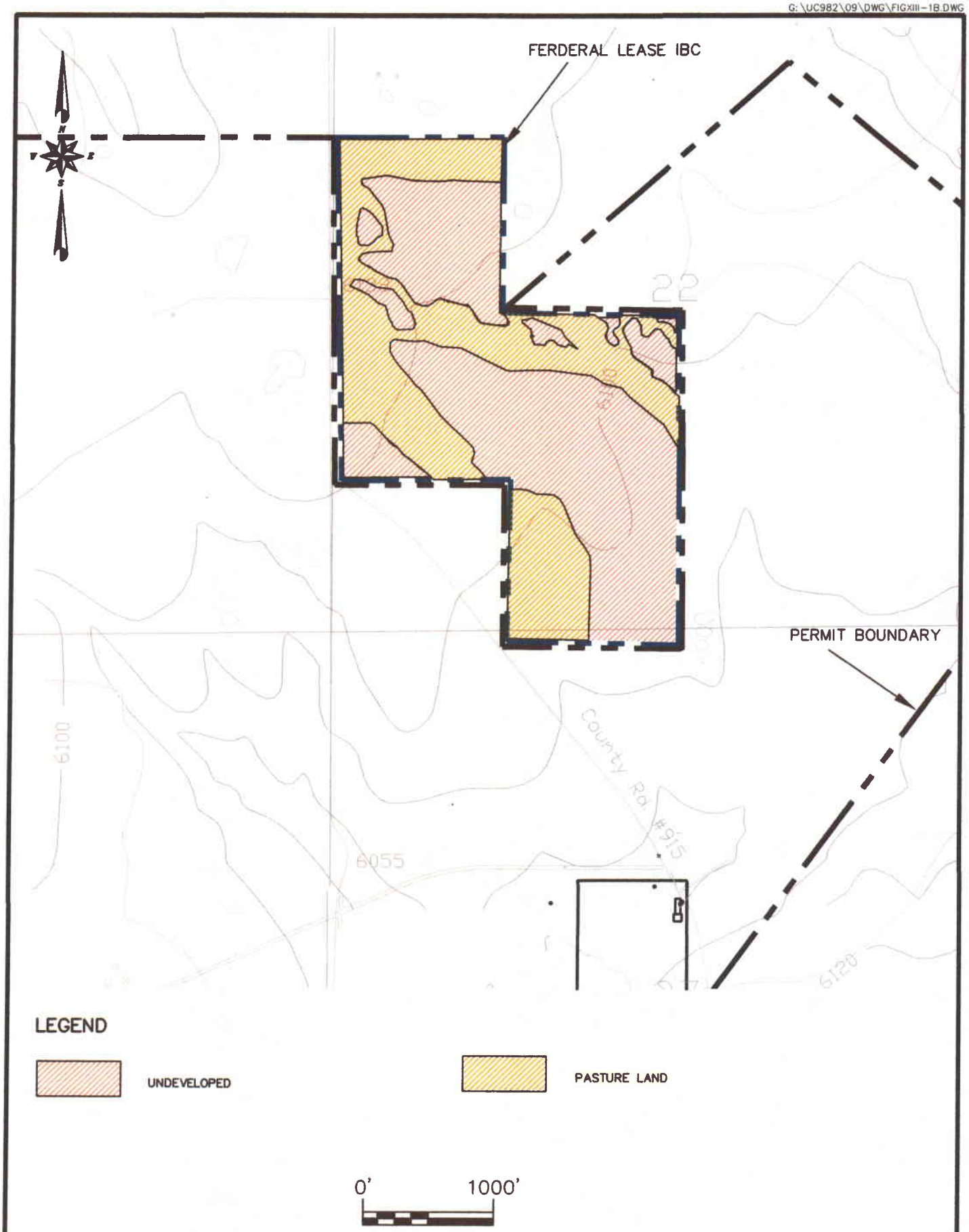


FIGURE XIII-1B. LAND USE MAP OF THE FEDERAL LEASE IBC AREA

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According to Section V.A.4 of the approved MRP, the pH of the roof material ranges from about 5 to 9, with the pH of the floor materials tending to be slightly higher. The roof and floor materials tend to have low salinity (specific conductance less than 4.0 mmhos/cm), with moderate to high sodium adsorption ratios (1.8 to 28) and concentrations of heavy metals that are sufficiently low to not influence reclamation decisions.

The coal, overburden, and underburden in the IBC area are unlikely to have substantial acid-forming potential, as indicated by the pH of the rock and the slightly alkaline nature of water that has historically discharged from the Emery Mine (pH 7.1 to 8.5 – see Section V.A.5 of the approved MRP). Furthermore, as indicated in Section V.A.6 of the approved MRP, the sulfur content of the coal is generally low (typically 0.5 to 2.0 percent, with an average of about 0.7 percent), with variable proportions of the sulfur existing as pyrite. Concentrations of toxic constituents in the coal, overburden, and underburden are low (see Section V.A.4 of the approved MRP).

A comparison of Plates V-20 and VI-4 of the approved MRP indicates that the complete thickness of the Ferron Sandstone is probably saturated within the IBC area. Additional information regarding groundwater within the IBC and adjacent areas is provided below and in Chapter VI of the approved MRP.

XIII.C.6 HYDROLOGIC RESOURCE INFORMATION

XIII.C.6.1 Baseline Information

Mining within the IBC area will not involve the construction of additional surface facilities. ~~Furthermore, as indicated in Section XIII.A, coal will be mined under this application using room and pillar methods without pillar extraction (i.e., first mining only).~~ Hence, no surface disturbance is planned.

Baseline hydrologic data have been collected from several surface and groundwater monitoring locations adjacent to the IBC area (see Plates VI-1 and VI-3 of the approved MRP). These data are discussed in Chapter VI of the approved MRP. Given the lack of surface disturbance planned for the IBC area and the close location of the IBC area relative to the existing permit area, the existing baseline data are considered adequate for the IBC area.

XIII.C.6.2 Groundwater Information

As indicated in ~~Chapter~~ Section VI.A.2 of the approved MRP, groundwater within the mine permit and adjacent areas (including the IBC and adjacent areas) occurs primarily within the Ferron Sandstone. This sandstone is situated between the overlying Bluegate Member of the Mancos Shale and the underlying Tununk Member of the Mancos Shale, both of which are relatively impermeable and considered aquicludes. The Ferron Sandstone outcrops in a series of prominent cliffs along the eastern edge of the Emery coal field and dips to the northwest beneath the ground surface. The continuity of the Ferron is broken in the subsurface by the Joes Valley-Paradise fault zone, which exists immediately northwest of the permit area.

~~the~~ The complete thickness of the Ferron Sandstone is probably saturated within the IBC area, normally under confined conditions (compare Plate VI-4 with Plates V-19 through V-22), except along the outcrop to the east and where water levels have been locally altered due to mining activities. Although the formation dips to the northwest (see, for instance Plate V-20), groundwater flows generally to the south or southeast (see Plates VI-5 and VI-9 as well as Figure XIII-2) except where influenced by mining in the area (Plate VI-4). The hydrostatic pressure required to force groundwater up dip in the mine area is generally believed to originate from recharge along the Joe's Valley-Paradise fault zone located at higher elevations north and west of the mine area. As a result of this hydrostatic pressure, there are locations within the Federal IBC and adjacent areas where the potentiometric surface is above the ground surface. Because the Bluegate Member of the Mancos Shale acts as an aquiclude, the ground surface at these locations is not saturated, but the static water level would rise to an elevation above the ground surface if wells were installed into the Ferron Sandstone in these areas.

Figure VI-6 of the approved MRP provides hydrographs of water-level data collected from monitoring wells completed within the Emery Mine permit area in the Bluegate Shale. As indicated, no declines in water levels occurred during the period of record presented in that figure. In contrast, hydrographs that were prepared using data collected from wells completed in the upper Ferron Sandstone (Figure VI-7 of the approved MRP) show declines during the period of record. Similar conditions are expected in the Federal IBC area (no substantial influence on groundwater levels in the Bluegate Shale but declining water levels in the upper Ferron Sandstone). As noted in Section VI.A.2.4 of the approved MRP, gradual declines in groundwater levels may be experienced in the middle Ferron Sandstone within and adjacent to the Federal IBC area, while no substantial changes in water levels would be anticipated in the lower Ferron Sandstone.

Although the Ferron Sandstone is completely saturated within the existing mine area, historic inflows to the mine have been predominantly from the roof rather than the floor. This suggests that the upper and lower portions of the Ferron Sandstone are hydraulically separated. This hydraulic separation is also suggested by a comparison of Plates VI-4 and VI-5 of the approved MRP, which indicates that past impacts of mining on the potentiometric surface of the area have occurred primarily in the upper Ferron Sandstone, with no noticeable potentiometric-surface impacts in the lower Ferron Sandstone.

Groundwater discharges from the Ferron Sandstone by wells, by dewatering of the Emery Mine, by seepage into Quitchupah Creek and Christiansen Wash, and by leakage into the Bluegate and Tununk Shales. Within the immediate vicinity of the IBC area, the largest anthropogenic discharge of groundwater from the Ferron Sandstone is dewatering of the Emery Mine which, according to Chapter VI of the approved MRP, accounts for approximately 0.6 to 1.2 cubic feet per second of water being removed from the Ferron Sandstone.

Natural groundwater quality in the *upper* Ferron Sandstone is moderately saline, with total dissolved solids concentrations in monitoring well and mine roof inflow samples averaging approximately 1000 to 1300 mg/l (see Table VI-9 of the approved MRP). The total dissolved solids concentration of groundwater in the *lower* Ferron Sandstone tends to be slightly less, averaging approximately 800 mg/l (see the previously noted table). This difference in salinity

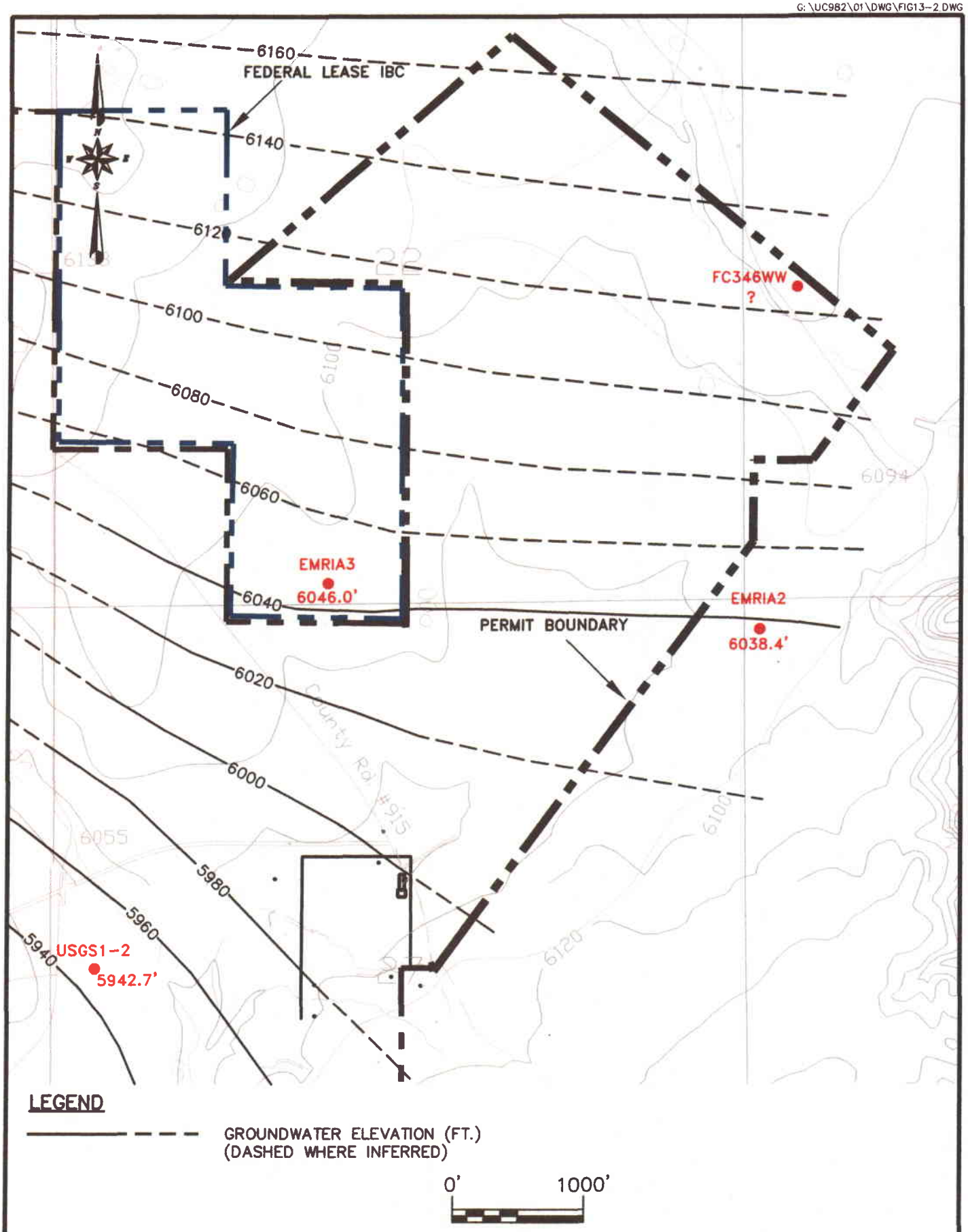

FIGURE XIII-2. UPPER FERRON SANDSTONE POENTIOMETRIC SURFACE, 2004/05

CONSOLIDATION COAL COMPANY

further suggests a hydraulic separation between the upper and lower Ferron Sandstone. Sodium and sulfate are the dominant ions in groundwater occurring in both the upper and lower Ferron Sandstone.

XIII.C.6.3 Surface Water Information

The IBC area lies within the drainage basin of Christiansen Wash, a perennial tributary to Quitchupah Creek. The only surface water courses within the IBC area are small ephemeral rills. No definitive stream channels exist within the IBC area.

Information regarding surface water resources in the vicinity of the IBC area is provided in Section VI.A.3 of the approved MRP. As indicated in that section, streamflow in Christiansen Wash generally increases in the downstream direction, primarily due to irrigation return flow and inflow from a tributary south of the IBC area that carries spring water to the wash. Peak flows in Christiansen Wash typically occur in mid to late spring as a result of snowmelt runoff and then again in mid to late summer due to thunderstorms. Irrigation return flows contribute to Christiansen Wash during the summer months.

Information regarding water rights in the vicinity of the IBC area is provided in Section VI.A.4. The data contained in that section are consistent with the State of Utah Division of Water Rights data base.

The source of irrigation water in the IBC vicinity originates from Muddy Creek. This point of diversion is over 20 miles from the proposed IBC permit area; therefore it is not shown on Plate V-3. This water is covered under the water rights controlled by the Muddy Creek Irrigation Company listed within Chapter VI, Volume 1, Section VI.A.4, of the MRP.

Data presented in Chapter VI of the approved MRP indicate that concentrations of dissolved constituents generally increase in the downstream direction along Christiansen Wash. This is attributed to irrigation return flow seeping into the steam. The total dissolved solids concentration of Christiansen Wash ranges from about 1,000 to 5,000 mg/l and is typically indirectly related to discharge rate. Calcium, sodium, and sulfate are the dominant ions. Total suspended solids concentrations vary widely in Christiansen Wash (from less than 100 to more than 3,000 mg/l) and tend to be directly related to discharge rate.

XIII.C.6.4 Baseline Cumulative Impact Information

The Federal Lease IBC area lies within the cumulative impact area of the Emery Mine.

XIII.C.6.5 Modeling

No surface or groundwater modeling was performed for this IBC application.

XIII.C.6.6 Alternative Water Source Information

As indicated in Section VI.A.4 of the approved MRP, two private wells in the vicinity of the Emery Mine (the Bryant well and the Lewis well) have stopped flowing at the surface as a result of dewatering activities at the Emery Mine. Consol has furnished and installed pumps and associated appurtenances to allow continued use of this water. Consol has also committed to drill new wells if needed to replace these water supplies.

It is doubtful that mining within the IBC area will substantially change the magnitude of past impacts to the hydrology of the Emery Mine area (see Section XII.C.6.7 of this application). However, the above commitment to provide alternative sources of water, if necessary, remains in effect for mining activities in the IBC area.

No appropriated points of diversion exist within the IBC and adjacent areas. Appropriated points of use within the area are associated with surface irrigation rights. These rights are presented in Table VI-20 of the approved MRP. If the surface effects of subsidence within the Federal IBC contaminate, diminish, or interrupt State-appropriated water supplies in this area, these impacts will be repaired or replaced as indicated in Section V.B.1, subsection UMC 817.124 of the approved MRP.

XIII.C.6.7 Probable Hydrologic Consequences Determination

The probable hydrologic consequences of mining in the IBC area will ~~be the same~~consist predominantly of the following as noted in Section VI.A.7 of the approved MRP, namely:

- Changes to the potentiometric surface of the Ferron Sandstone (particularly the upper portion) due to mine dewatering activities and
- Changes in the quality and quantity of surface water in the area due to the discharge of intercepted mine water.

The *maximum* quantity of groundwater to be encountered in the IBC area was estimated based on the inflow per unit area to the existing portion of the Emery Mine. Data presented in Section VI.A.7 of the MRP indicate that ~~inflow to~~discharge from the Emery Mine ~~in 1989 and 1990~~prior to 1991 averaged approximately 1.0 cubic foot per second (i.e., 450 gallons per minute). Mine workings at that time occupied an underground area of approximately 1,440 acres (see, for instance, Plate VI-4 and several other plates that utilize the same base map). Assuming mine workings in the IBC area occupy the entire underground area of approximately 160 acres (see Plate IV-2 of the approved MRP) and assuming an equivalent ~~inflow~~ discharge per unit area, mining in the IBC area may increase ~~inflow to~~discharge from the Emery Mine by a *maximum* of about 0.11 cubic foot per second (about 50 gallons per minute).

Notwithstanding the above estimate, the IBC area is located up dip from most of the remainder of the Emery Mine, indicating that hydraulic pressures are naturally less in the IBC area than in the area of current mine workings further west. In addition, the discharge from the mine since 2002 has been substantially less than that prior to 1991 (0.63 cfs as opposed to

about 1 cfs). Furthermore, dewatering operations in the remainder of the Emery Mine have likely already dewatered a portion of the IBC area (see Plate VI-~~8~~ 4 of the approved MRP). These factors indicate that groundwater ~~inflow to~~discharge from the IBC workings ~~will be less per unit area than in the remainder of the Emery Mine. Hence, total inflow to the IBC workings~~ should be substantially less than 0.11 cubic foot per second (50 gallons per minute).

According to Section VI.A.7 of the MRP, mining of the IJ zone will not degrade groundwater quality in the Emery Mine permit and adjacent areas. A similar lack of groundwater quality impacts is anticipated from mining in the IBC area.

It is estimated from information contained in Section VI.A.7 of the MRP that approximately ~~0.1~~0.63 cubic foot per second of groundwater ~~that normally would seep into the~~is currently discharged to Quitchupah Creek ~~is intercepted in~~from the Emery Mine ~~and prevented from naturally discharging to the creek. However, this reduction in surface-water flow is offset by discharging to the creek approximately 1.0 cubic foot per second of groundwater intercepted in the mine~~. Hence, the net impact of mining in the Emery Mine on the flow of Quitchupah Creek is a flow increase of approximately ~~0.9~~0.63 cubic foot per second. Water intercepted in the IBC area may slightly increase this net effect.

Water in the Emery Mine comes into contact with rock dust, thereby increasing the total dissolved solids concentration of this water prior to being pumped to the surface into Quitchupah Creek. Similar impacts are anticipated from mining in the IBC area. According to Section VI.A.7 of the approved MRP, the salt load of Muddy Creek (into which Quitchupah Creek eventually discharges) is expected to increase ~~10 to 17~~about 5 percent as a result of mining in the Emery Mine. ~~The salt load of the Dirty Devil River (into which Muddy Creek discharges) has historically increased less than 1 percent due to mine-water discharges.~~ Assuming the total dissolved solids concentration of water discharging from the IBC area is similar to that in the remainder of the Emery Mine, and assuming that mining in the IBC area results in a~~n~~ slight increase in the mine-water discharge to Quitchupah Creek ~~of 5 percent~~, the total salt load of Muddy Creek will increase ~~1 to 2 percent~~a de minimus amount due to mining in the IBC area. No water rights exist downstream of the mine discharge point on Quitchupah Creek or Ivie Creek (the receiving stream for Quitchupah Creek). Hence, no substantially increased impacts to water users are anticipated from salt loading due to mining in the IBC area.

No additional surface area will be disturbed under this application. Hence, additional sediment loads to local streams will not occur.

XIII.D OPERATION PLAN

XIII.D.1 MINING OPERATIONS AND FACILITIES

Coal will be extracted under this application using room and pillar methods with~~out~~ pillar extraction ~~(i.e., first mining only)~~ (planned subsidence). It is anticipated that approximately ~~900,000~~1.27 million tons of coal will be mined from the IBC area. Mining will occur using a

continuous miner. General criteria for pillar design are provided in Section V.B.1 of the approved MRP.

No new surface facilities will be constructed under this application. Facilities associated with the Emery Mine that will be used during mining of the IBC area are discussed in Chapter II of the approved MRP.

The anticipated sequence of mining in the IBC area is indicated on Plate IV-2. This map also shows existing and anticipated underground workings within the current permit area and, for completeness only, potential mine workings outside of both the current permit area and the Federal Lease IBC area. Coal will not be extracted from areas outside the current permit area or the Federal Lease IBC area until those areas are properly permitted.

~~Although no subsidence is planned under this application,~~ Plate V-5 shows locations of proposed subsidence monitoring stations in the IBC and adjacent areas. These stations will be established as indicated in Figure V-8 of the approved MRP. These stations will be monitored as outlined in Section V.B.1 of the approved MRP.

XIII.D.2 EXISTING STRUCTURES

No "existing structures", as defined in R645-100-200, exist in the IBC area. Structures located in other portions of the permit area that will be used during mining of the IBC area are discussed in Chapter II of the approved MRP. These structures will not be modified under this application.

Plate V-1 of Chapter V, Volume 2 delineates items #89, #90, #91, #92 and #93 as structures found within or adjacent the IBC area. Description of these items can be found in Chapter V, Volume 2, Appendix V-3.

The pre- subsidence survey will be updated on all surface areas depicted on Plate V-5 prior to secondary mining. If the irrigation system is still functional at the time of subsidence, Consol will visually inspect the irrigation system before and during the growing season. Mitigation of any effects to the irrigation system caused by subsidence will be negotiated between Consol and the surface land owner, as described in Chapter V, Pages 41 and 42.

XIII.D.3 COAL RECOVERY

Coal will be recovered in a manner that maximizes utilization and recovery of the resource, (planned subsidence), while maintaining environmental integrity. ~~This plan will be modified if future designs call for extraction of the pillars.~~

XIII.D.4 SUBSIDENCE CONTROL PLAN

~~No s~~Subsidence ~~is planned for~~control, monitoring, and mitigation within the IBC area will occur as indicated in Section V.B of the approved MRP.

XIII.D.5 HYDROLOGIC INFORMATION

Information regarding surface and groundwater resources and probable hydrologic impacts of mining in the Federal Lease IBC and adjacent areas is provided in Section XIII.C.6 of this application. A discussion of surface and groundwater monitoring programs associated with the Emery Mine is provided in Section VI.A.5 of the approved MRP. Information regarding the acid- and toxic-forming potential of the coal, overburden, and underburden is discussed in Section XIII.C.5 of this application.

No surface disturbances are planned in the IBC area. Hence, no new diversions, stream buffer zones, sediment control structures, or other treatment facilities will be installed as a result of mining in the Federal Lease IBC area.

XIII.E RECLAMATION PLAN

No new surface disturbances will occur as a result of mining in the Federal Lease IBC area. Hence, no additional land reclamation will be required as a result of this action. Information regarding reclamation of the Emery Mine surface facilities is provided in Chapter III of the approved MRP. This information includes a discussion of surface and groundwater monitoring programs, structure removal, backfilling and grading operations, drainage control, topsoil redistribution, site revegetation, etc.

XIII.F CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT

The Federal Lease IBC area lies within the existing cumulative hydrologic impact assessment ("CHIA") area associated with the Emery Mine. The CHIA that was previously prepared in conjunction with permitting the Emery Mine should be sufficient for evaluating the hydrologic impacts of the Federal Lease IBC area.

XIII.G REFERENCES

Swenson, J.L., D.T. Erickson, K.M. Donaldson, and J.J. Siozaki. 1970. Soil Survey of Carbon-Emery Area, Utah. U.S. Soil Conservation Service (now the U.S. Natural Resources Conservation Service). Salt Lake City, Utah.

U.S. Natural Resources Conservation Service. 2006. Official Soil Series Descriptions. Available online at http://soils.usda.gov/technical/classification/osd/index.html. Accessed 28 Aug 2006.

APPENDIX XIII-1

Soil Descriptions

BEEBE SERIES

The Beebe series consists of deep, well drained, rapidly permeable soils that formed in sandy alluvium derived mainly from sandstone. These soils are on flood plains and alluvial fans and have slopes of 0 to 6 percent. Mean annual temperature is about 50 degrees F., and the average annual precipitation is about 9 inches.

TAXONOMIC CLASS: Sandy, mixed, mesic Typic Torrifluvents

TYPICAL PEDON: Beebe loamy fine sand, rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 2 inches; pale brown (10YR 6/3) very fine sandy loam, brown (10YR 4/3) moist; weak medium and thick platy structure; soft, very friable; few medium and many fine roots; common medium and fine pores; slightly calcareous, moderately alkaline (pH 8.0); clear smooth boundary. (2 to 4 inches thick)

C1--2 to 12 inches; light yellowish brown (10YR 6/4) loamy fine sand, yellowish brown (10YR 5/4) moist; weak thick platy structure; soft, very friable; few coarse and medium, and many fine roots; few medium fine pores; slightly calcareous, very strongly alkaline (pH 9.7); clear smooth boundary. (10 to 20 inches thick)

C2--12 to 16 inches; light yellowish brown (10YR 6/4) fine sand, yellowish brown (10YR 5/4) moist; single grain; loose; many fine roots; few fine pores; slightly calcareous, very strongly alkaline (pH 9.6); clear wavy boundary. (0 to 6 inches thick)

C3--16 to 34 inches; light yellowish brown (10YR 6/4) loamy fine sand, yellowish brown (10YR 5/4) moist; massive; soft, very friable; many fine and medium roots; few medium and fine pores; slightly calcareous, strongly alkaline (pH 8.5); clear smooth boundary. (10 to 20 inches thick)

C4--34 to 39 inches; light yellowish brown (10YR 6/4) loam, yellowish brown (10YR 5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few medium and many fine roots; few medium and common fine pores; strongly calcareous, moderately alkaline (pH 7.9); clear smooth boundary. (2 to 5 inches thick)

C5--39 to 71 inches; light yellowish brown (10YR 6/4) loamy fine sand, yellowish brown (10YR 5/4) moist; massive; soft, very friable; many fine and few medium roots; few fine pores; strongly calcareous, moderately alkaline (pH 8.2).

TYPE LOCATION: Emery County, Utah; 4 miles east of Emery, Utah; 260 feet south and 10 fee west of the NW corner of sec. 7, T. 22 S., R. 7 E.

RANGE IN CHARACTERISTICS:
Soil moisture: The soils are usually dry when not frozen, unless irrigated. Typic aridic moisture regime.

Mean annual soil temperature: 47 degrees to 56 degrees F.
Exchangeable sodium: 20 to 70 percent in the upper 20 inches of the soil in areas that are not irrigated.
Calcium carbonate: 3 to 20 percent.
Reaction: slightly alkaline to strongly alkaline.
Texture: The particle size control section averages loamy fine sand but ranges from fine sand to loam in individual strata.

A1 horizon
Hue: 10YR or 7.5YR
Value: 5 or 6 dry, 4 or 5 moist
Chroma: 2 to 4.
Texture: In many pedons the A1 horizon contains or is covered by silt deposited from irrigation water.

C horizon
Hue: 10YR or 7.5YR
Value: 6 or 7 dry, 4 or 5 moist
Chroma: 3 to 5.

GEOGRAPHIC SETTING: These soils are on flood plains and alluvial fans. Slopes are from 0 to 6 percent. Parent material is sandy alluvium derived mainly from sandstone, but it includes material from other sedimentary rocks. Elevation ranges from 4,800 to 6,000 feet. The climate is semiarid. Mean annual temperature is 47 degrees to 55 degrees F., and the freeze-free period ranges from 110 to 160 days. Mean annual precipitation ranges from 6 to 11 inches.

DRAINAGE AND PERMEABILITY: Well drained; slow runoff; rapid permeability.

USE AND VEGETATION: Cultivated areas are used for growing corn, grain, alfalfa, and pasture. The present vegetation on rangeland is mainly greasewood, broom snakeweed, prickly pear, shadscale and Indian ricegrass.

DISTRIBUTION AND EXTENT: Central and eastern Utah, north western New Mexico and possibly other adjoining states. This series is of small extent. MLRA 35.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon: The zone from 0 to 2 inches (A horizon).
Entisol feature: Lack of diagnostic horizons.
Fluvent feature: Irregular decrease in organic carbon.

CHIPETA SERIES

The Chipeta series consists of very shallow and shallow, well drained, slowly permeable soils that formed in residuum and colluvium from shale. Chipeta soils are on upland pediments and hills and have slopes of 0 to 35 percent. The average annual precipitation is about 7 inches and the mean annual temperature is about 50 degrees F.

TAXONOMIC CLASS: Clayey, mixed, active, calcareous, mesic, shallow Typic Torriorthents

TYPICAL PEDON: Chipeta silty clay loam -cultivated. (Colors are for air-dry soil unless otherwise noted.)

Ap--0 to 5 inches; light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; few fine discontinuous pores; violently effervescent; slightly alkaline (pH 7.7); clear smooth boundary. (1 to 5 inches thick)

C--5 to 13 inches; light brownish gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; moderate medium and fine subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few large continuous pores, few fine discontinuous pores; violently effervescent; slightly alkaline (pH 7.6); clear wavy boundary. (6 to 10 inches thick)

Cy--13 to 17 inches; light brownish gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; weak, moderately thick platy structure parting to weak medium blocky; hard, very firm, sticky and plastic; few fine and medium roots; many fine crystals and mycelia-like veins of gypsum; 20 percent unweathered shale fragments; violently effervescent; slightly alkaline (pH 7.4); gradual irregular boundary. (3 to 5 inches thick)

Cr--17 inches; weathered marine shale.

TYPE LOCATION: Emery County, Utah; 1 mile south and 1-1/2 miles east of Castle Dale, 1,000 feet south and 20 feet east of the northwest corner, sec. 11, T. 19 S., R. 8 E.

RANGE IN CHARACTERISTICS:
Soil moisture regime: Typic Aridic.
Soil temperature regime: Mesic.
Depth to shale: 5 to 20 inches.
Salinity: moderate to strong.
Particle-size control section: 35 to 50 percent clay.
Mean annual soil temperatures: 49 to 57 degrees F.
Reaction: slightly alkaline to strongly alkaline.

A horizon:
Hue: 10YR to 5Y
Value: 5 to 8 dry, 3 to 6 moist
Chroma: 2 to 4
Texture: loam or silty clay loam

C horizon:
Hue: 10YR to 5Y
Value: 4 to 6 dry, 3 to 5 moist
Chroma: 1 to 4
Textures: silty clay loam or silty clay
Gypsum: 0.5 to 10 percent and gypsum crystal ranges from few to many.

GEOGRAPHIC SETTING: These soils are on gently sloping to steep upland pediments and hills. Slopes are complex and range from 0 to 35 percent. These soils formed in residuum from alkaline marine shales containing gypsum. The climate is semiarid. The mean annual temperature is 45 to 55 degrees F. The freeze-free period ranges from 90 to 160 days. Mean annual precipitation ranges from 5 to 11 inches.

DRAINAGE AND PERMEABILITY: Well drained; medium to very high runoff; slow permeability.

USE AND VEGETATION: A few of the smoother areas of deeper soil are irrigated and used for growing grain and hay crops. Potential vegetation is mat saltbush and galleta.

DISTRIBUTION AND EXTENT: Western Colorado, Wyoming, eastern Utah, and New Mexico. LRR D, MLRA 34. The series is extensive.

REMARKS:
All pH values given are of soil paste.
Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon-the zone from the surface to 5 inches (Ap horizon)
Shallow feature-weathered shale at 17 inches (Cr horizon)

CHIPETA-PERSAYO ASSOCIATION, 1 TO 3 PERCENT SLOPES (CPB): This mapping unit consists of about 60 percent Chipeta silty clay loam, 1 to 3 percent slopes, and of about 40 percent Persayo loam, 1 to 3 percent slopes. These soils are intermingled and occur in no consistently identifiable pattern. Consequently, they were not separated in mapping. As a rule, the Chipeta soil is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were some areas of very shallow unnamed soils. Also included were other soils that are 20 to 40 inches thick over shale and small areas, generally less than 1 acre in extent, of strongly saline-alkali soils.

The profile of Chipeta silty clay loam, 1 to 3 percent slopes, is the one described as typical for the series. In most places this soil is 10 to 20 inches thick over shale. It has good drainage and is slowly permeable. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale and then spread horizontally. This Chipeta soil retains about 3 inches of available water. The soil is hard to work and to irrigate. Leveling is not practical, because this soil is too shallow.

The Persayo soil in this mapping unit has a profile like the one described for the Persayo series. Erosion has mainly caused the formation of rills and shallow gullies.

The dominant use of the soils in this mapping unit is spring and fall range. Alfalfa, grain, and pasture plants are grown in the irrigated areas, but the soils are poorly suited to those crops. Hay and pasture effectively reduce soil losses most of the time. (Both soils are in capability unit VIe-23, irrigated. The Chipeta soil is in capability unit VIIe-D3, nonirrigated; Desert Shale range site. The Persayo soil is in capability unit VIIe-D4, nonirrigated; Desert Loamy Shale range site)

FERRON SERIES

The Ferron series consists of very deep, poorly drained, moderately permeable soils that formed in alluvium on flood plains. Slopes are 0 to 3 percent. The average annual precipitation is about 8 inches and mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Coarse-silty, mixed, active, calcareous, mesic Aeric Fluvaquents

TYPICAL PEDON: Ferron silt loam. (Colors are for air-dry soil unless otherwise noted.)

0i--1 inch to 0; undecomposed organic material, mainly grass roots; strongly calcareous, moderately alkaline (pH 8.3); abrupt smooth boundary. (0 to 3 inches thick)

Agy--0 to 3 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist, common fine prominent yellowish red (5YR 4/8) redoximorphic and common medium faint dark gray (4/0) redoximorphic depletions; weak thick platy structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; many fine and few medium roots; few medium and fine pores; moderately calcareous; moderately alkaline (pH 8.3); clear smooth boundary. (3 to 8 inches thick)

Cgy--3 to 15 inches; light brownish gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) moist, many medium distinct olive brown (2.5Y 5/6) redoximorphic concentrations; weak moderately thick platy structure parting to weak medium granular; soft, friable, slightly plastic; many medium and fine roots; common fine pores; many gypsum mycelia; moderately calcareous; mildly alkaline (pH 7.8); gradual wavy boundary. (6 to 12 inches thick)

Cg--15 to 60 inches; light brownish gray (2.5Y 6/2) very fine sandy loam, brownish gray (2.5Y 5/2) moist, many medium and faint light olive brown (2.5Y 5/6) redoximorphic concentrations; massive; soft, friable; common medium and few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7).

TYPE LOCATION: Emery County, Utah; 2 miles northwest of Huntington, 350 feet north and 20 feet west of the southeast corner of sec. 11, T. 17 S., R. 8 E.

RANGE IN CHARACTERISTICS: Mean annual soil temperatures range from 49 to 54 degrees F.

Ferron soils have mottles within 20 inches of the surface. The seasonal high water table ranges between the 6 and 30 inch depths. Calcium carbonate equivalent ranges from 10 to 25 percent. It ranges from slightly saline to strongly saline. Reaction ranges from mildly alkaline to strongly alkaline. The 10 to 40 inch contains less than 18 percent clay and less than 15 percent sand coarser than very fine sand, and it ranges in texture from very fine sandy loam to light silt loam, with the strata of fine sandy loams.

The A horizon has hues of 2.5Y through 5Y, values of 5 or 6 dry, 4 or 5 moist, and chromas of 1 or 2.

The C horizon has hues of 2.5Y through 5Y, values of 5 or 6 dry, and 4 or 5 moist, and chromas of 2. There is a subhorizon in the upper C horizon between 10 and 30 inches that has hue of 2.5Y, value 4 or 5 moist, and a chroma of 2.

GEOGRAPHIC SETTING: These soils are on flood plains and in the bottoms of narrow alluvial valleys. Slopes are 0 to 3 percent. Parent material is alluvium derived from marine shale and sandstone. The climate is semiarid. Mean annual temperatures is 47 to 52 degrees F. Mean annual precipitation ranges from 6 to 10 inches. The freeze-free period is from 100 to 140 days.

DRAINAGE AND PERMEABILITY: Poorly drained. Runoff slow; permeability moderate.

USE AND VEGETATION: Used for pasture. Potential vegetation is tufted hairgrass, redtop, native clover, and sedges.

DISTRIBUTION AND EXTENT: Mainly in eastern Utah. The series is inextensive. MLRA 34

REMARKS: Diagnostic horizons and features in this pedon include:

Ochric epipedon - the zone from 0 to 3 inches (Agy horizon).

Aquic feature - 2 chroma matrix and redoximorphic concentrations from 3 to 20 inches (Agy and upper Cgy horizons).

There is an irregular decrease in organic matter with depth.

All pH values given are of soil paste.

The classification was changed from Typic Fluvaquent to Aeric Fluvaquent in 9/94.

FERRON SILTY CLAY LOAM, HEAVY VARIANT, 0 TO 3 PERCENT SLOPES (FE): This soil occurs in small, low areas that receive seep water from higher lying canals and irrigated areas. Its profile is the one described for the heavy variant of the Ferron series.

Grazing is the only use of this soil. Some areas can be grazed only in winter when the soil is frozen. (Capability unit Vw-2W, nonirrigated; Wet Meadow range site)

KILLPACK SERIES

The Killpack series consists of moderately deep, well drained, slowly permeable soils that formed in alluvium and residuum from saline marine shale. Killpack soils are on sideslopes and toeslopes of rolling shale hills. Slopes are 1 to 25 percent. Average annual precipitation is about 7 inches and mean annual temperature is about 52 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, active, calcareous, mesic Typic Torriorthents

TYPICAL PEDON: Killpack clay loam, cropland. (Colors are for air-dry soil unless otherwise noted.)

Ap--0 to 9 inches; brownish gray (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) moist; weak medium and fine granular structure; hard, firm, slightly sticky and slightly plastic; common fine roots; common fine pores; strongly calcareous; mildly alkaline (pH 7.8); clear smooth boundary. (6 to 9 inches thick)
C--9 to 23 inches; light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; moderate coarse subangular blocky parting to weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual wavy boundary. (8 to 21 inches thick)

Cy--23 to 29 inches; light brownish gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; massive; hard, very firm, sticky and plastic; few fine roots; strongly calcareous; mildly alkaline (pH 7.7); many gypsum crystals 5 to 15mm in diameter; gradual wavy boundary. (6 to 10 inches thick)

Cr--29 inches; light brownish gray weathered shale.

TYPE LOCATION: Emery County, Utah; 2 miles northwest of Elmo, northeast of the Elmo road and the Cleveland-Price road; 2,450 feet north and 300 feet east of the SW corner of sec. 30, T. 16 S., R. 10 E.

RANGE IN CHARACTERISTICS: Soil temperatures are more than 47 degrees F. Depth to shale bedrock ranges from 20 to 40 inches. There is a few to common gypsum crystals accumulated immediately above the shale. Clay minerals are mixed but dominantly illite and kaolinite. The particle-size control section ranges from silty clay loam to silt loam with 18 to 35 percent clay.
The A horizon has hue of 10YR through 5Y, dry value of 5 or 6, moist value of 4 or 5, and chroma of 2 through 4.

The C horizon has hue of 10YR through 5Y, value of 5 through 7 dry, 3 through 7 moist, and chroma of 2 through 4.

The Cy horizon has the same color as the C horizon and contains 5 to 15 percent shale channers.

GEOGRAPHIC SETTING: These soils are on the gentle sideslopes of rolling shale hills. Slope gradients range from 1 to 25 percent. Killpack soils formed in alluvium and residuum from saline marine shale. The climate is semiarid with mean annual temperature of 47 to 55 degrees F. Mean annual precipitation ranges from 5 to 11 inches.

DRAINAGE AND PERMEABILITY: Well drained; medium to rapid runoff; slow permeability.

USE AND VEGETATION: Cultivated areas are used for grain, alfalfa hay, and irrigated pasture. The remaining areas are used for rangeland. Potential vegetation is shadscale, greasewood, galleta grass, and gardner saltbush.

DISTRIBUTION AND EXTENT: Eastern Utah and western Colorado. The series is moderately extensive.

REMARKS: The pH values were determined of soil paste.

KILLPACK CLAY LOAM, 1 TO 3 PERCENT SLOPES (K1B): The profile of this soil is the one described as typical of the series. Included in mapping were small areas in which the soil is thicker than 40 inches and places where it is less than 20 inches thick over shale. Also included were small areas of strongly and very strongly saline soils, and a small area south and west of Moore in which the soil is brown above a depth of 24 inches.

Drainage is good, and permeability is slow. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale, and then they spread horizontally. About 4 to 5 inches of water is retained by this soil, but only about 2 to 2.5 inches, the amount depending on the depth to shale, is readily available to plants. This soil is hard to work, and generally it is hard to irrigate. The seedbed is more easily prepared if this soil is plowed in fall when it is barely moist, and is allowed to remain rough over winter, than when it is plowed in spring.

This soil is used for spring and fall range, for irrigated pasture, and for irrigated alfalfa and small grains. The growing season is only long enough for two full crops of alfalfa and for a part of a third to mature. (Capability units IVe-25, irrigated, and VIIs-D, nonirrigated; Desert Loam Bottom range site)

KILLPACK CLAY LOAM, 3 TO 6 PERCENT SLOPES, ERODED (KIC2): This soil is steeper and more eroded than the one for which a profile is described as typical for the series. Included in mapping were small areas of clayey soils and some areas in which the soils are deeper that 40 inches over shale. Also included were places, generally near the shaly colluvial slopes, where gravel is on the surface and in the surface layer.

This Killpack soil is fairly close to nearly bare shale hills that contribute considerable runoff. Runoff is rapid, and the susceptibility to erosion is high. Gullies 3 to 6 feet deep and 100 to 300

feet apart are common. In some places most of the surface layer has been lost through sheet erosion.

This soil is used mainly for range. It is also used for alfalfa, small grains, and pasture crops grown under irrigation, but it is not well suited to those uses. (Capability units VIe-23, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom Range site)

KILLPACK LOAM, 1 TO 3 PERCENT SLOPES (KpB): The profile of this soil is similar to the one described as typical of the series, except that the surface layer is heavy loam, and the subsoil below a depth of 15 to 24 inches is light silty clay loam to light silty clay. In addition, the gypsum horizon is less prominent.

Included in mapping were small areas in which the surface layer is clay loam.

This Killpack soil is easy to work, and it absorbs water readily. The area that is cultivated and irrigated is limited in extent and is used for alfalfa, small grains, corn, and pasture. (Capability units IVe-25, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom range site)

KILLPACK LOAM, 3 TO 6 PERCENT SLOPES, ERODED (KpC2): The profile of this soil is similar to the one described as typical of the series, except the surface layer is heavy loam and the subsoil below a depth of 15 to 24 inches is silty clay loam or light silty clay.

Included in mapping were areas of deep loam and silty clay loam.

This Killpack soil is on the side slopes of shale hills. Runoff is rapid, sheet erosion is active, and the susceptibility to erosion is high. Near bare shale hills, this soil contains gullies 3 to 6 feet deep and 100 to 300 feet apart. This soil absorbs water readily. It is easy to till and cultivate but is difficult to irrigate.

Most areas of this soil are in native range. Areas that are cultivated and irrigated are limited in extent and are used mainly for alfalfa and pasture. Controlling erosion is an important management requirement. (Capability units VIe-23, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom range site)

LIBBINGS SERIES

The Libbings series consists of moderately deep, poorly drained, slowly permeable soils that formed in alluvium and residuum from shale. Libbings soils occur on low rolling hills and have slopes of 0 to 3 percent. The average annual precipitation is about 7 inches and the mean annual temperature is about 47 degrees F.

TAXONOMIC CLASS: Fine, mixed, active, mesic Gypsic Aquisalids

TYPICAL PEDON: Libbings silty clay loam. (Colors are for air-dry soil unless otherwise noted.)

A1z--0-1/2 inch; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate thick platy parting to moderate fine granular structure; hard, friable, sticky and plastic; many very fine vesicular pores; strongly calcareous; very strongly saline; thin salt crust on surface; strongly alkaline (pH 8.5); abrupt smooth boundary; (1/2 to 1 inch thick)

A2z--1/2 to 2 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate fine granular structure; soft, firm, sticky and plastic; few very fine roots; many very fine vesicular pores; strongly calcareous; very strongly saline; very fine salt grains; strongly alkaline (pH 8.9); abrupt smooth boundary. (1 to 3 inches thick)

Cz--2 to 9 inches; light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine granular structure; very hard, very firm, sticky and very plastic; few fine and very fine roots; few fine and very fine discontinuous pores; strongly calcareous; very strongly saline; effloresced salt on some peds and in pores; strongly alkaline (pH 8.6); clear smooth boundary. (6 to 10 inches thick)

Czy1--9 to 25 inches; gray (2.5Y 6/1) silty clay, dark gray (2.5Y 4/1) moist; massive; very hard, very firm, sticky and very plastic; few medium and fine roots; few very fine discontinuous pores; strongly calcareous; very strongly saline; many salt and gypsum nodules; strongly alkaline (pH 8.6); gradual smooth boundary. (5 to 16 inches thick)

Czy2--25 to 34 inches; gray (2.5Y 6/1) silty clay, dark gray (2.5Y 4/1) moist; massive; very hard, very firm, sticky and plastic; few very fine roots; few very fine discontinuous pores; strongly calcareous; numerous soft gypsum nodules 5 to 15 mm in diameter; 5 to 10 percent shale fragments; strongly saline; strongly alkaline (pH 8.7); clear smooth boundary. (7 to 10 inches thick)
Cr--34 inches; soft platy shale. Roots and water concentrated between shale plates.

TYPE LOCATION: Emery County, Utah; 330 feet south and 160 feet east of the northwest corner of sec. 8, T. 17 S., R. 10 E.; about 2 miles south of Elmo, 1/4 mile west of Elmo-Cleveland Road.

RANGE IN CHARACTERISTICS: Depth to bedrock ranges from 20 to 40 inches. Depth to high water tables ranges from 10 to 30 inches. Salt content above 20 inches ranges from 2 to 5 percent. Exchangeable sodium is highest near the surface, 50 to 65 percent, and decreases with depth below 20 inches. Reaction is strongly alkaline to very strongly alkaline. The particle-size control section (10 to 40 inch depth) is dominantly silty clay, but ranges from heavy silty clay loam to clay more than 35 percent clay. Mean annual soil temperatures ranges from 49 to 53 degrees F.

The A horizon has hue of 10YR through 5Y with dry values of 5 or 6, moist values of 4 or 5, and chroma of 2.

The C horizon has hue of 1Y through 5Y, with dry values of 5 or 6, moist values of 4 or 5, and chromas of 1 or 2. Gypsum accumulation ranges from few to many, but there is typically 2 to 7 percent more gypsum in this horizon than in the underlying shale.

GEOGRAPHICAL SETTING: Libbings soils are on the footslopes of low rolling hills. Elevation is 5,400 to 5,500 feet. Slopes range from 0 to 3 percent. They are developed in residuum and alluvium from saline marine shale in areas where irrigation water or seepage from canals has caused salts to accumulate. The climate is semiarid, with mean annual temperature of 47 to 49 degrees. Mean annual precipitation ranges from 6 to 11 inches. Freeze-free period ranges from 110 to 140 days. GEOGRAPHICALLY ASSOCIATED SOILS: These are the Killpack, Chipeta, Persayo, Billings, and the competing Cache and Saltair soils. Killpack soils lack very strong salt horizons above 20 inches. Chipeta and Persayo are less than 20 inches deep over shale and lack very strong salt horizons. Billings soils are very deep and lack very strong salt horizons.

DRAINAGE AND PERMEABILITY: Poorly drained; runoff is medium; slow permeability. USE AND VEGETATION: Native range is the only use of this soil. The potential vegetation is alkali sacaton, alkali bluegrass, saltgrass, pickleweed and greasewood.

DISTRIBUTION AND EXTENT: Eastern Utah. Libbings soils are extensive.

REMARKS: All pH values were determined of soil paste. The name is coined.

LIBBINGS SILTY CLAY LOAM, 0 TO 3 PERCENT SLOPES (Lb): The profile of this soil is the one described as typical of the series. The surface layer is only ¼ to ½ inch thick. It has a platy structure but typically breaks to granules containing numerous crystals of salt. The layer over the shale contains numerous crystals of gypsum or salt, but in some places these crystals are not present.

Included in mapping were minor areas in which shale is at a depth of more than 40 inches, and some areas in which the shale is at a depth of less than 20 inches. Also included were some areas of saline soils that contain less than 2 percent salt.

Drainage is poor, and permeability is slow above the shale. Runoff is medium, and this soil is moderately susceptible to erosion. The water table is 10 to 30 inches below the surface, and is highest early in summer. Mottles occur in some places. Water spread horizontally to top of the shale and penetrates to a depth of only a few inches. In some places, water moves freely between the plates of shale. Roots penetrate to the shale, and then they spread horizontally.

This soil is used for grazing. (Capability unit VIIw-28, nonirrigated; Salt Meadow range site)

MINCHEY SERIES

The Minchey series consists of very deep, well drained, moderately permeable soils that formed in material weathered from sandstone and quartzite. Minchey soils are on mesas, benches, and old alluvial fans and have slopes of 0 to 10 percent. The average annual precipitation is about 8 inches, and the mean annual temperature is about 48 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, active, mesic Typic Haplocalcids

TYPICAL PEDON: Minchey loam--rangeland. (Colors are for air-dry soil unless otherwise noted.)

A1--0 to 3 inches; pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; weak thin platy structure parting to weak fine granular; soft, friable, slightly sticky and slightly plastic; few fine and medium roots; common medium vesicular pores; moderately calcareous; moderately alkaline (pH 8.2); clear smooth boundary. (2 to 6 inches thick)

A2--3 to 12 inches; brown (10YR 5/3) clay loam, dark brown (10YR 4/3) moist; moderate medium subangular blocky structure; hard, firm, slightly sticky and plastic; few medium and fine roots; many medium pores; moderately calcareous; moderately alkaline (pH 8.0); gradual wavy boundary. (6 to 10 inches thick)

Bk1--12 to 20 inches; pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few fine pores; strongly calcareous; carbonates are fine nodules and disseminated; moderately alkaline (pH 8.3); gradual wavy boundary. (8 to 12 inches thick)

Bk2--20 to 32 inches; very pale brown (10YR 8/3) sandy clay loam, very pale brown (10YR 7/3) moist; massive; hard, firm, slightly sticky and slightly plastic; few fine and medium roots; few fine pores; very strongly calcareous; carbonates are disseminated and in fine nodules; moderately alkaline (pH 8.2); diffuse wavy boundary. (10 to 15 inches thick)

C1--32 to 48 inches; pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 5/3) moist; massive; slightly hard, very friable, slightly plastic; few fine roots; few fine pores; strongly calcareous; moderately alkaline (pH 7.9); gradual wavy boundary. (10 to 20 inches thick)

C2--48 to 64 inches; light yellowish brown (10YR 6/4) very gravelly sandy loam, yellowish brown (10YR 5/4) moist; single grained; loose, very friable, slightly plastic; few fine roots; strongly calcareous; moderately alkaline (pH 8.4).

TYPE LOCATION: Emery County, Utah; 4 miles north and 1 mile east of Elmo; 1,980 feet south and 140 feet west of the northeast corner of sec. 9, T. 16 S., R. 10 E.

RANGE IN CHARACTERISTICS: Average annual soil temperature is 47 to 53 degrees F. The soil moisture regime is Typic Aridic.

The depth to the calcic horizon ranges from 10 to 30 inches. The calcium carbonate equivalent ranges from 15 to 40 percent. The particle-size control section is clay loam, sandy clay loam, gravelly sandy loam, or gravelly sandy clay loam. It averages 18 to 35 percent clay and is more than 15 percent coarser than very fine sand. Gravel and cobbles range from 15 to 35 percent and occur in the lower one third of the particle-size control section. Below 40 inches, textures range from very gravelly sandy loam to extremely gravelly loamy sand, with 40 to 80 percent rock fragments. Reaction is moderately or strongly alkaline.

The A horizon has hue of 7.5YR or 10YR and value of 5 through 7 dry, 4 or 5 moist, and chroma of 2 or 4.

The Bk and C horizon has hue of 7.5YR or 10YR, value of 5 through 8 dry, 4 through 7 moist, and chroma of 3 or 4.

GEOGRAPHIC SETTING: These soils are on mesas or benches and old alluvial fans. Slope gradients are from 0 to 10 percent. Parent material is glacial outwash derived dominantly from sandstone and quartzite. Elevation is 5,400 to 6,000 feet. The climate is semiarid, with mean annual temperatures of 47 to 51 degrees F. Mean annual precipitation ranges from 5 to 9 inches. The freeze-free period is 110 to 130 days.

DRAINAGE AND PERMEABILITY: Well drained; medium runoff; moderate permeability.

USE AND VEGETATION: Cultivated areas are used for corn for silage, alfalfa, grain and improved irrigated pasture. Potential vegetation is galleta grass, blue grama, shadscale, needleandthread, Indian ricegrass, and winterfat.

DISTRIBUTION AND EXTENT: Plateau areas in Utah and Colorado. MLRA 34 and 35. The series is of moderate extent.

REMARKS: These soils have been correlated to desert range sites in Utah.

Diagnostic horizons and features in this pedon include:

Ochric epipedon - from 0 to 12 inches (A1 and A2 horizons).

Calcic horizon - from 12 to 32 inches (Bk1 and Bk2 horizons).

Classification change from Typic Calciorthids to Typic Haplocalcids on 11/94.

MINCHEY LOAM, 1 TO 3 PERCENT SLOPES (MIB): A profile of this soil is the one described as typical of the series. This soil normally is nonsaline.

Included in mapping were small areas of gravelly soils and of soils similar to this Minchey soil, except that the subsoil is loam or very fine sandy loam.

Drainage is good, and permeability is moderate. Runoff is medium, and the susceptibility to erosion is moderate. Roots generally penetrate deeply, but in places they are restricted by gravel and cobblestones at depths below 20 inches. The soil retains between 8 and 9 inches of water, but only 4.5 to 5.5 inches of water is readily available to plants. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range. In addition, some areas are irrigated and are used for alfalfa, small grains, corn, and pasture. (Capability units IIe-24, irrigated, and VIIc-S, nonirrigated; Semi-Desert Loam Bench range site)

PALISADE SERIES

The Palisade series consists of very deep, well drained soils that formed in lake sediments derived from limestone and sandstone. The Palisade soils are on lake terraces. Slope ranges from 1 to 10 percent. The mean annual temperature is 48 degrees F., and the mean annual precipitation is about 10 inches.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, mesic Xeric Haplocalcids

TYPICAL PEDON: Palisade loam. (Colors are for dry soil unless otherwise noted).

A--0 to 6 inches; pale brown (10YR 6/3) silt loam, dark grayish brown (10YR 4/2) moist; weak, thin, platey structure; slightly hard, friable, slightly sticky, slightly plastic; common very fine roots; many fine and medium pores; moderately calcareous, lime is disseminated; moderately alkaline (pH 8.4); clear smooth boundary. (3 to 7 inches thick.)

Bw--6 to 12 inches; very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; weak, medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common very fine roots; common very fine vesicular pores; moderately calcareous, lime is disseminated; strongly alkaline (pH 8.5); clear smooth boundary. (6 to 9 inches thick.)

Bk1--12 to 19 inches; very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; weak, medium and coarse, subangular blocky structure; hard, friable, slightly sticky, slightly plastic; few very fine roots; many very fine vesicular pores; strongly calcareous, lime is disseminated; strongly alkaline (pH 8.7); gradual wavy boundary. (5 to 8 inches thick.)

Bk2--19 to 30 inches; light gray (10YR 7/2) loam, brown (10YR 5/3) moist; weak, medium and coarse, subangular blocky structure; very hard, friable, nonsticky, nonplastic; few very fine roots; many very fine vesicular pores; strongly calcareous, lime is disseminated; very strongly alkaline (pH 9.4); gradual smooth boundary. (10 to 16 inches thick.)

C1--30 to 43 inches; pale brown (10YR 6/3) very fine sandy loam, brown (10YR 5/3) moist; massive; soft, friable, nonsticky, nonplastic; strongly calcareous, lime is disseminated; very strongly alkaline (pH 9.1); gradual wavy boundary.

C2--43 to 60 inches; pale brown (10YR6/3) very fine sandy loam, dark brown (10YR4/3) moist; massive; soft, friable, nonsticky, nonplastic; strongly calcareous, lime is disseminated; very strongly alkaline (pH 9.2).

TYPE LOCATION: Box Elder County, Utah; located about 400 feet north and 700 feet east of the southwest corner of sec. 11, T.9N., R.7W.; about 7 miles southwest of Golden Spike Monument.

RANGE IN CHARACTERISTICS: Soil temperatures are 48 to 54 degrees F.

The control section contains 8 to 18 percent clay and more than 15 percent coarser than very fine sand. Textures include very fine sandy loam, silt loam, and loam. In some places, the lower one-third of the control section contains gravel fragments and cobbles not exceeding 50 percent by volume.

The A horizon has hue of 10YR, values of 5 or 6 dry, and 4 or 5 moist, and chromas of 2 to 5.

The B and C horizons have hues of 7.5YR or 10YR, values of 5 to 7 dry, and 4 to 6 moist, and chromas of 2 to 4. Calcium carbonate content of the calcic horizons ranges from 20 to 40 percent.

GEOGRAPHIC SETTING: These soils are on lake terraces. Slope ranges from 1 to 10 percent. Parent material is lake sediments derived from limestone and sandstone. Mean annual air temperature is 46 to 52 degrees F. and the freeze free period ranges from 90 to 130 days. The mean annual precipitation ranges from 8 to 12 inches.

DRAINAGE AND PERMEABILITY: Well drained. Runoff is medium; permeability is moderate.

USE AND VEGETATION: Irrigated areas are used for growing alfalfa, small grains, and corn for silage. Present vegetation on unirrigated areas is dominantly shadscale and rabbitbrush. Potential vegetation under excellent management would be Indian ricegrass, needle-and-thread, squirreltail, and bud sage.

DISTRIBUTION AND EXTENT: Southern and eastern Utah, and possibly Colorado. The series is extensive.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - from the surface to 6 inches (A horizon).

Calcic horizon - from 12 to 30 inches (Bk1 and Bk2 horizons).

The classification is based on the "Keys to Soil Taxonomy, Eighth Edition, 1998". This Palisade series was last reviewed in the field in 1965. The type location was moved to Box Elder county with the 1998 update of the series.

PALISADE VERY FINE SANDY LOAM, 1 TO 3 PERCENT SLOPES (PdB): The profile of this soil is the one described as typical of the series. Where this soil has been cultivated, the surface layer is mixed with material from the subsoil and can no longer be recognized. Gravel and cobblestones are between depths of 2 and 5 feet in places.

Included in the mapping were areas of Minchey loam, and places where gravel and cobblestones are at a depth of less than 20 inches. Also included was a small acreage near the Carbon County

Airport of a soil that contains a lime-cemented hardpan. Another inclusion, on the Porphyry Bench west of Price, consists of a small acreage of soils in which the surface layer and the subsoil are not calcareous.

Drainage is good, and permeability is moderate. Root penetration is deep. About 9 inches of water is retained by this soil, but only 4.5 to 5.5 inches is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is easy to work and to irrigate. Leveling is needed in many areas, however, to help obtain the uniform distribution of irrigation water. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range, and for irrigated alfalfa, small grains, corn, and pasture. Because of the short growing season, alfalfa produces only two full crops and part of a third. Corn does not mature for grain and is used for ensilage. Alfalfa needs a large amount of phosphorus. (Capability units IIe-24, irrigated and VIIc-S, nonirrigated; Semi-Desert Loam Bench range site)

PENOYER SERIES

The Penoyer series consists of very deep, well drained soils that formed in silty alluvium from limestone, volcanic rocks and lacustrine sediments. Penoyer soils are on inset fans, fan skirts, alluvial flats, flood plains, lake plains and alluvial fans. Slopes are 0 to 2 percent. The mean annual precipitation is about 7 inches and the mean annual temperature is about 54 degrees F.

TAXONOMIC CLASS: Coarse-silty, mixed, superactive, calcareous, mesic Typic Torriorthents

TYPICAL PEDON: Penoyer silt loam - rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 4 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; moderate thick platy structure; hard, friable, slightly sticky and slightly plastic; few fine and medium roots; strongly effervescent; strongly alkaline (pH 8.8); clear smooth boundary. (3 to 10 inches thick)

C1--4 to 17 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots; common fine and medium vesicular pores, few fine tubular pores; strongly effervescent; strongly alkaline (pH 8.8); gradual smooth boundary. (4 to 20 inches thick)

C2--17 to 41 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; few fine and medium roots; common fine and medium vesicular pores; strongly effervescent; strongly alkaline (pH 8.8); clear smooth boundary. (5 to 40 inches thick)

C3--41 to 60 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; weak thick platy structure that approaches massive in places; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; few fine and very fine tubular pores; strongly effervescent; strongly alkaline (pH 8.8).

TYPE LOCATION: Lincoln County, Nevada; about 20 miles west of Caliente; 3.1 miles west of junction of Delamar road and U.S. Highway 93, and 0.2 mile north of U.S. Highway 93; about 700 feet south and 200 feet east of the northwest corner of section 8, T. 4 S., R. 64 E.; 37 degrees, 37 minutes, 14 seconds north latitude, 114 degrees, 50 minutes, 28 seconds west longitude.

RANGE IN CHARACTERISTICS:

Soil moisture - Usually dry, moist in some part for short periods during winter and early spring months for 10 to 20 days cumulative between July and October due to convection storms.

Soil temperature - 53 to 59 degrees F. Control section - Clay content: Averages 10 to 18 percent.

A horizon - Hue: 7.5YR or 10YR. Valve: 6 or 7 dry, 3 through 5 moist. Chroma: 2 through 4.

C horizon - Hue: 7.5YR or 10YR. Value: 6 or 7 dry, 3 through 5 moist. Chroma: 2 through 4.

Structure: Subangular blocky platy or massive. Consistence: Soft to hard, very friable or friable, slightly sticky to sticky and slightly plastic to plastic. Texture: Silt loam, but strata of very fine sandy loam, loam or silty clay loam are in some pedons. Effervescence: Strongly effervescent or violently effervescent. Reaction: Moderately alkaline to very strongly alkaline.

GEOGRAPHIC SETTING: Penoyer soils are on inset fans, fan skirts, alluvial flats, flood plains, lake plains, and alluvial fans. Slopes are 0 to 2 percent but are generally less than 1 percent. Elevations are 3,500 to 7,000 feet. They are crossed by a few shallow drainage channels. In places, wind deposited sandy hummocks, 2 to 4 inches high, are around the base of shrubs. Penoyer soils formed in silty alluvium derived from limestone, andesite, volcanic ash, basalt, tuff, sandstone and lacustrine sediments. The annual precipitation is 6 to 9 inches, the mean annual temperature is 51 to 56 degree F., and the frost-free season is 130 to 170 days.

DRAINAGE AND PERMEABILITY: Well drained; very slow runoff; moderate permeability.

USE AND VEGETATION: Most areas are used for rangeland. A few are irrigated and are used for growing alfalfa, small grain, potatoes and sugar beets. Dominant native plants are winterfat and some Indian ricegrass and galleta. Saltbush and greasewood are on saline or saline-alkali areas. Most of the surface area is bare.

DISTRIBUTION AND EXTENT: Central Nevada and southwestern Utah. The soil is of moderate extent. MLRA 29.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from the surface to 7 inches.

Particle-size control section - The zone from 10 to 40 inches.

Torriorthent features - Calcareous in all parts from 10 to 20 inches.

PENOYER LOAM, EXTENDED SEASON, 0 TO 1 PERCENT SLOPES (PnA): This soil is similar to the one for which a profile is described as typical of the series, except that it is nearly level and is near Green River, where the growing season is 140 to 160 days.

Included in mapping were soils that have slopes of 1 to 2 percent and some soils that have slopes of 3 to 6 percent. Included also were minor areas of soils that have a silty clay loam surface layer and a sandy loam subsoil.

Land leveling has been done in many fields, but it is still needed in some areas to improve the distribution of irrigation water. Runoff is slow, and the susceptibility to erosion is slight.

This soil is used for irrigated pasture, alfalfa, small grains, corn, melons, and sugar beets. Alfalfa produces three full cuttings a year, and corn matures for grain. (Capability unit I-1, irrigated; not rated for other uses)

PERSAYO SERIES

The Persayo series consists of shallow, well drained soils on hills, terraces, and ridges. These soils formed in thin sediments weathered from underlying soft sedimentary bedrock. Slopes are 1 to 45 percent. The mean annual precipitation is about 9 inches and the mean annual temperature is about 51 degrees F.

TAXONOMIC CLASS: Loamy, mixed, active, calcareous, mesic, shallow Typic Torriorthents

TYPICAL PEDON: Persayo silty clay loam - grassland. (Colors are for dry soil unless otherwise noted.)

A--0 to 4 inches; light yellowish brown (2.5Y 6/3) silty clay loam, light olive brown (2.5Y 5/3) moist; moderate fine granular structure, weak platy in the upper 1/2 inch; soft, very friable; calcareous; moderately alkaline (pH 8.2); gradual smooth boundary. (3 to 7 inches thick)

C--4 to 14 inches; light yellowish brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) moist; weak medium subangular blocky structure parting to moderate fine granules; hard, very friable; few small calcium sulfate crystals; calcareous; moderately alkaline (pH 8.2) gradual smooth boundary. (7 to 14 inches thick)

Cr--14 inches; calcareous; gray and yellow shale and siltstone.

TYPE LOCATION: Montrose County, Colorado; 0.1 mile north of the southeast corner of Sec. 22, T. 51 N., R. 10 W.

RANGE IN CHARACTERISTICS:

These soils are dry in all parts of the moisture control section for more than three-fourths of the time that the soil temperature is above 41 degrees F. Moisture regime is Typic Aridic. Mean annual soil temperature: 47 to 58 degrees F. Mean summer soil temperature: 60 to 75 degrees F. Depth to paralithic contact: 4 to 20 inches. Organic carbon: approximately .4 percent. The sand/clay ratio: less than 1 to about 3. Exchangeable sodium: typically less than 3 percent, but tends to increase as depth increases and differs among pedons. Calcium carbonate equivalent: 5 to 14 percent. Calcium sulfate: less than 1 to about 10 percent.

Particle-size control section (weighted average): Texture: silt loam, loam, clay loam, or silty clay loam
Clay content: 18 to 35 percent
Silt content: 30 to 65 percent
Sand content: 5 to 45 percent
Coarse fragments: usually less than 5 percent and range from 0 to 15 percent.

A horizon
Hue: 10YR to 5Y
Value: 5 to 7 dry, 4 to 6 moist
Chroma: 2 through 4
Reaction: slightly to strongly alkaline
Consistence: soft to slightly hard.

C horizon
Hue: 10YR through 5Y
Value: 5 or 6 dry, 4 or 5 moist
Chroma: 2 to 4
Reaction: slightly alkaline to strongly alkaline
It contains some visible calcium carbonate and gypsum which are not concentrated into a definite horizon of secondary accumulation and are considered to be characteristics of the parent sediments rather than pedogenic.

GEOGRAPHIC SETTING: These soils are on upland hills, terraces, and ridges. Slopes range from 1 to 45 percent. The soil formed in thin sediments weathered from underlying soft sedimentary bedrock. Elevation ranges from 5,000 to 6,800 feet. At the type location mean annual precipitation is 7 to 11 inches with peak periods of precipitation occurring during the late summer. Mean annual temperature ranges from 47 to 53 degrees F., and mean summer temperature is about 66 to 70 degrees F. Frost-free period ranges from 95 to 150 days. In Utah this soil has a mean annual precipitation of 6 to 8 inches, mean annual temperature of 48 to 50 degrees, and a frost-free season of 115 to 140 days at an elevation of 5,300 to 6,200 feet.

DRAINAGE AND PERMEABILITY: Well drained; medium to rapid runoff; moderate or moderately slow permeability.

USE AND VEGETATION: These soils are used almost exclusively for native pastureland. Native vegetation is salt sage, greasewood, shadscale, and scattered grasses.

DISTRIBUTION AND EXTENT: Western Colorado and Wyoming, northwestern New Mexico, and eastern Utah. The series is of large extent. MLRA 35.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Paralithic contact - at about 14 inches.

PERSAYO-CHIPETA ASSOCIATION, 1 TO 20 PERCENT SLOPES, ERODED (PCE2): About 60 percent of this mapping unit is Persayo loam, 1 to 20 percent slopes, eroded, and 40 percent is Chipeta silty clay loam, 3 to 20 percent slopes, eroded. These soils are intermingled and occur in no identifiable pattern. The Chipeta soil generally is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were areas of 1 to 5 acres made up of a very strongly saline soil and of areas of a moderately deep soil. Also included was an area of about 200 acres, 5 miles east of Castle Dale, of a brown soil that is similar to the Persayo component mapped in this unit.

The Persayo soil has the profile described as typical of the series. It is well drained and has moderate permeability. Roots penetrate to the shale, and then they spread horizontally. This soil holds 1 to 3 inches of available water, the amount depending on the depth to bedrock. Runoff is medium, and the susceptibility to erosion is moderate.

The Chipeta soil has a profile similar to the one described as typical for the Chipeta series, except that the slopes are stronger and it is eroded. Rill and gully erosion are active.

The soils in this mapping unit are used mainly for spring and fall range, but in places they are used for irrigated pasture. Sheet erosion is active, and in many places shallow gullies have cut into the shale bedrock. (The Persayo soil is in capability unit VIIe-D4, nonirrigated; Desert Loamy Shale range site. The Chipeta soil is in capability unit VIIe-D3, nonirrigated; Desert Shale range site)

RAVOLA SERIES

The Ravola series consists of very deep, well drained soils that formed in alluvium derived from shale, siltstone, and sandstone. Ravola soils are on alluvial fans and flood plains. Slopes range from 0 to 10 percent. Mean annual precipitation is about 7 inches and the mean annual temperature is about 50 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, active, calcareous, mesic Typic Torrifluvents

TYPICAL PEDON: Ravola loam under cultivation. (Colors are for dry soil unless otherwise noted.)

Ap1--0 to 6 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure parting to weak fine subangular blocky; slightly hard, friable, slightly plastic; many fine roots, few coarse roots; common fine and medium pores; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary. (2 to 6 inches thick)

Ap2--6 to 9 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; strongly compacted plowpan layer; weak coarse subangular blocky structure parting to weak coarse granular; hard, friable, slightly sticky and slightly plastic; many fine roots; common fine pores; few medium pores; strongly effervescent; slightly alkaline (pH 7.7); clear smooth boundary. (0 to 3 inches thick).

C1--9 to 18 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak thin platy structure parting to weak very thin platy; hard, friable, slightly sticky and slightly plastic; few coarse and many fine roots; many medium and common fine pores, strongly effervescent; slightly alkaline (pH 7.7); gradual wavy boundary. (9 to 24 inches thick)

C2--18 to 45 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; few medium and many fine roots; common medium pores; strongly effervescent; moderately alkaline (pH 7.9); gradual irregular boundary. (6 to 30 inches thick)

C3--45 to 60 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; massive; soft, very friable; few fine roots; few fine pores; strongly effervescent; moderately alkaline (pH 7.9).

TYPE LOCATION: Emery County, Utah; about 1 1/2 miles south and 1/2 mile east of Huntington; located about 2,000 feet west and 600 feet north of the southeast corner of sec. 31, T. 17 S., R. 9 E.

RANGE IN CHARACTERISTICS:
Mean annual soil temperature: 49 to 56 degrees F

Particle-size control section: 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand

A horizon:
Hue: 10YR to 5Y
Value: 5 to 7 dry, 4 or 5 moist
Chroma: 2 or 4 dry or moist
Texture: loam, clay loam, very fine sandy loam, or silt loam
Calcium carbonate equivalent: 5 to 25 percent
Reaction: slightly to strongly alkaline

C horizon:
Hue: 10YR to 5Y
Value: 5 to 7 dry, 4 or 5 moist
Chroma: 2 to 4 dry or moist
Texture: stratified loamy sand to clay loam
Calcium carbonate equivalent: 5 to 25 percent
Reaction: slightly to strongly alkaline

GEOGRAPHIC SETTING:
Parent material: alluvium derived from shale, siltstone, and sandstone
Landform: alluvial fans and flood plains
Slopes: 0 to 10 percent
Elevation: 4,500 to 6,000 feet
Mean annual temperature: 47 to 56 degrees F
Mean annual precipitation: 5 to 11 inches
Frost-free period: 110 to 160 days

DRAINAGE AND PERMEABILITY: well drained, negligible to medium runoff, moderate or moderately slow permeability. These soils are subject to occasional brief flooding following high intensity summer thunderstorms.

USE AND VEGETATION: Irrigated areas are used for growing small grains, corn, sugar beets, alfalfa, and pasture. Potential vegetation is shadscale, greasewood, Indian ricegrass, and galleta.

DISTRIBUTION AND EXTENT: Eastern Utah, northwest New Mexico and western Colorado. LRR D, MLRA 28A, 34, 35, 37. This series is of large extent.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon: The zone from 0 to 9 inches. (Ap1 and Ap2)

RAVOLA LOAM, 1 TO 3 PERCENT SLOPES (R1B): In most places the profile of this soil is like the one described as typical of the series. In some places, however, the texture between depths of 10 and 40 inches is silt loam to very fine sandy loam and the texture below 40 inches is

sandy loam to silty clay loam. Salinity generally is slight to moderate. Alkalinity ranges from none to moderate. Veins of gypsum are common below a depth of 20 to 30 inches. The frost-free season is 110 to 130 days in 3 out of 4 years.

Included in mapping were areas of Billings silty clay loam, and other areas ½ acre to 1 acre in extent, of poorly drained, strongly or very strongly saline-alkali soils. Also included were areas of a soil that is brown or light olive in color, and areas of Ravola loam in which the slopes are slightly less than 1 percent.

Drainage is good, and permeability is moderate. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to a depth of 5 feet or more. This soil retains about 10.5 inches of water, but only about 6 inches of water is readily available to plants. Natural fertility is low, but the fertility in many fields is high because fertilizer has been applied. This soil is easy to work and to irrigate. The uniform distribution of irrigation water is needed. Land leveling can be done with little or no damage to the soil.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, corn, and sugar beets. The growing season is long enough for alfalfa to produce two full cuttings and part of a third. Corn does not mature for grain and is used for ensilage. (Capability units IIe-2, irrigated and VIIc-D, nonirrigated; Desert Loam Bottom range site)

RAVOLA-BUNDERSON COMPLEX, 1 TO 3 PERCENT SLOPES, ERODED (RuB2): About 80 percent of this mapping unit is Ravola loam, 1 to 3 percent slopes, eroded, and 20 percent is Bunerson loam, 1 to 3 percent slopes, eroded. Typically, the Bunderson soil occupies slickspots that are interspersed with areas of the Ravola soil. Both soils are on flood plains and alluvial fans.

Included in Mapping were small areas of Billings silty clay loam.

Runoff is rapid from the Bunderson soil, and most areas contain gullies 5 to 20 feet deep and 500 to 1,300 feet apart. Head cutting is common, and it is forming shallow gullies. In places windblown hummocks less than 2 feet high occur. Typically, these are on the east and north sides of greasewood and other plants.

The soils in this mapping unit are suited to the production of range forage. Controlling gully erosion and regulating the amount and season of range use are needed. Clearing the brush and reseeding grasses are not feasible, because of the small amount of rainfall. (Both soils are in Capability unit VIIe-D, nonirrigated; Ravola soil is in Desert Loam Bottom range site)

SANPETE SERIES

The Sanpete series consists of very deep, well to somewhat excessively drained, moderately rapidly permeable soils that formed in alluvium dominantly from limestone, sandstone, and shale. Sanpete soils are on alluvial fans and alluvial plains and have slopes of 1 to 30 percent. The average annual precipitation is about 11 inches and the mean annual air temperature is about 48 degrees F.

TAXONOMIC CLASS: Loamy-skeletal, carbonatic, mesic Xeric Haplocalcids

TYPICAL PEDON: Sanpete gravelly fine sandy loam--rangeland. (Colors are for air-dry soil unless otherwise stated.)

A1--0 to 3 inches; pale brown (10YR 6/3) gravelly fine sandy loam, brown (10YR 4/3) moist; weak thin platy structure; soft, very friable, nonsticky and slightly plastic; few fine roots; common very fine pores; 30 percent coarse fragments, dominantly gravel; strongly effervescent; carbonates are disseminated; moderately alkaline (pH 8.4); abrupt smooth boundary. (2 to 3 inches thick)

A2--3 to 11 inches; very pale brown (7.5YR 6/3) gravelly loam, brown (7.5YR 5/3) moist; weak medium subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many fine roots; common very fine and few fine pores; 18 percent coarse fragments, dominantly gravel; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.2); clear wavy boundary. (5 to 12 inches thick)

Bk1--11 to 17 inches; very pale brown (10YR 7/3) very gravelly sandy loam, light brown (7.5YR 6/3) moist; massive; soft, very friable, slightly sticky and slightly plastic; many fine roots; common very fine pores; 50 percent coarse fragments, dominantly gravel; violently effervescent, carbonates are disseminated and coated on the rock fragments and accumulated in soft rounded accretions; moderately alkaline (pH 8.3); clear wavy boundary. (9 to 16 inches thick)

Bk2--17 to 48 inches; light brown (7.5YR 6/3) extremely gravelly sandy loam, brown (7.5YR 5/3) moist; massive; soft, very friable, slightly sticky and slightly plastic; many fine roots; common very fine pores; 65 percent coarse fragments, dominantly gravel; violently effervescent, carbonates are disseminated and coated on the rock fragments and accumulated in soft rounded accretions; moderately alkaline (pH 8.3); clear wavy boundary. (11 to 28 inches thick)

C--48 to 60 inches; light brown (7.5YR 6/3) very gravelly sandy loam, brown (7.5YR 4/4) moist; massive; soft, very friable, nonsticky and slightly plastic; few very fine roots; common very fine pores; 45 percent gravel, 10 percent cobbles; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.4).

TYPE LOCATION: Sanpete County, Utah; 3 miles south and 5 miles west of Gunnison; 30 feet east of telephone pole on south side of road, about 412 feet north and 600 feet east of the southwest corner of Section 3, T. 20 S., R. 1 W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 47 to 54 degrees F., the mean summer soil temperature is 64 to 68 degrees F. In more than 7 out of 10 years the soils are dry in the moisture control section for 60 to 80 consecutive days between June 21 and September 21, and are dry in the moisture control section 50 to 60 percent of the time the soil temperature at 20 inches is above 41 degrees F. in most years, and are moist for 60 to 75 consecutive days during the 120 days after the winter solstice.

The particle-size control section ranges from 10 to 27 percent clay. Coarse fragments in the particle-size control section range from 35 to 80 percent and range from gravel to stones. Depth to the calcic horizon ranges from 4 to 15 inches. The calcium carbonate equivalent content of the 10 to 40 inch control section averages more than 40 percent including the lime in the coarse fragments less than 20 millimeter in diameter.

The A horizon has hue of 10YR or 7.5YR, value of 5 to 7 dry 4 or 5 moist, and chroma of 2 to 4. It is moderately to strongly alkaline.

The Bk horizon has hue of 10YR, 7.5YR or 5YR, value of 6 to 8 dry, 4 to 6 moist, and chroma of 2 to 6 dry or moist. It is loam, silt loam or sandy loam, with 35 to 80 percent coarse fragments. It is moderately to strongly alkaline. Calcium carbonate equivalent is 40 to 70 percent. SAR ranges from 0 to 25 and gypsum content is 0 to 2 percent.

The C horizon has hue of 10YR, 7.5YR or 5YR, value of 6 or 7 dry, 4 to 6 moist and chroma of 2 to 4. It is a loam, sandy loam or sand with 25 to 80 percent rock fragments. This horizon is moderately alkaline or strongly alkaline. Calcium carbonate equivalent is 40 to 70 percent. SAR ranges from 0 to 25 and gypsum content is 0 to 2 percent.

GEOGRAPHICAL SETTING: Sanpete soils occur on alluvial fans, alluvial flats and foothills. Slope range is 1 to 30 percent. These soils formed in alluvium from limestone, sandstone, shale, and igneous rock. These soils occur at elevations of 5,000 to 6,600 feet. The climate is semiarid to dry subhumid with a mean annual air temperature of about 45 to 52 degrees F., mean summer temperature of about 64 to 68 degrees F. and average annual precipitation is about 8 to 12 inches. The freeze-free period ranges from 100 to 140 days.

DRAINAGE AND PERMEABILITY: Well to somewhat excessively drained; medium to rapid runoff; moderate and moderately rapid permeability.

USE AND VEGETATION: These soils are used mainly for rangeland and for irrigated crops of alfalfa, small grains and pasture. The principal vegetation is Indian ricegrass, needleandthread grass, winterfat, bud sage, black sagebrush, and shadscale.

DISTRIBUTION AND EXTENT: Central and northern Utah. MLRA 28A. This series is moderately extensive.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface of the soil to 11 inches (A1 and A2 horizon).

Calcic horizon - the zone from 11 to 48 inches (Bk1 and Bk2 horizons).

Xeric feature - soil moisture regime is Aridic bordering Xeric.

Particle-size control section - the zone from 10 to 40 inches.

This soil was reclassified from a Xerollic Calciorthids to a Xeric Haplocalcids on 9/94.

SANPETE SANDY CLAY LOAM, 1 TO 3 PERCENT SLOPES (SIB): The profile of this soil is the one described as representative of the series. Typically, gravel is in the upper 10 inches, and in places gravel is on the surface. Near the mountains on the upper parts of benches, the coarse fragments typically range from 3 to 20 inches in diameter. On the lower ends of the benches, 3 or 4 miles away from the mountains, the coarse fragments typically range from 1½ to 10 inches in diameter.

Drainage is good, and permeability is rapid. Root penetration is restricted by gravel and cobblestones below a depth of about 20 inches. About 3.5 inches of water is retained in this soil, but only about 2 inches of water is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is fairly hard to work. Leveling is difficult because of the cobblestones and gravel.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, and corn. Because of the short growing season, alfalfa produces only two full crops and part of a third in a year. Erosion is reduced if this soil is used for hay or pasture most of the time. Alfalfa responds well to applications of a phosphate fertilizer. (Capability units IVs-24, irrigated, and VIIs-S4, nonirrigated; Semi-Desert Limy Loam range site)

TUSHER SERIES

The Tusher series replaces the Trook series which replaced the Palisade series in the 1970 Carbon-Emery soil survey (Swenson et al., 1970). Tusher soils (Utah series) have a longer growing season than Trook soils (Wyoming series). Otherwise, they are very similar. Tusher soils do not have a natirc horizon (sodic) that is characteristic of the Palisade soils.

Given the provisional nature of the Tusher classification, a description of this series was not available on the NRCS web site as of 6 Feb 2007. A description of the Palisade series is provided in this appendix. A description of the Trook series is provided below, as obtained from the NRCS web site:

The Trook series consists of very deep, well drained soils on old alluvial fan surfaces or on high terraces. Typical slope gradients range from 1 to about 10 percent. The soil formed in thick, calcareous, alluvial sediment. At the type location, the mean annual precipitation is about 7 inches. The mean annual temperature is 44 degrees F., mean summer temperature is 66 degrees F.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, mesic Typic Haplocalcids

TYPICAL PEDON: Trook sandy loam - native grassland (Colors are for dry soil unless otherwise noted.)

A1--0 to 7 inches; pale brown (10YR 6/3) sandy loam, brown (10YR 4/3) moist; moderate fine granular structure; 1/8 to 1/4 inch vesicular crust at surface; soft, very friable; few gravel fragments; calcareous; slightly alkaline, (pH 7.8); clear wavy boundary. (5 to 10 inches thick)

Clca--7 to 12 inches; pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 5/3) moist; very weak subangular blocky structure; soft, very friable; 15 percent gravel fragments; moderate amounts of visible secondary calcium carbonate occurring as concretions and in thin seams and streaks; calcareous; moderately alkaline (pH 8.4); diffuse wavy boundary. (3 to 6 inches thick)

C2ca--12 to 27 inches; very pale brown (10YR 7/3) gravelly loam, pale brown (10YR 6/3) moist; massive; slightly hard, very friable; 20 percent gravel fragments; large amounts of visible secondary calcium carbonate occurring as concretions, in thin seams and streaks, as coatings on sand and gravel fragments, and in finely divided marl-like forms; calcareous, moderately alkaline (pH 8.4); diffuse irregular boundary. (10 to 18 inches thick)

IIC3ca--27 to 42 inches; very pale brown (10YR 8/2) gravelly sandy loam, light gray (10YR 7/2) moist; massive; slightly hard, very friable; 20 percent gravel; large amounts of visible secondary calcium carbonate occurring as concretions in thin seams and streaks, as coatings on

the gravel fragments, and in fine marl-like forms; calcareous; strongly alkaline (pH 8.6); diffuse irregular boundary. (10 to 20 inches thick)

C4ca--42 to 60 inches; pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 4/3) moist; massive; slightly hard, very friable; 25 percent gravel; some visible secondary calcium carbonate in the form of concretions, and in thin seams and streaks, or as coatings on the gravel fragments but less than in the horizon above; calcareous; moderately alkaline (pH 8.4). (Several feet thick)

TYPE LOCATION: Fremont County, Wyoming; NE1/4SE1/4 sec. 9, T.4N., R.3E.

RANGE IN CHARACTERISTICS: These soils are typically calcareous at the surface, but they are leached to depths of 1 or 2 inches in some pedons. Depth to the calcic horizon is less than 40 inches. The surface 15 inches averages about .1 to .4 percent organic carbon and the sand/clay ratio ranges from 3 to 16. The 10 to 40 inch control section is typically sandy loam, but clay ranges from 5 to 18 percent, silt from 5 to 35 percent and sand from 50 to 80 percent with more than 35 percent fine sand or coarser; loamy sand is excluded from the preceding ranges. Coarse fragments range from 15 to 35 percent with the content of gravel usually increasing with increasing depth. The mean annual soil temperature is 47 degrees to 52 degrees F. and the mean summer soil temperature is 60 degrees to 68 degrees F. The A1 horizon has hue of 2.5Y through 7.5YR, value of 6 or 7 dry, 4 or 5 moist and chroma of 2 through 5. It usually has granular or crumb structure but has weak subangular blocky structure in some pedons. This horizon is soft or slightly hard. It ranges from slightly to strongly alkaline (pH 7.8 to 8.6). The Cca horizon has hue of 2.5Y through 7.5YR. It is moderately or strongly alkaline (pH 8.0 to 8.8) and contains 15 to 40 percent calcium carbonate equivalent.

GEOGRAPHIC SETTING: Trook soils are on old alluvial fan surfaces or on high terraces. Typical slope gradients range from 1 to about 10 percent. The soil formed in thick, calcareous, alluvial parent sediment. At the type location, the mean annual precipitation is 7 inches with peak periods of precipitation during the spring and summer months. The mean annual temperature is 44 degrees F., mean summer temperature is 66 degrees F.

DRAINAGE AND PERMEABILITY: Well drained; slow runoff; moderate to rapid permeability.

USE AND VEGETATION: These soils are usually used as native pastureland; however, they may be irrigated where water is available. Principal native plants are threadleaf sage, blue grama, needle-and-thread grass, Indian ricegrass, and big sage.

DISTRIBUTION AND EXTENT: Basin areas of central and northern Wyoming. The series is of moderate extent.

REMARKS: Diagnostic horizons and features:
Ochric epipedon- the zone from the soil surface to 7 inches (A1 horizon).
Calcic horizon - the zone from 7 to 60 inches (Cca horizons).

APPENDIX XIII-2

Vegetation and Wildlife Report

VEGETATION & WILDLIFE
of the
FEDERAL LEASE IBC AREA

at the
EMERY MINE SITE

for
CONSOL ENERGY

Prepared by

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September 2006

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VEGETATION & WILDLIFE
of the
FEDERAL LEASE IBC AREA

INTRODUCTION

Consolidation Coal Company (Consol) has applied for an Incidental Boundary Change (IBC) to the Emery Mine permit area. The new area has been called Federal Lease IBC Area and is approximately 160 acres in size and is located north of the 4th East Portal site.

No surface disturbance has been planned for the new area. Moreover, subsidence caused by underground mining is also not anticipated during this phase of the mining operations. Therefore, there should be no change to the ground surface or the existing plant communities in the Federal Lease IBC Area as a result of the proposed mining activities.

The major plant communities of the Federal Lease IBC Area have been mapped (see attached *Vegetation Map of the Federal Lease IBC Area*). A wildlife habitat map has also been prepared (see attached *Wildlife Habitat Map of the Federal Lease IBC Area*). A discussion about the plant communities and big game wildlife species as well as the potential for the occurrence of threatened or endangered species have also been included in this document.

METHODS

The vegetation of the Federal Lease IBC Area was mapped in the field by walking the area and by using aerial photography. The field work was conducted July 6, 2006.

Species of concern by the State of Utah, Division of Wildlife Resources (DWR) were reviewed in the state's GIS database system. Potential threatened and endangered species lists were compiled after consulting previously with the U.S. Fish & Wildlife Service, Salt Lake City, Utah and files located at *Mt. Nebo Scientific, Inc.*, Springville, Utah.

RESULTS

VEGETATION

Beginning at the higher elevations and moving downward, there were 3 major plant community types in the Federal Lease IBC Area including: Shadscale/Winterfat, Greasewood and Pasture Lands. These communities are shown on the vegetation map included with this report. A brief description of each of these communities follows below; color photographs of each community type have also been included in this report.

Shadscale/Winterfat

A Shadscale/Winterfat plant community occupied a small percentage of the plant communities in the Federal Lease IBC Area. It was located in an isolated area near one corner of the study area (see Vegetation Map and Photo 1). As the community name suggests, this community was dominated by shadscale (*Atriplex confertifolia*) and winterfat (*Ceratoides lanata*).

Greasewood

Greasewood communities can be found as the elevation decreases. This community occupies the largest portion of the study area (see Vegetation Map and Photos 2,3). This community is known for its relatively low species diversity with the dominant plant species comprised of greasewood (*Sarcobatus vermiculatus*) and Torrey's seepweed (*Suaeda torreyana*).

Some of this native plant community has been disturbed by cultivation and conversion to pasture land. There were often "weedy" or exotic species such as halogeton (*Halogeton glomeratus*) and Western stickseed *(Lappula occidentalis*) present in these areas.

Pasture Land

Some of the lower elevation areas have been converted to pasture land. A portion of the pasture lands are currently irrigated (see Photo 4); others had been irrigated in the past and

are currently dry (see Photos 5, 6). This differentiation was also delineated on the vegetation map included in this report.

The lowest elevation areas were the natural drainages in the study area. Some of these areas (see Photo 7) were dominated by saltgrass (*Distichlis strictus*). Undoubtably in the past, prior to the flood irrigation techniques presently being used in the area, there were many more areas dominated by saltgrass. With the increase in water from irrigation runoff, some isolated areas that were once dominated by saltgrass, have been converted and support more hydrophilic plant species as dominates such as willow (*Salix exigua*), sedges (*Carex* spp.), rushes (*Juncus* spp.) and spikerushes (*Eleocharis* spp.). Some of these distinctions are shown in the color photographs included in this report (see Photo 8).

Threatened and Endangered Species

There are several federally listed plant species that are known to occur in Emery County, Utah (Table 1). However, there is almost no chance of these species occurring directly in the study area. Because it was late in the

Table 1: Potential Threatened or Endangered Plant Species of the Federal Lease IBC Area at the Emery Mine

Scientific Name	Common Name	Status
Pediocactus winkleri	Winkler Footcactus	T
Pediocactus despainii	Despain Footcactus	E
Schoencrambe barnebyi	Barneby's schoencrambe	E
Sclerocactus wrightiae	Wright Fishhook Cactus	E
Townsendia aprica	Last Chance Townsendia	T
Erigeron maguirei	Maguire Daisy	T
Cycladenia humilis var. jonesii	Jones Cycladenia	T

E = Federal Protection, Endangered
T = Federal Protection, Threatened

flowering season for some of the target species, the field work conducted on the site was done to assess the habitats as well as to search for sensitive species in the study area. If the species were not visually observed, assessment of the habitat provided clues to the probability of one of these species existing at each site.

No threatened or endangered plant species were found within the boundaries of the study area. Additionally, the habitat assessment suggested a very low probability (or almost no chance) that any of these species could occur at the sites. Finally, if any sensitive species were to exist in the area, they would not be impacted by the underground mining activities (no surface disturbance has been planned in the study area).

WILDLIFE

Geographical database information from the State of Utah, Division of Wildlife Resources (DWR) suggest the area is not critical habitat for pronghorn, elk, mule deer, sage grouse, or rocky mountain bighorn sheep. The database does, however, suggest the study area to be "High Value Winter Habitat" for elk (see attached *Wildlife Habitat Map of the Federal Lease IBC Area*).

Raptors

In 2001 DWR biologists visited the site along with representatives from Consolidation Coal Company. At that meeting it was suggested that there was a low probability of raptor occurrence in the area (refer to: *Biological Impacts at the 4th East Portal Area at the Emery Deep Mine.* 2002. Mt. Nebo Scientific. Springville, UT). Since that time Consolidation Coal Company has participated in the annual raptor surveys conducted by DWR and other coal mine operators in the area.

In addition, during site visits by *Mt. Nebo Scientific, Inc.* surveys were conducted for major prairie dog communities in the study area. Prairie dog communities are known to be important habitat for burrowing owls (*Athene cunicularia*). One such community was located previously and is shown on a map in the Emery Mine's Mining & Reclamation Plan [Selected

Wildlife Information (Plate 10-1)]. Because no surface disturbance that could impact this community is expected within the boundaries of the Federal Lease IBC Area, it has not been studied for either prairie dogs or burrowing owls.

Threatened and Endangered Species

There are also several federally listed animal species that are known to occur in Emery County, Utah (Table 2). However, there is almost no chance of these species occurring directly in the study area for lack of habitat.

Table 2: Potential Threatened or Endangered Animal Species of the Federal Lease IBC Area at the Emery Mine

Scientific Name	Common Name	Status
Gilia elegans	Bonytail	E
Ptychocheilus lucius	Colorado Pike minnow	E
Gila cypha	Humpback Chub	E
Xyrauchen texanus	Razorback Sucker	E
Haliaeetus leucocephalus	Bald Eagle	T
Strix occidentalis lucida	Mexican Spotted Owl	T
Mustela nigripes	Black-footed Ferret	E
Empidonax traillii extimus	Southwestern Willow Flycatcher	E
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo	C

E = Federal Protection, Endangered
T = Federal Protection, Threatened
C = Candidate

COLOR PHOTOGRAPHS
of the
PLANT COMMUNITIES

Photo 1: Shadscale/Winterfat Community

Photo 2: Greasewood Community

Photo 3: Greasewood Community

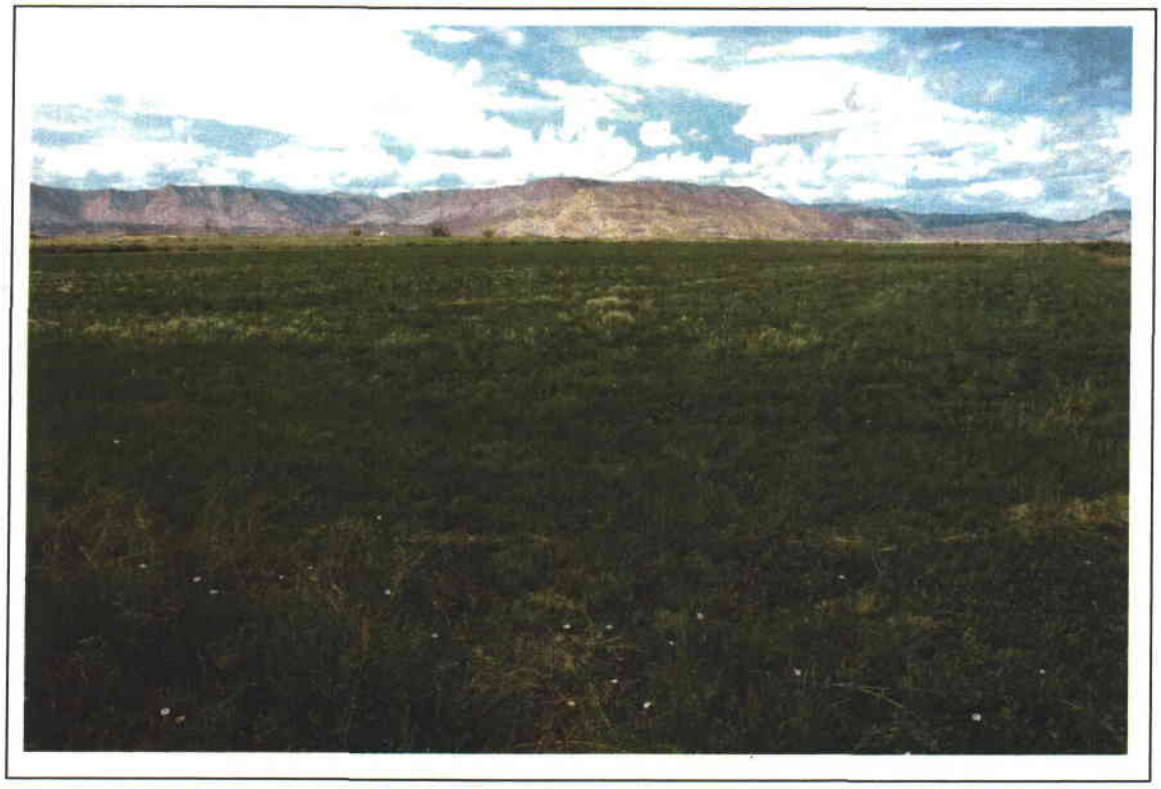

Photo 4: Pasture Land (Irrigated)

Photo 5: Pasture Land (Dry)

Photo 6: Pasture Land (Dry)

Photo 7: Pasture Land (Saltgrass Area)

Photo 8: Pasture Land (Willows, Sedges, Rushes, Saltgrass Areas)

VEGETATION & WILDLIFE MAPS
of the
FEDERAL LEASE IBC AREA

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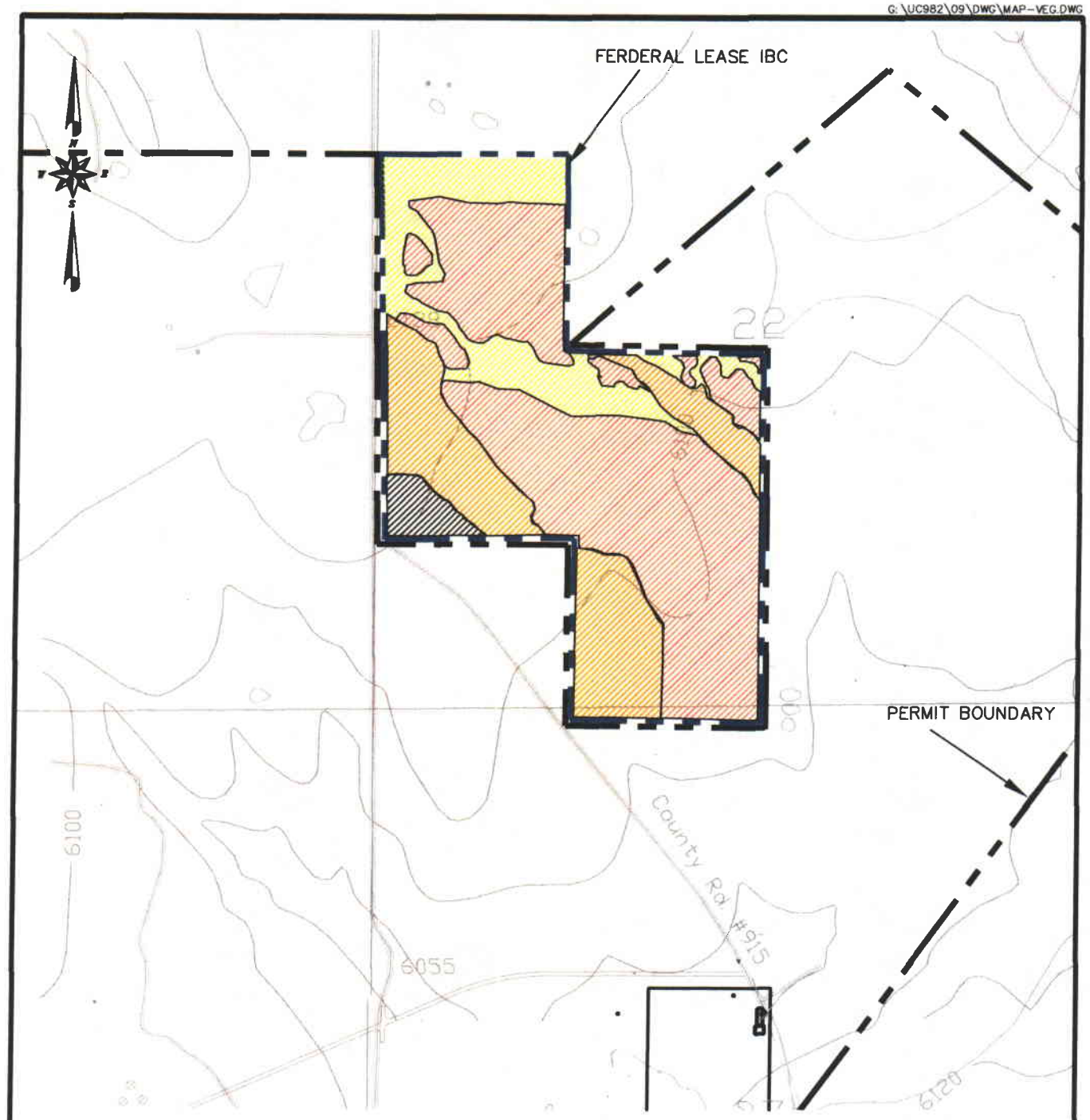

LEGEND

GREASEWOOD

PASTURE LAND (DRY)

PASTURE LAND (IRRIGATED)

SHADSCALE/WINTERFAT

0' 1000'

VEGETATION MAP OF THE FEDERAL LEASE IBC AREA

CONSOLIDATION COAL COMPANY

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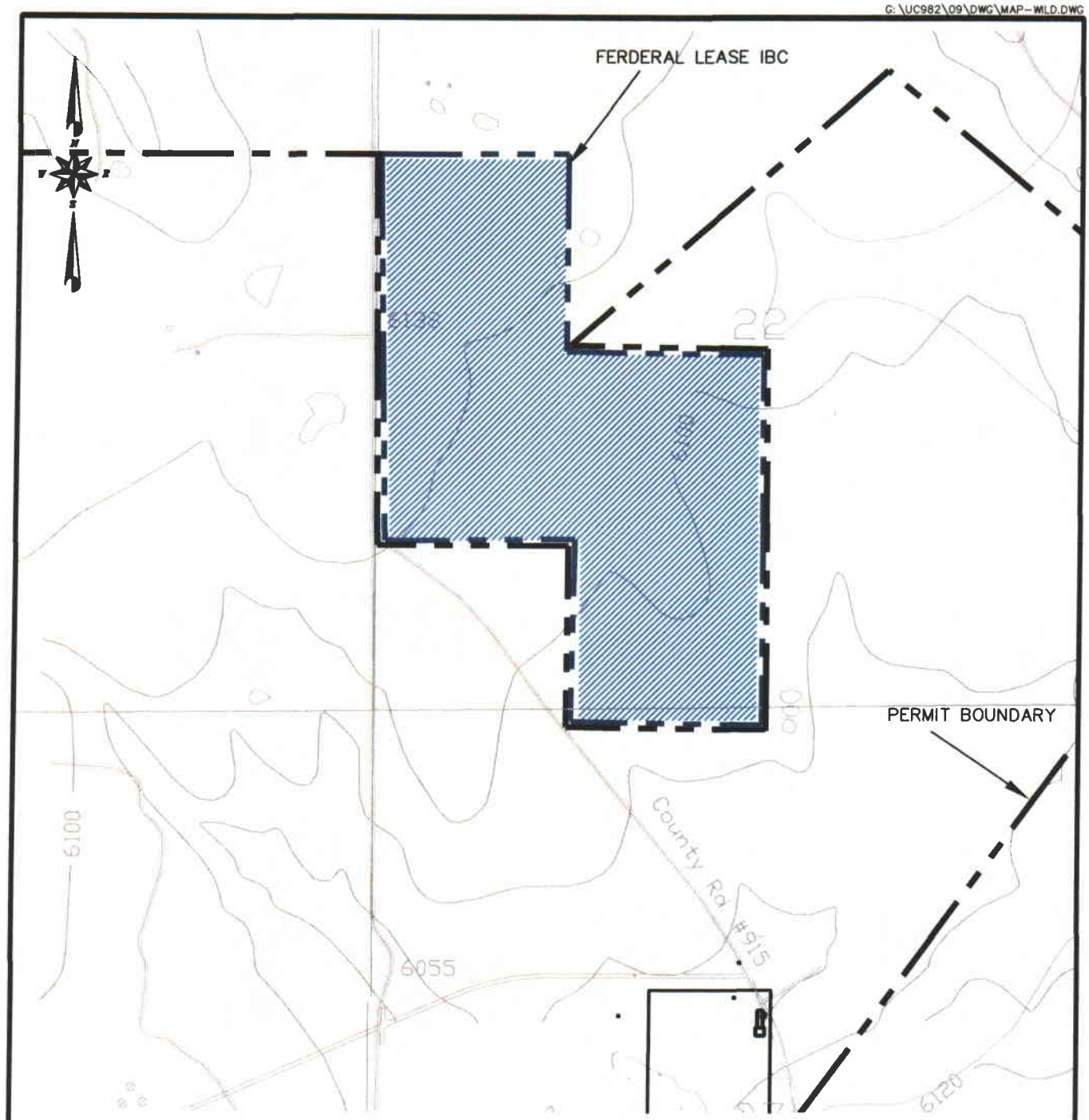

LEGEND

ROCKY MOUNTAIN ELK (HIGH VALUE WINTER HABIITAT)

FEDERAL LEASE BOUNDARY

PERMIT BOUNDARY

0' 1000'

WILDLIFE HABITAT MAP OF THE FEDERAL LEASE IBC AREA

CONSOLIDATION COAL COMPANY

☐ Confidential
☐ Shelf
☒ Expandable
Refer to Record No 0005 Date 2/13/2007
In C/0150015, 2007, Incoming
For additional information

APPENDIX XIII-3

Class 3 Cultural Resources Report

CONFIDENTIAL

This document has been placed in the confidential file of the Utah Division of Oil, Gas and Mining.

UMC 782.17

Underground operations at the Emery Mine is an ongoing situation which does not occur in phases. The extent of the underground workings over the life of the permit is shown on Plates IV-I and IV-2. The permit area encompasses approximately 5,~~408~~568 acres.

It is anticipated that mining activities will continue considerably beyond the five (5) year permit term. This will require renewals at the end of each term.

UMC 782.18, UMC 800.60

Appendix I-5 contains a copy of the insurance certificate, for the Emery Mine, covering personal injury and property damage.

Revised 8-31-95
Revised 4/05
Revised 9/06

The Emery mine pumps approximately 14~~937~~,000,000 gallons of water per year from the mine. The water that is used for dust suppression is accounted for in the ventilation calculation and the coal moisture consumption calculation. Portions of the water sprayed on the coal are either evaporated by the ventilation process, drain back into the mine drainage system, or is carried out in the product. The consumed volume is accounted for in the ventilation evaporation calculation and the coal moisture consumption calculation.

Mining consumption: See above explanation, and coal moisture consumption calculation

Ventilation consumption: See Ventilation evaporation calculation

Coal producing consumption: See coal moisture calculation

Ventilation evaporation: There is no data currently available to calculate the loss due to ventilation. With the fan returning approximately 218,000 CFM, this could evaporate approximately 25 ac-ft per year. This amount will vary based on the volume of air returned from the mine, the barometric conditions of the mine air and the barometric conditions of the outside air, as well as temperature of both.

Sediment pond evaporation: Water entering the sediment ponds is stored long enough to allow the accumulated sediment to drop out. The water is allowed to discharge into the receiving stream. This would not be considered a consumptive mechanism.

Springs and seep effects from subsidence: There have been no reports of seeps from subsidence.

Alluvial aquifer abstractions into mines: There are no water infiltrations from alluvial systems into the mine.

Alluvial well pumpage: There is zero pumpage from alluvial wells.

Deep aquifer pumpage: There is zero pumpage from deep aquifer wells.

Post mining inflow to old workings: There is zero post mining inflow to the old workings

Coal moisture consumption: The inherent moisture in the Emery coal is approximately 4 %. The as received moisture of the coal is approximately 6 %. The maximum Emery Mine production~~ed~~ could be 1,300,000~~243,153~~ tons of coal. ~~in 2003.~~ Using these values, the consumption was approximately 19.2~~3.6~~ ac-ft. ~~in 2002.~~

Direct diversion: There are no direct diversions at the Emery mine therefore zero consumption.

Adding the two approximate losses together equals 44.2~~26.6~~ ac-ft. The mine pumps and discharges approximately 14~~937~~,000,000 million gallons (45~~620~~ ac-ft) of water per year. Doing the math, you arrive at a 411.8~~394~~ ac.ft. per year enhancement to the Colorado River Basin. Water consumption by the Emery mine will not jeopardize the existence of or adversely modify the critical habitat of the Colorado River endangered fish species.

Inserted 5/05
Revised 2/07

The permittee is committed to develop an investigative study into past reclamation practices conducted at the Emery and Hidden Valley mine sites.

The scope of the investigation shall include but not limited to:

1. Evaluate current vegetation and soil chemistry of all topsoil and subsoil stockpiles. Past reclamation sites of disturbed land are to be included within the scope of study.

2. Based on findings from the study, plans shall be developed to enhance the vegetation of each site. The plan is to be reviewed with Division of Oil Gas and Mining (DOGM) prior to implementation of the plan. Period for implementing enhancement methods should be performed when warm season planting may be conducted.

3. The qualitative part of the study will be performed annually and the quantitative aspects be performed between the 4th and 6th year, following initial implementation of enhancement methods. The present reclamation methods shall be correlated with the historical weather information obtained from local sources~~on-site weather station~~.

4. Based on the follow-up study, a total reclamation plan shall be developed for the surface disturbed (bonded area) of the Emery mine site. The plan is to incorporate and utilize the best reclamation practices found through the previous investigative studies. A revegetation plan will be developed in conjunction with DOGM using the 2004 field visit data. In 2004 DOGM , Consol , Mt. Nebo scientific reviewed all field vegetation plots and decided which ones would be used for future data. collection. This revegetation plan will be compiled during 2007 and submitted with the 2007 annual report.

The permittee ~~shall~~ developed and submitted ~~for consultation~~ to DOGM, a detailed plan for the scope of study and methods to be used to conduct the investigation. The completed scope of study was~~shall be~~ submitted to DOGM by the end of March 2003.

All information obtained through all studies shall be submitted with the annual report.

Inserted 10/2002
Revised 2/07

CHAPTER IV ENGINEERING DESIGNS

IV.A UNDERGROUND MINE PLAN

This part covers the description of the underground mining operations to be conducted at the Emery Mine.

IV.A.1 UNDERGROUND MINE PLAN

UMC 783.12(a), 783.24(c),783.25(e), 783.25(h), 784.11(a), 784.23(a)

The permit area for the Emery Mine encompasses approximately 5,~~408~~568 acres. The boundary of the permit area is shown on the Permit Boundaries and Bonding map (Plate III-9). The description of the permit area is as follows:

Township 22 South, Range 6 East

Section 19: S/2NE/4, SE/4, E/2SW/4
Section 20: S/2NE/4, SE/4NW/4, S/2
Section 21: S/2N/2, S/2
Section 22: ~~SE/4, SW/4, SE/4NW/4, NE/4~~All
Section 23: SW/4NW/4, W/2SW/4
Section 27: W/2, NE/4
Section 28: All
Section 29: All
Section 30: E/2, E/2NW/4, SW/4NW/4, N/2NW/4SW/4, E/2SW/4
Section 31: N/2,W/2SW/4,E/2SE/4,SW/4SE/4
Section 32: All
Section 33: W/2NE/4

Mining operations at the Emery Mine are conducted in the IJ Zone utilizing the room and pillar mining method. Plate IV-1 shows the layout, the present mine workings and the projected areas to be mined during the permit term. The existing workings have been marked to show the extent of underground mining operations (1) before August 3, 1977, (2) between August 3, 1977 and May 3, 1978, and (3) after May 3, 1978 up to the permit approval date of January 5, 1986. There are no surface mining operations at the Emery Mine. The projected mine workings are delineated by year for the next five year permit term. Plate IV-2 shows the same plan on a 1"=1000' map to show the extent of the projected life of mine plan in the IJ Zone. The Emery Mine operates under the General Safety Orders, Utah Coal Mines issued by the Industrial Commission of Utah and the applicable regulations issued by the Mine Health and Safety Administration (MSHA).

Access to the underground workings is through the portals shown on Plate II-1. All of the present portals are drift openings at the outcrop of the seam. These openings consist of intake, return, and belt entries. It may be necessary in the future to install ventilation raises in other areas of the property; however, these locations are not known at the present time. Future portals may consist of ramp excavations and shafts to access the coal seam. The new 4 East portal will use a ramp excavation down to the top of the IJ seam. A new set of portals will be installed for the southern main entries of the mine when production from the southern part of the mine warrants it.

Revised 8-31-95
Revised 4/05
Revised 9/06

Development of the mine is accomplished with seven or eight entry mains with entries on 80 foot centers and crosscuts on 100 foot centers. The submains for panel development typically use a five entry system with similar entry centers. Panels are developed off the mains or submains with a four or five entry system with rooms driven on either side of the development entries. The Emery Mine ~~does not~~ uses a ~~maximum~~ partial extraction techniques~~, but instead uses a system of partial~~during secondary extraction (unplanned subsidence), which leaves the roof intact (see Chapter V Part B), ~~(~~except in areas designated as full extraction (planned subsidence) as depicted on Plate V-5~~the First South panel where full extraction will occur) which leaves the roof intact (see Chapter V Part B)~~.

During the term of this permit the planned production for the Emery Mine is 1.7 million tons per year. The mine will produce this coal with five continuous miner sections. Producing at this rate, the mine will continue operations until 2010 at which time the IJ Zone will be mined out. At that time final reclamation will begin as discussed in Chapter III.

4 EAST PORTAL

Site Description

The site is entirely within the surface area owned by Consolidation Coal Company. Coal ownership is also in Consolidation Coal Company's name.

Geology:

Drill hole FC 702, located on the site, was cored from the surface to below the IJ seam. It provides a detailed stratigraphic sequence and geochemical analyses to characterize the overburden to be stockpiled on the site. The following three pages show the lithology of the overburden and contain the geochemical test results on strata intervals. The portal excavation does not go any deeper than the top eleven (11) feet of the IJ seam.

Acid-Forming Potential:

Sulphur values (PS, SO4S, OS, and TS) are low throughout the strata. Moreover, pyritic sulphur, a potential acid former, is present in very low concentrations (less than 0.01 percent), so the acid-forming potential is quite small. As a result, acid production is not anticipated to be a problem within the proposed construction area.

Alkalinity-Forming Potential:

High pH and/or high SAR can cause piping, surface crusting, soil structure problems, and plant toxicities. The only samples with alkaline pH (8.1-8.3) occurred below the coal seams. Likewise the floor strata samples tested distinctly more sodic than the overburden. Since the excavation does not go this deep, alkaline material production is not anticipated.

Revised 8/05
Revised12/06

IV.A.3 MAXIMUM ECONOMIC RECOVERY

UMC 784.13(b)(6), 817.59

The mining operation at the Emery Mine maximizes the recovery of the IJ Zone while maintaining safety as a primary priority. The following criteria are used to determine the mineability of the coal:

1. The minimum required mining height is 5 feet.

2. Two feet of combined roof and floor coal is left. The shale under the coal has a high clay content making it susceptible to water requiring a minimum 1.5 feet of floor coal to be left in place to prevent floor heaving. In areas of shale top, top coal must be left to maintain roof stability.

3. The maximum mining height will be 10 feet from a safety standpoint to provide stable coal pillars (see Chapter V Part B).

The Emery Mine uses a partial extraction technique (unplanned subsidence) to maintain a stable top during secondary mining, except in areas designated as full extraction (planned subsidence) as depicted on Plate V-5.~~the First South panel, to maintain a stable top.~~ Partial and full pillar extraction plans for the mine are described in Chapter V, Section V.B.1. In those areas where protection must be given to prevent subsidence (see Chapter V Part B), no secondary mining will take place. By leaving larger pillars in these areas the surface should remain unaffected.

There are no coal seams above the IJ Zone that are considered mineable under the above mentioned criteria. Any future operations will take place in coal seams below the IJ Zone and will not be adversely affected by current mining operations in the IJ Zone.

Additional information related to recoverability of the other coal seams is in Appendix IV-I. This appendix deals with the maximum economic recovery of the coal in Federal Lease U-5287.

Revised 8/05
Revised12/06

The mining method used in most of the mine is room and pillar with partial pillar removal. Full extraction mining (planned subsidence) is proposed at Emery ~~only in the First South panel,~~ in areas designated as full extraction as noted on Plate V-5. As a result, any subsidence outside of ~~the First South panel~~ these areas would fall into the unplanned category. Figure 1 pg. 28 shows the partial pillar splitting diagram employed underground. This layout is the result of past experience as well as state and federal regulations pertaining to roof control and ventilation. All pillar splitting will be approved by MSHA. A pillar split diagram specific to full extraction is provided in Figure 2 (page 29).

Maximum subsidence at the Emery Mine will be approximately 50% of the extraction height. Given the current mining horizon this would relate to 3 feet of subsidence in areas of 6 foot extraction to 5 feet of subsidence in areas of 10 foot extraction. The predicted angle of draw will range from approximately 5 degrees at 150 feet of cover, 12 degrees at 350 feet of cover and 15 degrees at 750 feet of cover or greater. Please refer to Plate V-5 (Subsidence Monitoring Points and Buffer Zones) for estimated subsidence isopacs.

Consol intends to prevent subsidence from affecting Quitchupah Creek, Christiansen Wash and the alluvial valley floor area on the west side of the permit area (Refer to Plate V-5). There will be no full extraction within the designated buffer zones. An intermittently occupied dwelling in Section 30 will also be protected from subsidence. As of the date of this writing, a subsidence waiver has not been obtained on this dwelling. At such time as a waiver is obtained, the Division shall be notified and the buffer around this dwelling will be removed. Other than these features, the presubsidence survey, and our knowledge of the permit area confirms that there aren't any structures overlying present or future underground workings for which mitigation of subsidence effects would be overly difficult.

The three above noted features will be protected by establishing buffer zones which in turn are created by leaving coal pillars of adequate size beneath these areas. The dimensions of the buffer zone will be determined by the overburden depth and the angle of draw. With respect to Quitchupah Creek and Christiansen Wash, the buffer zone will include an additional standoff distance of 100 ft. on either side, as required by UMC 817.57. The pillar dimensions are based on established geotechnical information and a factor of safety for long term pillar stability. The partial pillar splitting design data can be found at CH V Page 28a, 28b, and 28c. A pillar split plan sketch can be found at CH V Page 28 and Figure V-1 on CH V Page 28d. As can be seen from the following design data this partial pillar splitting plan will not result in subsidence, and is considered unplanned subsidence per the MRP.

Replaced 12/04
Revised 1/05
Revised 8/05
Revised 2/07

A subsidence monitoring plan has been in place at Emery and contains the following features:

1. A series of reference points will be established outside the theoretical angle of draw for a particular area of mining.

1a. A mine representative will inspect monthly the surface area ~~overlying the~~ outlined on Plate V-5 as full extraction areas (planned subsidence) ~~1st and 2nd south when partial~~ pillar splitting begins and continue until the survey monitoring points below indicate that there is no subsidence. A record of this inspection will be kept at the mine office.

2. New reference points will be established as the area of mining increases to include old reference points.

3. Subsidence monitoring should, at a minimum, be established: a) at a point coincident to the geometric center of high extraction panels at least three months prior to mining activities beneath the station, and b) at periodic intervals over mains and sub mains at least three months prior mining activities beneath the stations.

4. New monitoring points established over partial pillar sections will be resurveyed within six months after final mining has taken place beneath them.

5. New monitoring points established over advancing sections such as mains and sub mains will be resurveyed within one year after mining has been completed beneath the station.

6. Monitoring points over partial pillar sections that have been resurveyed once and where no significant movement (".5') was found will be surveyed again within one year. If this subsequent survey shows no significant movement from the original survey, the point will be surveyed again at one year intervals. Points over advancing sections need not be resurveyed unless there has been evidence underground, (such as massive caving) that indicates subsidence may have taken place above them. If these sections have been abandoned, resurveys shall take place every two years.

   This program will remain in effect during the permit term (5 years), after which it will be reevaluated and modified if necessary to reflect the data collected to that point.

7. If a resurveyed point does demonstrate significant movement, the Division shall be notified of the survey discrepancies, and the point resurveyed at six-month intervals until no movement is indicated. Subsequent surveys will then take place as indicated in item 6.

8. When a new point is installed it shall be surveyed (the "Initial survey"), into a closed loop containing at least one "reference point", or any other point, (not located over high extraction areas) that is "linked" to a reference point, and has been surveyed within 6 months prior and no movement found. The initial survey should Consist of a horizontal traverse having a closure of at least 1:10,000 and a vertical traverse having a closure of at least 0.10 feet.

9. Resurveys of a point should consist of a vertical traverse having a closure of at least 0.50 feet. If significant movement is detected, (±.5'), a horizontal survey to that point will also be performed to check horizontal movement. The horizontal check survey may consist of a "side shot" where angles and distance are double checked, and need not be a closed traverse.

10. Monitoring points will consist of a concrete base and brass cap installed according to Figure V-8.

Plate V-5 shows the existing and future monitoring points for the permit area.

Consol will provide 3 copies of a subsidence monitoring report to DOGM within one month after completion of any subsidence monitoring field survey conducted pursuant to the approved subsidence control plan. Subsidence monitoring reports shall contain the following information:

1. Mine maps showing where pillars have been pulled and the month and year that such pillars were removed or partially removed.

2. Maps showing the location of survey monitoring stations and tension cracks and/or compression features visible on the surface.

2a. The subsidence monitoring points above the areas outlined on Plate V-5 as full extraction areas (planned subsidence)~~1st South panel~~ will have photographs recorded both pre subsidence and post subsidence.

3. The differential level and horizontal survey summary.

4. Brief narrative explaining any "significant movement" and any action the applicant has taken to mitigate the effects of such movement or any tension or compression features visible on the surface.

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Consol will meet the commitments made in response to UMC 784,20(c). In the past, Consol has both repaired subsidence effects and provided compensation through replacement of lost production This was done for an actively flood-irrigated field owned by J. Lewis in the SW1/4 of Section 29, T22S, R6E.

Consol will repair or replace any adversely affected State appropriated water supplies that are contaminated, diminished or interrupted.

A wetland mitigation plan will be implemented in areas where jurisdictional wetlands are identified in areas where planned subsidence is contemplated per CH V, Plate V-5 (Subsidence Monitoring Points and Buffer Zones). Prior to subsidence, Consol will invite representatives from Consol , DOGM and COE, to assess the existence of and possible impacts to wetlands as a result of the subsidence. This team will then formulate a wetland mitigation plan to mitigate for the impacts on a site by site approach.

A wildlife enhancement (or mitigation) plan will be implemented in areas where planned subsidence is contemplated per CH V, Plate V-5 (Subsidence Monitoring Points and Buffer Zones). Prior to subsidence Consol will invite representatives from Consol, DOGM, DWR and other biologists to assess the possible impacts to the biological resources as a result of the subsidence. This team will then formulate a wildlife enhancement plan to mitigate for the impacts on a species-by-species approach.

The landowner's wishes will be considered during the design of any mitigation plan and the plan will be discussed with the landowner prior to implementation. A good faith effort will be made to accommodate the landowner's wishes during both the design and construction phase of the mitigation plan. Permission will be obtained prior to entering onto areas which Consol has not obtained legal access and surface rights.

The timing of the implementation of a mitigation plan is influenced by several factors. Rather than establish an inflexible timetable to be used in all cases, it is preferable to establish a list of items to be considered on a case by case basis to arrive at a time table which maximizes the benefits of the mitigation plan for the landowner, maximizes the chances of a successful mitigation plan and minimizes inconvenience to the landowner both from the standpoint of needless repetitions of repair work and unnecessary delays in implementation of the mitigation plan.

Factors to be considered:

1. The effect of the subsidence on the landowner - In most cases it will be necessary to weigh the benefits of prompt mitigation against the inconveniences of needless repetition of mitigation. For instance, if subsidence should prevent flow through an irrigation ditch which is not scheduled for use again for 5 years, it would be preferable to wait on repair work until the construction season prior to when the ditch will next be used than inconvenience the landowner by per-forming repair work the year it is noticed and each year thereafter if subsidence should continue. However, if subsidence occurs which prevents flow through a ditch that is used each summer, then it will be necessary to repair the ditch as soon as practical even though future subsidence may necessitate further work.

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2. The effect of the weather on mitigation plans - In some cases, it may be practical to perform repair work in the winter or spring while in other cases it would not. For instance, it would probably not be practical to repair a road embankment, where compaction is critical, during winter weather. However it may be practical to repair a fence. Another example would be if it was necessary to remove and stockpile topsoil to perform mitigation work. It would be better to perform the work in the summer when the soil could be properly segregated than to try to do the work in the spring when conditions are normally muddy.
3. The effects of mitigation work on non-renewable resources -The best example of this situation is the case where it is necessary to regrade an area to mitigate the effects of subsidence. If it is necessary to remove the topsoil prior to regrading, it would be better to wait until all probable subsidence had occurred than to risk topsoil contamination through repeated removal and respreading of the topsoil should subsidence continue for several years. However in this case, it may be necessary to perform lesser or temporary mitigative work to minimize the effects of pending water on the soil resources or hazardous conditions for people, wildlife or livestock.

As discussed above, we do not believe it is possible to commit to a specific timetable for performing subsidence mitigation. However, when subsidence mitigation is required by applicable laws and regulations, mitigation will be performed as soon as practical taking into consideration the above items.

UMC 817.126

As described in the subsidence control plan, under UMC 784.20, the two (2) perennial streams in the permit area will be protected by buffer zones (Refer to Plate V-5). There are no impoundments of 20 acre-feet or more in the permit area.

Underground water rights described in Chapter VI, under UMC 784.14, show that the Town of Emery maintains two (2) wells developed in different aquifers within the Ferron Sandstone formation. These wells are used as a backup water source to the town's present water supply system which relies on surface water from Muddy Creek. Emery Town Well No. 1 is developed in the Lower Ferron aquifer, which lies well below current mining activities. Well No. 2 is developed in the Middle and Upper Ferron aquifers which are directly below and above the seam being mined. No adverse impacts to either well are anticipated since the wells are located about 3 to 4 miles from the mine and are up gradient within the regional ground water flow pattern. Static water level readings taken from wells maintained as part of the mine's ground water monitoring program also indicate that no disruption of the aquifers in the vicinity of the town's wells has occurred.

Underground operations at the Emery Mine are not conducted beneath or in close proximity to any public buildings, including churches, schools, hospitals, court houses, and government offices.

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CHAPTER VI

HYDROLOGY

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CHAPTER VI – HYDROLOGY

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VI.A.7 PROBABLE HYDROLOGIC CONSEQUENCES

This section addresses the probable hydrologic consequences of coal mining and reclamation operations in the mine permit and adjacent areas. Mitigating measures are discussed generally in this section and in detail elsewhere in Chapter VI of the MRP.

VI.A.7.1 Potential Impacts to Surface and Groundwater

The following potential impacts of coal mining on the quality and quantity of surface and groundwater flow within and adjacent to the Emery Mine permit area were evaluated:

- Contamination from acid- or toxic-forming materials;
- Increased sediment yield from disturbed areas;
- Impacts to groundwater availability;
- Impacts to surface water availability;
- Increased total dissolved solids concentrations in surface and groundwater;
- Flooding or streamflow alteration;
- Hydrocarbon contamination from above ground storage tanks or from the use of hydrocarbons in the permit area; and
- Contamination of surface water from coal spillage due to hauling operations.

These potential impacts are addressed in the following sections of this MRP.

VI.A.7.2 Baseline Hydrologic and Geologic Information

Baseline geologic information is presented in Chapter V of this MRP. Baseline hydrologic information is presented in Sections VI.A.1 through VI.A.3 of this MRP.

VI.A.7.3 PHC Determination

Potential impacts to the hydrologic balance are addressed below.

Contamination from Acid- or Toxic-Forming Materials. Information concerning acid-and toxic-forming materials in rock at the Emery Mine is presented in Sections V.A.4 through V.A.6 of the MRP. As noted, the pH of roof and floor materials ranges from 5.0 to 9.1, with the acid-base potential indicating a net base potential. The alkaline nature of the system is further indicated by the fact that the pH of groundwater in the area is typically in the range of 7.0 to 9.5 (see Section V.A.2.7).

Except near outcrops, the electrical conductivity of the rock is generally low. However, naturally-occurring sodium adsorption ratios and exchangeable sodium percentages of the rock are moderately high. As a result, sodium adsorption ratios calculated from the data presented in Table VI-9 suggest that groundwater discharged from the mine may have a low to medium sodium hazard if that water is used for irrigation without further treatment. Analyses of rock samples presented in Section V.A.4 indicate that concentrations of trace elements are generally sufficiently low that the rock can be considered non toxic-forming. Thus, with the exception of moderate sodium concentrations in some samples, analytical data obtained from the local rock and mine-water discharges indicate that no significant potential exists for the contamination of surface and groundwater in the permit and adjacent areas by acid- or toxic-forming materials.

Increased Sediment Yield from Disturbed Areas. Mining and reclamation at the Emery Mine has the potential to increase sediment concentrations in the surface waters downstream from disturbed areas. However, sediment-control measures such as sedimentation ponds, diversions, etc. have been installed to minimize this impact. These facilities have been designed to meet applicable regulatory requirements and are regularly inspected and maintained to ensure that they continue to meet those standards (see Section VI.B).

Information contained in the Utah Division of Oil, Gas and Mining water-quality database indicates that water has never discharged from the Emery sedimentation ponds, with over 500 no-flow observations recorded for these ponds. Thus, these sediment-control measures at the mine are effective at minimizing sediment yields to adjacent streams.

Impacts to Groundwater Availability. As noted previously in this chapter, coal at the Emery Mine occurs in the Ferron Sandstone Member of the Mancos Shale. For the purposes of this MRP, the Ferron Sandstone Member has been divided into three units (see Section VI.A.2): the upper Ferron Sandstone, Kmf(u); the middle Ferron Sandstone, Kmf(m); and the lower Ferron Sandstone, Kmf(l). In the upper Ferron, sandstones are lenticular, channel-shaped bodies that are generally less than 40 feet thick. These channel sandstones are characterized by unidirectional cross-stratification, fining-upward cycles, and lateral interfingering with mudstones. The middle and lower Ferron consists of thin-bedded sandstone and shale at the base that grade upward to thick, cliff-forming sandstones.

The Ferron Sandstone lies between and intertongues with marine shales in the Tununk and Blue Gate Members of the Mancos Shale. The Blue Gate Member unconformably overlies the Ferron and is composed primarily of gray bentonitic, calcareous shale. The Tununk Member is lithologically similar to the Blue Gate Member.

The Ferron Sandstone outcrops in a series of prominent cliffs along the eastern edge of the Emery coal field and dips 2 to 10° to the northwest beneath the ground surface. The continuity of the Ferron is broken in the subsurface by the Joes Valley-Paradise fault zone, which exists immediately northwest of the permit area. This fault zone extends for about 60 miles northeast and 20 miles southwest of the mine area[1]. A comparison of Plate VI-4 with Plates V-19 through V-22 indicates that the Emery Mine usually operates within the saturated zone, except along the outcrop to the east and where water levels have been locally altered due to mining activities.

Morrissey et al. (1980) indicate that recharge to the Ferron aquifer originates in the Wasatch Plateau west of the Emery Mine and discharges to the southeast along the Joes Valley-Paradise fault zone. Hence, this fault zone effectively acts as a linear source of groundwater recharge to the Ferron Sandstone. The contribution of precipitation to direct recharge of the Ferron Sandstone overlying the mine is probably small, since precipitation in this area is low (averaging about 8 inches annually) and the area is overlain by the relatively impermeable Blue Gate Member of the Mancos Shale. Currently, water is discharged from the Ferron aquifer in the region by mining operations, wells, leakage along streams, and springs.

Mining within the Emery Mine has locally changed the pattern of ground water flow near the mine, and part of the upper section of the Ferron Sandstone aquifer has experienced water-

[1] Hintze, L.F. 1980. Geologic Map of Utah. Utah Geological and Mineral Survey. Salt Lake City, Utah.

level declines (see Plate VI-4). As mining has progressed, the mine has intercepted more and more ground water and caused a cone of depression near the northwest corner of mined area.

Groundwater has the potential to enter the Emery Mine through both the floor and roof from permeable, saturated sandstones. Hydrographs of water-level data collected from monitoring wells at the mine (Figures VI-6 through VI-9) show that water level declines have been experienced in all three sections of the Ferron aquifer and also in the Blue Gate shale. However, the hydrographs indicate that the primary source of inflow to the mine is primarily from the upper Ferron aquifer (Kmf[u]). Significant upward leakage from the middle Ferron (Kmf[m]) is impeded by shales that constitute the floor of the mine. In-mine observations have verified that most inflow to the mine occurs from the roof rather than the floor.

As water flows into the mine, the flow pattern within the Ferron Sandstone aquifer is altered. These conditions in turn induce groundwater level declines in the area. Since the principal avenue of inflow to the mine is through the roof of the workings, the upper portion of the Ferron Sandstone is most subject to water level declines.

Average discharge from the Emery Mine during the period of 1979 through 2005 is shown in Figure VI-20A (see also Appendix VI-9). No data are available for the years prior to 1979. Discharge from the mine continued through a period of temporary shutdown (1991 through 2001) when Consol pumped water to maintain the mine in an accessible condition.

A mass balance approach was used to predict future groundwater inflow to and discharge from the mine. The water balance equation used for this analysis is:

Outflow = Inflow + Change in storage

Given the probable lack of substantial direct recharge from precipitation to the Ferron Sandstone in the mine area, subsurface inflow occurs predominantly from groundwater that flows from the Joes Valley-Paradise fault zone into the Ferron Sandstone and then toward the mine. Outflow occurs when groundwater is either pumped from the mine or used underground for various purposes (i.e., dust suppression, equipment cooling, etc.) and then removed from the mine as moisture in the coal or in the mine air.

Groundwater inflow to the mine occurs either horizontally (due to the mine being within the flow path) or vertically (due to gravity drainage from the overlying sandstone into the mine void). In a study by the U.S. Geological Survey of the Emery Mine area, Lines (1987)[2] found that "prior to mining, the vertical component of flow was upward from the Ferron into the Blue Gate Member. As mining progressed, ground-water flow was directed toward the mine workings, and much of the aquifer and other rocks above the mined coal bed were dewatered. The steady-state pattern of [predominantly horizontal] flow . . . probably would not develop unless mining ceased and dewatering of the mine continued for several years." These conditions are depicted on Figure VI-20B.

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[2] Lines, G.C. 1987. Ground-Water Study 11. pp. 365-396 *in* Ground-Water Information Manual: Coal Mine Permit Applications – Volume II. U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement. Available online at http://www.ott.wrcc.osmre.gov/library/hbmanual/grdh20info/OSM-GWInfoManual-II-11.pdf

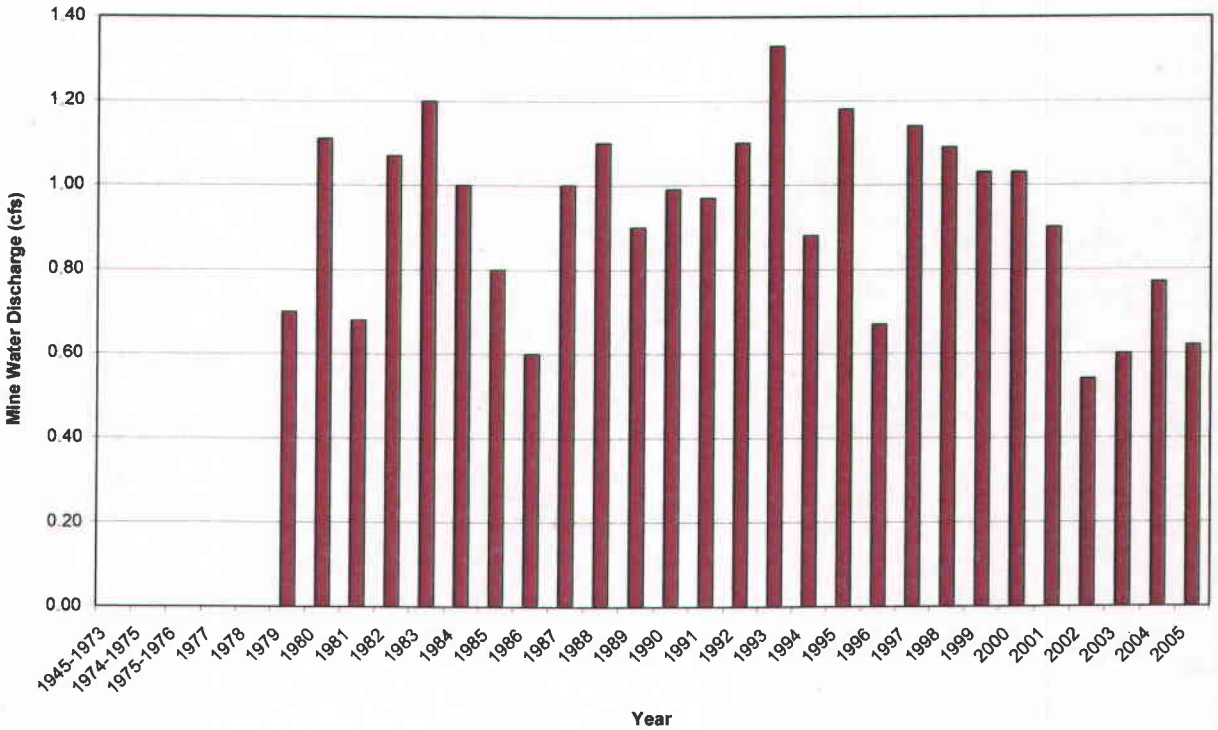

Figure VI-20A. Average Mine Water Discharge By Year

For the sake of this analysis, it was assumed that the steady state condition identified in Figure VI-20B(c) was reached during the several-year shutdown period of 1991 through 2001. Under this condition and assuming no substantial change in underground water storage in the mine during the shutdown, water discharged from the mine during this period would equal the amount of predominantly horizontal inflow to the mine. Data contained in Appendix VI-9 indicate that discharge from (and therefore horizontal inflow to) the mine during the shutdown period averaged 1.03 cfs. Since groundwater flows horizontally out of the Joes Valley-Paradise Fault Zone toward the mine, the amount of water flowing into the mine would be a function of the length of mine workings parallel (i.e., exposed) to the fault zone. During the period of temporary shutdown, this length was 2.17 miles (see Plate VI-6A), resulting in a ratio of horizontal inflow per unit length of mine exposed to the groundwater flow path of 0.47 cfs/mi. This value was used to predict future quantities of horizontal inflow to the mine as the mine expands.

Following the restart of mining in 2002, some groundwater encountered in the mine was used underground by the mining equipment. The quantity of water used underground was assumed to equal the difference between the mine-water discharge during the period of inactivity (1.03 cfs) and the mine-water discharge following the restart of mining (averaging 0.63 cfs from 2002 through 2005 – see Appendix VI-9). Hence, in-mine water usage averaged 0.40 cfs from 2002 through 2005. With an average annual mined area of 18.1 acres from 2002 to 2005 (see Plate VI-6A), in-mine water usage is estimated to be 0.022 cfs/acre under current operational conditions. This value was used to predict future quantities of in-mine water usage as the mine expands.

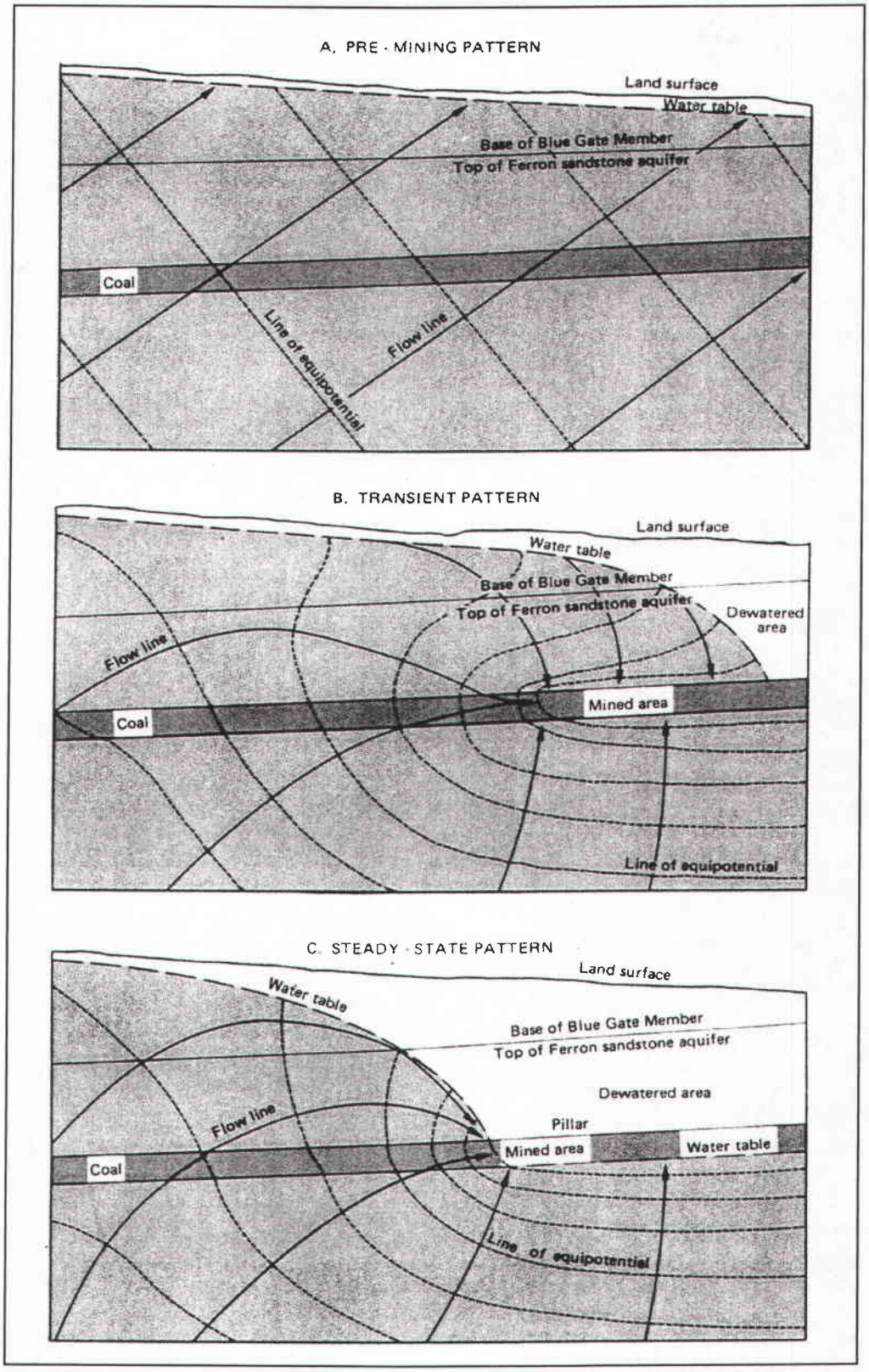

Figure VI-20B. Approximate Pre-mining, Transient, and Steady-state groundwater flow around the Emery Mine (from Lines, 1987)

Although vertical inflow to the mine is likely limited in areas that were mined prior to 1991 (due to the development of steady-state conditions noted in Figure VI-20B(c)), a condition more like Figure VI-20B(b) has probably existed in areas mined since 2002 (i.e., components of both vertical and horizontal inflow as the mine expands unto areas where the groundwater has not yet reached static equilibrium). Under these conditions, it was necessary to estimate the vertical component of inflow to the mine. This was accomplished using two analytical methods and then comparing the results to pre-1991 conditions to determine the method that most accurately predicts conditions at the mine site.

Each method is limited in its application to simplified flow situations, assuming that the aquifer is of infinite areal extent with uniform thickness. The first method used to estimate vertical mine-water inflow was the tunnel inflow equation presented by Freeze and Cherry (1979)[3]. This method assumes that the mine acts as an infinitely long tunnel in a homogeneous, isotropic porous medium. Under this assumption, the rate of ground water inflow Q_o per unit length of mine can be calculated using the following equation:

$$Q_o = \frac{2\pi K H_o}{2.3\log(2H_o / r)}$$

where r is the mine radius, H_o is the depth from the potentiometric surface to the center of the mine, and K is the hydraulic conductivity, with all units being compatible.

The second method used to estimate vertical mine-water inflow was the Hantush equation presented by Singh and Atkins (1985)[4]. This equation, which assumes that the aquifer is homogeneous, isotropic, and pumped at a constant rate, is applied to large underground openings as illustrated in Figure VI-20C. Inflow to the mine is calculated by:

$$Q = 2\pi TDG(\lambda, r/B)$$

$$\lambda = Tt / r^2 S$$

$$r/B = r(K'/KLL')^{\frac{1}{2}}$$

where B is the leakage factor; D is drawdown to a level H from the original head H_o; $G(\lambda, r/B)$ is the Hantush well function; K is the aquifer hydraulic conductivity; K' is the aquitard hydraulic conductivity; L is the thickness of the formation being dewatered; L' is the aquitard thickness, Q is the quantity of inflow; r is the radius at which drawdown occurs; and t is elapsed time, with all units being compatible.

Vertical inflow to the mine was estimated using the two methods described above for the period of 1980 through 1990 when Figure VI-20B(b) was again assumed to represent mine hydrologic conditions (i.e., prior to attaining steady-state conditions during the temporary shutdown). Assuming no change in water storage in the mine (i.e., discharge is equal to inflow), and accounting for lateral groundwater inflow and in-mine water usage as outlined above, these calculations were then compared with measured discharge rates during the same period.

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[3] Freeze, R.A. and J.A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

[4] Singh, R.N. and A.S. Atkins. 1985. Analytical Techniques for the Estimation of Mine Water Inflow. International Journal of Mining Engineering. Vol. 3, pp. 65-77.

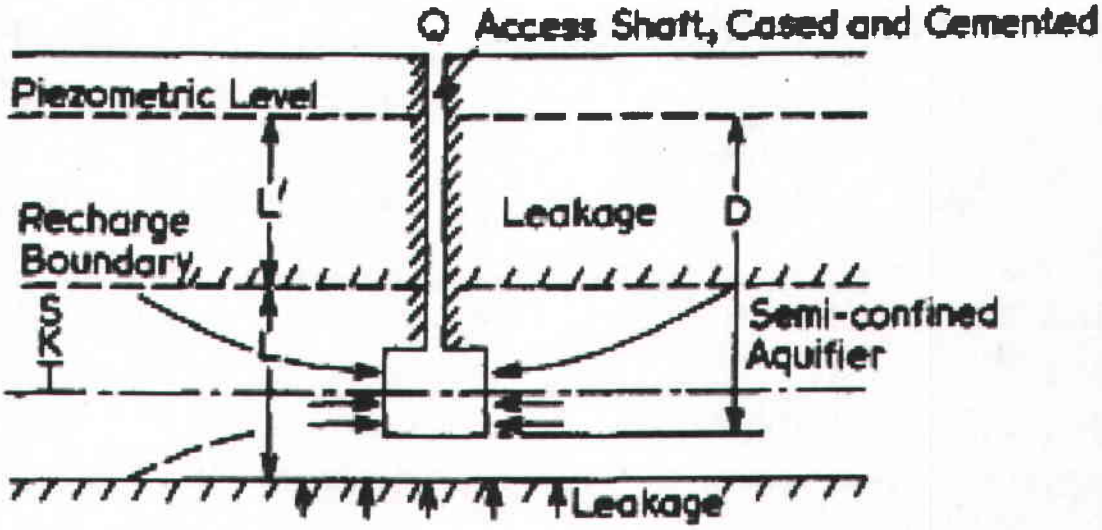

FIGURE VI-20C. Conceptual Hantush Flow Model (from Singh and Atkins, 1985).

Based on these calculations, the best approach for estimating future conditions was selected.

Preliminary calculations using the two methods indicated that the Hantush equation was a much better predictor of vertical mine-water inflow than was the tunnel inflow equation. To more accurately predict inflow, the average hydraulic conductivity of the aquifer was therefore derived by calibration using the Hantush equation, attempting to mimic measured discharge rates as closely as possible. The average hydraulic conductivity of the Ferron Sandstone overlying the coal seam was thereby determined to be 0.20 ft/day. This value compares well with aquifer data presented previously in this chapter and independent data presented by Lines et al. (1983).[5] Assuming an aquifer thickness of 400 feet (based on a review of Plate V-20), the transmissivity data presented in Table VI-4 of this MRP convert to hydraulic conductivities ranging from 0.01 to 1.9 ft/day and averaging 0.9 ft/day. Laboratory hydraulic conductivity data provided by Lines et al. (1983) ranged from 2.6×10^{-6} to 0.77 ft/day, averaging 0.11 ft/day in the horizontal direction and 0.076 ft/day in the vertical direction. Hydraulic conductivities derived from field tests summarized by Lines et al. (1983) ranged from 0.025 to 2.0 ft/day, averaging 0.55 ft/day (again assuming an aquifer thickness of 400 feet).

Results of the mine-water inflow/discharge calculations for the period of 1980 through 1990, using the Hantush and tunnel inflow equations, are summarized in Table VI-23A and detailed in Appendix VI-9. Each set of calculations accounted for lateral groundwater inflow and in-mine water usage, and assumed that no change in underground water storage occurred (i.e., that discharge was equal to inflow). The equations were able to account for less inflow as the mine expanded since vertical inflow was assumed to enter the mine only in the area of current mining. As indicated in Table VI-23A and Figure VI-20D, the Hantush equation provides a

[5] Lines, G.C., D.J. Morrisey, T.A. Ryder, and R.H. Fuller. 1983. Hydrology of the Ferron Sandstone Aquifer and Effects of Proposed Surface-Coal Mining in Castle Valley, Utah. U.S. Geological Survey Water-Supply Paper 2195. Alexandria, Virginia.

reasonable estimate of mine water discharge. Hence, this equation was used to predict future mine-water discharge rates.

Table VI-23A. Estimated mine-water discharge rates using two analytical methods

Year	Mine-Water Discharge Rate (cfs)		
	Measured discharge	Hantush inflow equation	Tunnel inflow equation
1980	1.11	1.05	11.38
1981	0.68	0.96	1.38
1982	1.07	1.04	7.42
1983	1.20	1.08	1.98
1984	1.00	0.98	2.13
1985	0.80	0.66	7.60
1986	0.60	0.79	1.67
1987	1.00	1.09	2.95
1988	1.10	1.03	7.13
1989	0.90	0.95	12.10
1990	0.99	1.07	2.47
Average	0.95	0.97	5.29

Predicted mine-water inflow/discharge rates through the period of the current mine plan (2013) are summarized in Table VI-23B, based on the Hantush equation and accounting for mine-water inflow and usage as described above. These calculations again assume that no substantial change in underground water storage will occur during the period of evaluation (i.e., discharge is equal to inflow). Spreadsheets detailing these calculations are provided in Appendix VI-9. Based on these calculations, discharge rates are expected to average 1.50 cfs, ranging from about 1.2 to 2.0 cfs during the calculation period. Variations in discharge rates are anticipated depending on the depth of mining below the potentiometric surface and the area over which mining will occur. These estimates are based on the assumed hydraulic conductivity of 0.20 ft/day (i.e., the calibrated value arrived at in the comparison with measured historic discharge rates). Since pillars had been pulled prior to the 1991 temporary shutdown, this hydraulic conductivity is assumed to be representative of average post-subsidence conditions. Hence, the estimates presented in Table VI-23B assume full extraction of the coal.

Inflow of water to and discharge of water from the mine will continue to influence the shape of the potentiometric surface in the vicinity of the mine. As a result, it is anticipated that the cone of depression noted on Plate VI-4 will change as mining continues. Consol is currently modeling groundwater in the permit and adjacent areas, using the software package MODFLOW, to predict future water-level declines due to mining. The results of this modeling effort will be provided to UDOGM when available.

It is anticipated that the modeling effort will predict future groundwater conditions similar to those that have been measured in the past within the permit and adjacent areas. Figure VI-6 of the approved MRP provides hydrographs of water-level data collected from monitoring wells completed within the Emery Mine permit area in the Bluegate Shale. As indicated, no declines

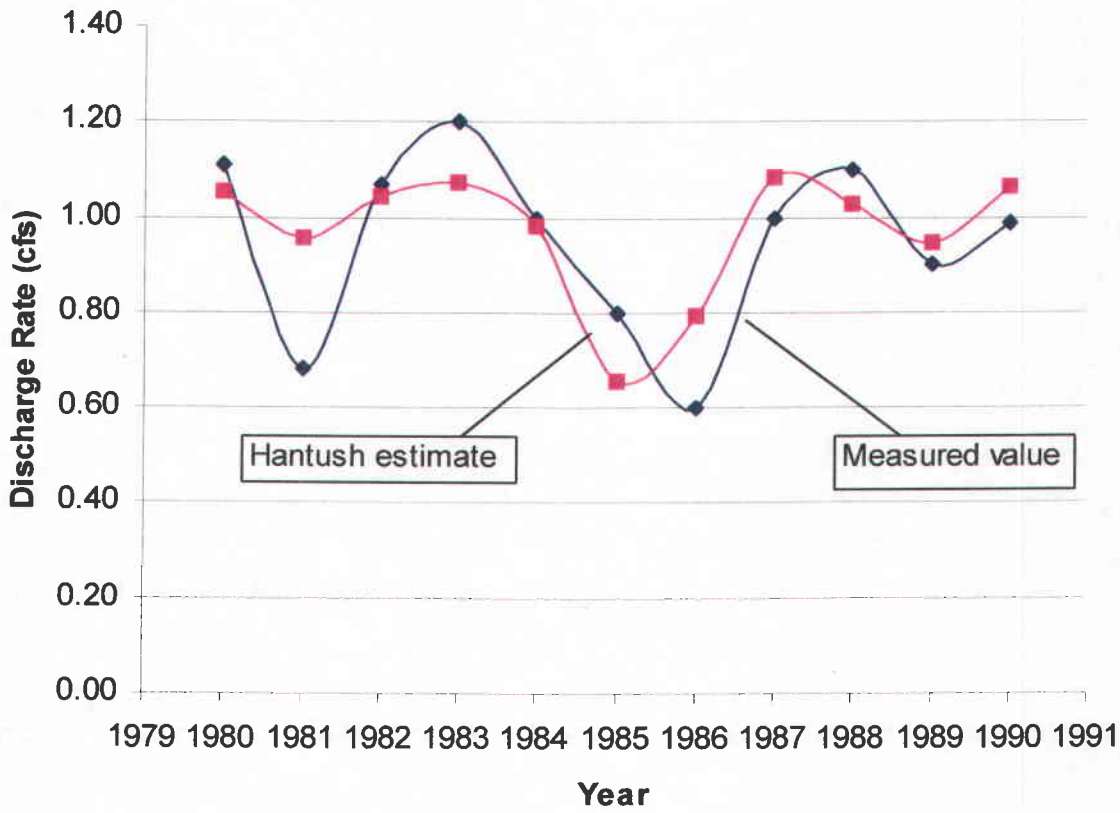

Figure VI-20D. Comparison of measured and calculated mine discharge data (Hantush equation)

Table VI-23B. Predicted mine water discharge rates

Year	Predicted Discharge (cfs)
2006	1.29
2007	1.19
2008	1.33
2009	1.77
2010	1.28
2011	1.52
2012	1.63
2013	1.98
Average	1.50

in water levels occurred during the period of record presented in that figure. In contrast, hydrographs that were prepared using data collected from wells completed in the upper Ferron Sandstone (Figure VI-7 of the approved MRP) show declines in groundwater levels during the period of record. Similar conditions are expected in the future (i.e., no substantial influence on groundwater levels in the Bluegate Shale but declining water levels in the upper Ferron Sandstone). Based on prior data presented in Section VI.A.2.4 of the MRP, gradual declines in groundwater levels may be experienced in the middle Ferron Sandstone in the future, while no substantial changes in water levels would be anticipated in the lower Ferron Sandstone.

Impacts to Surface Water Availability. Water removed from the mine will be discharged to Quitchupah Creek, increasing the flow of this receiving stream. Only limited streamflow data are available for Quitchupah Creek, with the U.S. Geological Survey maintaining a gaging station near the mine office from July 1978 through September 1981. The average annual flow of Quitchupah Creek at this location for the three complete water years of record was 8.43 cfs, ranging from 6.73 to 10.8 cfs (data obtained from http://waterdata.usgs.gov/nwis). As indicated in Table VI-23B, mine-water discharge rates are expected to average 1.50 cfs through 2013. This represents an 18% increase in the above-noted average annual flow of Quitchupah Creek.

As noted above, no water has been observed to discharge from the Emery Mine sedimentation ponds. Hence, a small quantity of runoff is precluded from reaching Quitchupah Creek that would discharge to this stream if the mine surface facilities were not present. Given the small amount of precipitation in the area and the relatively small area of the surface facilities, this reduction in the streamflow of Quitchupah Creek is likely minimal. Thus, the net effect of mining on the availability of surface water in the immediate area is an increase in the flow of Quitchupah Creek and downstream waters.

It should be noted that the discharge of mine water to Quitchupah Creek probably results only in a local increase in flow and not a basin-wide increase. As discussed above, the coal being mined at this location occurs in the Ferron Sandstone Member of the Mancos Shale, which is underlain by the Tununk Shale member of the same formation. The shales of this formation have a low permeability[6], thus forcing groundwater to the surface as streamflow. As a result, although the discharge of water from the mine results in a local loss of groundwater and gain in surface water, this discharge does not disrupt the hydrologic balance of the basin.

Given this condition, the only actual loss of groundwater from the hydrologic balance is that water which is contained in the coal and leaves the basin upon mining or is discharged from the mine in the ventilation air. These quantities are estimated in Section II.C, subsection UMC 817.97 of this MRP.

Increased Total Dissolved Solids Concentrations in Surface and Groundwater. Data summarized in Table VI-9 of this MRP indicate that the average TDS concentration of water entering the mine (as measured in roof samples) is 1025 mg/l. Assuming that the equivalent-weight bicarbonate concentration can be calculated by balancing the anions and cations in that table, the roof inflow is a sodium-bicarbonate water with an average sulfate concentration of 264 mg/l. The average TDS concentration of water discharging from the mine to Quitchupah Creek

[6] Waddell, K.M., P.K. Contrato, C.T. Sumsion, and J.R. Butler. 1981. Hydrologic Reconnaissance of the Wasatch Plateau-Book Cliffs Coal-Fields Area, Utah. U.S. Geological Survey Water-Supply Paper 2068. Washington, D.C.

(as measured at Ponds 1 and 6 and reported in Table VI-9) is 2390 mg/l. This is a sodium-sulfate water with an average sulfate concentration of 1340 mg/l.

These data indicate that the TDS concentration of water flowing through the mine increases by a factor of approximately 2.3. The sulfate concentration of this water increases by a factor of about 5.1. Furthermore, the ratio of calcium to sodium increases as the water flows through the mine. This increase in TDS and sulfate concentrations is probably the result of dissolution of rock dust used in the mine.

The impact of the TDS and sulfate concentration increases on surface-water resources in the permit and adjacent areas is considered minimal for two reasons. First, surface water in the permit and adjacent areas has been classified in the Utah Division of Water Quality *Standards of Quality for Waters of the State* (R317-2) as Class 2B (protected for secondary contact recreation such as boating, wading, or similar uses), Class 3C (protected for non-game fish and other aquatic life, including the necessary aquatic organisms in their food chain), and Class 4 water (protected for agricultural uses including irrigation of crops and stock watering). No sulfate discharge standard exists for any of these three classifications. The TDS standard for Quitchupah Creek is 2600 mg/l, which is greater than the average concentration presented above. Consol operates under a UPDES discharge permit issued by the Utah Division of Water Quality and controls discharges from the mine to be consistent with that permit.

Second, except where overlain by a thin veneer of alluvial deposits, surface water in Quitchupah Creek flows across the Tununk Member of the Mancos Shale immediately downstream from the mine permit area. Since this member is a gypsiferous formation, sulfate and TDS concentrations increase naturally in surface water that flows across areas underlain by this unit. Thus, the additional input of these constituents from the mine waters to local streams is considered minimal.

A TMDL study of the Muddy Creek watershed[7] (of which Quitchupah Creek is a tributary) indicated that Muddy Creek and its major tributaries (including Quitchupah Creek) would not support an agricultural beneficial use classification. This lack of beneficial-use support occurs at the location where these streams cross State Highway 10 (i.e., upstream from the mine water discharge point). The study concluded that elevated TDS concentrations in areas downstream from Highway 10 are caused predominantly by changes in surficial geology (i.e., outcropping of the saline Mancos Shale) and irrigated agriculture (i.e., return flows).

According to the U.S. Bureau of Reclamation[8], the salt load from the Muddy Creek watershed averages 86,000 tons/yr. The Emery Mine UPDES permit currently allows a maximum salt load of 12 tons/day to be discharged from the mine. Assuming that this load is discharged constantly throughout the year, the annual salt load from the mine to the Muddy Creek watershed would be 4380 tons/yr (about 5% of the basin-wide salt load). The UPDES permit indicates that the salt-load limit will change to 3839 tons/yr (rather than 12 tons/day) following EPA approval of the TMDL loading limit. Once this new limit is adopted, the salt load from the Emery mine will represent about 4.5% of the annual salt load of the Muddy Creek watershed.

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[7] MFG, Inc. 2004. Price River, San Rafael River, and Muddy Creek TMDLs for Total Dissolved Solids, West Colorado Watershed Management Unit, Utah. Report prepared for the Utah Division of Water Quality. Fort Collins, Colorado.

[8] U.S. Bureau of reclamation. 2003. Quality of Water, Colorado River Basin. Progress Report No. 21. Washington, D.C.

As indicated in Section VI.A.4, no surface-water rights exist on Quitchupah Creek downstream from the mine-water discharge point, nor do they exist on Ivie creek between the confluence of Quitchupah Creek and Muddy Creek. Hence, no substantial water-quality impact to downstream water users is anticipated.

In the post-mining situation, there is a potential for water-quality degradation within the upper Ferron as groundwater flows through previously mined areas and then into adjacent un-mined rock. However, it is expected that this condition will be tempered by the dilution effect of better-quality recharge water entering the area from the west. As far as the middle and lower Ferron are concerned, a fairly uniform shale floor impedes downward seepage of mine water to lower zones. Thus, groundwater quality in these lower sections of the Ferron should not be substantially affected either during or after mining.

Flooding or Streamflow Alteration. Runoff from all disturbed areas flows through sedimentation ponds or other sediment-control devices prior to discharge to adjacent undisturbed drainages. Three factors indicate that these sediment-control devices minimize or preclude flooding impacts to downstream areas as a result of mining operations:

1. The sediment-control facilities have been designed and constructed to be geotechnically stable. Thus, no substantial potential exists for breaches of the sediment-control devices to occur that could cause downstream flooding.
2. These sediment-control devices are sized sufficiently that no discharges have been recorded. This precludes flooding impacts to downstream areas.
3. By retaining sediment on site in the sediment-control devices, the bottom elevations of stream channels downstream from the disturbed areas are not artificially raised. Thus, the hydraulic capacity of the streams channels is not altered and flooding potential is further precluded.

Following reclamation, stream channels will be returned to a stable state. The reclamation channels have been designed in accordance with the requirements of UDOGM. Thus, flooding in the reclaimed areas will be precluded. Interim sediment-control measures and maintenance of the reclaimed areas during the post-mining period will preclude deposition of significant amounts of sediment in downstream channels following reclamation, thus maintaining the hydraulic capacity of the channels and further precluding adverse flooding impacts.

The mine has been designed to preclude subsidence in areas occupied by perennial streams (see Section 5.2.5.1). Thus, no alteration of perennial streamflow is anticipated.

Subsidence will occur in areas occupied by ephemeral stream channels. Although surface cracks that result from subsidence in the permit area are expected to heal with time in areas overlain by unconsolidated deposits and the Bluegate Member of the Mancos Shale, ephemeral stream flows may be partially intercepted prior to completion of the healing process. In addition, the broad depressions created by subsidence may locally retain runoff that would normally discharge from an area. However, the following factors indicate that the impact of subsidence on ephemeral streamflow will be minimal:

1. Ephemeral streamflow in the area is sporadic, allowing significant periods of time for surface cracks to heal between flow events.

2. Ephemeral streamflow typically carries a high sediment load. This sediment will fill remaining cracks. As the cracks heal, the potential for interception of streamflow is minimized.
3. The depressions created by subsidence are sufficiently broad that changes in slope are not typically of an ample magnitude to cause ponding in anything other than local areas.

Potential Hydrocarbon Contamination. Diesel fuel, oils, greases, and other hydrocarbon products are stored and used at the site for a variety of purposes. Diesel and oil stored in above-ground tanks at the mine surface facilities may spill onto the ground during filling of the storage tank, leakage of the storage tank, or filling of the vehicle tank. Similarly, greases and other oils may be spilled during use in surface and underground operations.

The probable future extent of the contamination caused by diesel and oil spillage is expected to be small for three reasons. First, because the tanks are located above ground, leakage from the tanks can be readily detected and repaired. Second, spillage during filling of the storage or vehicle tanks is minimized to avoid loss of an economically valuable product. Finally, the mine has a Spill Prevention Control and Countermeasure Plan that provides inspection, training, and operation measures to minimize the extent of contamination resulting from the use of hydrocarbons at the site.

Coal Spillage During Hauling. Coal is hauled over access road from the mine to State Highway 10 and future destinations. Past experience has indicated that no substantial quantities of coal have been spilled during transport. If coal is spilled, it may wash into local streams during a runoff event prior to cleanup. Possible impacts to the surface water include increases in total suspended solids and turbidity from the fine coal particulates. The probability of a spill occurring in an area sufficiently close to a stream channel to introduce coal to the stream bed is extremely small.

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DEFINITIONS:

E	A taxon that is listed by the U.S. Fish and Wildlife Service as "endangered with the possibility of worldwide extinction.
E Experimental	An "endangered" taxon that is considered by the U.S. Fish and Wildlife Service to be experimental and non-essential in their designated use areas in Utah.
E or T Extirpated	An "endangered" or "threatened" taxon that is "extirpated" and considered by the U.S. Fish and Wildlife Service to no longer occur in Utah.
E or T Proposed	A taxon that is listed by the U.S. Fish and Wildlife Service as "threatened" with becoming endangered.
C	A taxon for which the U.S. Fish and Wildlife Service ahs on file sufficient information on biological vulnerability and threats to justify it being a "candidate" for listing as endangered or threatened.

A burrowing owl survey will be conducted prior to full extraction mining in areas where planned subsidence is contemplated per CH V, Plate V-5 (Subsidence Monitoring Points and Buffer Zones). Appropriate burrowing owl survey protocols will be employed. The study will be conducted at the most suitable time of year, or between April 15 and July 15 during peak breeding season. First, the suitable habitat (in this case the prairie dog towns) will walked to determine whether or not the burrows are active. 'Active' means if they were used by prairie dogs, owls or other animals such as rabbits. Once it was ascertained that the site may be active, observation areas will be chosen that provide the best views of the burrow areas to survey for the presence of the owls.

This study will concentrate on the prairie dog towns located within the angle of draw of the particular study area. The survey will consist of site visits on four separate days. The visits will be planned for two morning and two evening surveys. The morning surveys were conducted from one hour before sunrise until two hours after (or from 6 am to 9 am), whereas the evening surveys will be conducted from two hours before sunset until one hour after (or from 6 pm to 9 pm) at an observation station far enough away from the town, but close enough to observe burrowing owls using high magnification field scopes.

All appropriate parameters and data will recorded on data sheets during the field survey. These data sheets have been included in a final report that will be submitted to the State of Utah, Division of Oil, Gas & Mining.

Revised 2/07