BOOK CLIFFS AREA V
CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

For

HORSE CANYON MINE
LILA CANYON MINE APPLICATION AREA
BOOK CLIFFS MINE

C/007/0013

In

CARBON AND EMERY COUNTIES, UTAH

April 30, 2007
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I. INTRODUCTION

It is the job of the Division to assess the potential for mining impacts, on and off the permit area, in accordance with the Utah Coal Mining Rules. Reviewing the Permittee’s application alone is not sufficient to assess impacts to the geologic and hydrologic regimes. Specific knowledge of the geologic mechanics and hydrologic functions is crucial in assessing the dynamics and interactions of chemistry, movement of surface and ground waters, and any associated subsidence impacts to a minesite. The Division uses pertinent information from many sources, e.g. geological and hydrological reports, texts, site visits, and a knowledge base built on experience and training.

The Book Cliffs V Cumulative Impact Area (CIA) is located in Carbon County, Utah, south of the town of Sunnyside (Plate 1). There are currently no active mines within the Book Cliffs V CIA. The Division refers to the existing Horse Canyon Mine’s Mining and Reclamation Plan (MRP) as the MRP-Part A, and the proposed Lila Canyon Mine Area (LCMA) application as the MRP-Part B.

The Horse Canyon Mine was previously called the Geneva Mine. It is referenced as such in many of the older reports and in the Horse Canyon Mine MRP. The Horse Canyon Mine and the LCMA are located approximately 30 miles southeast of Price, Utah in the Book Cliffs Coal Field (Plate 1). In and adjacent to the CIA, the Book and Roan Cliffs form a set of rugged escarpments (Figure 1) that face south and southwest along the edge of the West Tavaputs (or Roan) Plateau, which separates the Uinta Basin from the Price River Basin.

The CHIA is not only a determination if coal mining operations are designed to prevent material damage beyond their respective permit boundaries when considered individually, but also if there will be material damage resulting from effects that may be acceptable when each operation is considered individually, but are unacceptable when the cumulative impact is assessed. Currently, the only anticipated coal-mining operation in the CIA is the LCMA, but coal in what has been identified as the South Block could be leased and mined in the future (Plate 2).

“Renewable Resource Lands” means: an aquifers and areas for the recharge of aquifers and other underground waters, areas for agricultural or silvicultural production of food and fiber, and grazing lands. For the purposes of R645-103, Renewable Resources Lands means: geographic areas that contribute significantly to the long-range productivity of water supply or of food or fiber products, such lands to include aquifers and aquifer recharge areas. In the LCMA, renewable resources consist of ground water, grazing, timber, and water supply. Subsidence from underground coal mines can affect renewable resource lands through formation of fissures that intercept surface waters and drain near-surface soil moisture away from the root zone; alterations in ground slope and destabilization of critical slopes and cliffs; connection of previously separated aquifers and reduction in flows of seeps and springs; and emissions of methane originating from the coal seam through open fissures to the surface or at the base of the surficial soil with known deleterious effects on woody plants (MRP-Part B, 525.120).
“Regional aquifer” is a common phrase used by mining operators in the Carbon and Emery County coalfields. In such usage, “regional aquifer” usually refers to ground water found in the Star Point Sandstone and Blackhawk Formation irrespective of quality, quantity, use, storage, flow and transport, and discharge. (The Star Point Sandstone, which is absent south of Soldier Canyon, and Blackhawk Formation are part of the Mesaverde Group.) In some cases "regional aquifer" is a viable term, where water resources emanate from these geologic units and are readily used for a specific purpose. Regional flow systems are recharged along basin divides and transport water to valley bottoms, passing beneath local and intermediate flow systems; discharge at springs is fairly constant, with elevated water temperatures and TDS (Fetter, 1988). The Division has adhered to the definition of "aquifer" as found in the R645-100-200. There are saturated strata within the Blackhawk Formation and Star Point Sandstone and a few seeps and springs flow from local systems in these strata along the length of the Book Cliffs, but after evaluating the geologic and hydrologic evidence, the Division does not consider the saturated strata in the Blackhawk Formation and associated formations in the Horse Canyon Mine and Lila Canyon Extension permit area and adjacent areas to be a regional aquifer. Except if truly appropriate, the term "regional aquifer" has been deliberately avoided throughout this CHIA.
This CHIA finding complies with the federal Surface Mining Control and Reclamation Act of 1977 (SMCRA) and subsequent federal regulatory programs under 30 CFR 784.14(f), and with Utah regulatory programs established under Utah Code Annotated 40-10-et seq. and the attendant state R645 Rules.

The objective of a CHIA document is to:

1. Identify the Cumulative Impact Area (CIA).  
2. Describe the hydrologic system – including geology, identify hydrologic resources and uses, and document baseline conditions of surface and ground-water quality and quantity.  
3. Identify hydrologic concerns.  
4. Identify relevant standards against which predicted impacts can be compared.  
5. Estimate probable future impacts of mining activity with respect to the parameters identified in 4.  
6. Assess probable material damage.  
7. Make a statement of findings

A CHIA was prepared in 1991 for the Horse Canyon Mine, which at that time was permitted by Intermountain Power Agency (IPA).

The disturbed area for the Horse Canyon Mine is approximately 74.26 acres and has been partially reclaimed since 1986 (Table 1). The Utah Division of Oil, Gas and Mining (the Division) approved Phase I bond release on 51.56 acres in 1997, and Phase II bond release in April 2002. A 6.5-acre borrow site was reclaimed in 1991, but it was not included in the bond release so that additional fill material could be removed if needed. A small area around the bridge abutments (0.02 acre) was determined to be part of the right-of-way for the county road and not subject to reclamation by the mine operator.

On February 25, 2004 the Division gave final approval to a change in post-mining land use (PMLU) on the 16.18 unreclaimed acres. There is no further reclamation required on the 16.18 acres because of the change in PMLU.
Table 1. Disturbed Acreage, Horse Canyon Mine

<table>
<thead>
<tr>
<th>Description</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase II bond release</td>
<td>51.56</td>
</tr>
<tr>
<td>Bridge abutments</td>
<td>0.02</td>
</tr>
<tr>
<td>Borrow area</td>
<td>6.50</td>
</tr>
<tr>
<td>Sedimentation pond #2</td>
<td>1.44</td>
</tr>
<tr>
<td>Facilities area</td>
<td>10.80</td>
</tr>
<tr>
<td>Manway Portal area</td>
<td>2.83</td>
</tr>
<tr>
<td>Magazine area and road</td>
<td>0.57</td>
</tr>
<tr>
<td>Water tank area</td>
<td>0.54</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>74.26 acres</strong></td>
</tr>
</tbody>
</table>

In October 2005 the Permittee donated 896.13 acres to the College of Eastern Utah (CEU) for use as a science field camp for Utah universities. This included the 51.56 acres that had received Phase II bond release, the borrow site, the unreclaimed 16.18 acres and appurtenant structures, plus undisturbed acreage. On January 3, 2006 the Permittee applied for Phase III bond release for the entire disturbed area.

Utah American Energy Incorporated (UEI) acquired six federal coal leases from Basic Management in 1999, which had subleased them from IPA in August 1998. UEI purchased the leases in June 2000. These leases are in the North Block Logical Mining Unit (LMU) of the old Kaiser South Leases. UEI submitted an amendment to extend the Horse Canyon Mine permit into this LMU: this extension is known as the Horse Canyon Mine’s Lila Canyon Extension. The projected disturbed area for the Lila Canyon operations is 48 acres.

The South Lease LMU - South Block was withdrawn from leasing by the BLM. UEI might apply to lease this coal and extend the Horse Canyon Mine into this LMU at some undetermined time in the future.
II. CUMULATIVE IMPACT AREA (CIA)

The Book Cliffs Area V (Horse Canyon-Lila Canyon) CIA is shown on Plates 2 through 4. This area is shown on the Lila Point, Cedar, Grassy, and Woodside USGS 7.5 minute quadrangles. The CIA is a designated area surrounding mining activity within which past, present, and anticipated or foreseeable coal mining activities may interact to affect the surface and ground water.

The Book Cliffs area is classified as mid-latitude steppe to semi-arid desert. The climate is characterized by warm moist springs and hot summers, and by cold, dry winters. Precipitation varies from 20 inches at the highest elevations to 8 inches along the Price River downstream of the town of Wellington. Mean annual precipitation is about 12 inches, with most precipitation occurring during the late summer and early fall. Temperatures range from summer highs in the 90s to below zero during the winter months. Vegetation varies from the sagebrush/grass community type at lower elevations to pinyon/juniper, sagebrush, and saltbush/Salina wild rye at higher elevations. The pinyon/juniper community dominates most of the Lila Canyon area. Cliff-forming rock outcrops have little or no vegetation, and the Lila Canyon area doesn't have the deep, protected canyons with more mesic vegetation found at other places along the Book and Roan Cliffs, such as at the West Ridge Mine to the north. The land is mainly used for wildlife habitat and livestock grazing.

The Book Cliffs Area V CIA encompasses roughly 73,000 acres (114 square-miles). A large section of this CIA, the area that basically extends from the base of the Book Cliffs to Grassy Trail Creek and the Price River, will not be affected by mining operations but has been included in the CIA because adjacent watercourses that form part of the CIA boundary (Horse Canyon Wash, Grassy Trail Creek, and Price River) are included in the CHIA determination. The permit area of the Horse Canyon Mine, including the LCMA area, is 6,032 acres, which includes 5,544 acres in six federal coal leases plus state coal leases and fee coal. The estimated size of the disturbed area for the Lila Canyon project is 48 acres: the old Horse Canyon Mine disturbed 74 acres, which are either being reclaimed or do not require reclamation because of a post-mining land use change. There is additional federal coal south of the Horse Canyon permit area that has been leased in the past as part of an LMU, but which is not currently under lease. This area has been included in the CIA because UEI has indicated they anticipate mining that area at some as-yet undetermined future date.

Elevations along the Book and Roan Cliffs range from approximately 5,000 to 10,000 feet. Steep, narrow canyons and high peaks are characteristic. Because of the rugged topography, land uses are generally limited to wildlife habitat, rangeland, and recreation, but timber is harvested in some areas. A large portion of the surface area is public land managed by the Bureau of Land Management (BLM).
Surface runoff from the Book Cliffs Area V CIA flows into the Price River drainage basin of south-central Utah (Plate 1). The Price River flows southeasterly and joins the Green River approximately 15 miles north of the town of Green River, Utah. Water quality is good in the mountainous headwater tributaries, but deteriorates rapidly after the river leaves Price Canyon and flows across the Mancos Shale. The Mancos typically has low permeability, is easily eroded, and contains large quantities of soluble salts. Total dissolved solids (TDS) levels over 3,000 mg/L and sulfate concentrations over 1,000 mg/L are not uncommon in the lower reaches of the Price River (Mundorff, 1972).

Several drainages carry surface flows away from the LCMA. Horse Canyon, Lila Canyon and Lila Wash, the Right Fork of Lila Wash, and the newly named Stinky Springs Wash drain the escarpment of the Book Cliffs in the vicinity of the mine. Little Park Wash and its tributaries drain the relatively flat region between the top of the Book Cliffs and base of the Roan Cliffs, escarpments that form the mountainous terrain above the minesite. All drainages on the minesite have been shown, through monitoring and surveys, to have ephemeral flow, although Little Park Wash (and its tributaries), Lila Canyon, and Stinky Seep Wash drain areas greater than 1 mi² and are therefore considered as intermittent according to the Utah R645 Coal Rules. Except for Little Park Wash, surface waters in the CIA flow from the Book Cliffs escarpment, then several miles across the lower end of Clark Valley, an arid sagebrush desert formed on Mancos Shale, to the Price River. Little Park Wash flows south, reaching the Price River by way of Trail Canyon. The Price River eventually discharges to the Green River just above the Green’s confluence with the Colorado River.

Outcropping rocks of the Book and Roan Cliffs range from Upper Cretaceous to Quaternary in age. The rock record reflects an overall regressive sequence from marine (Mancos Shale) on the valley floor and at the base of the cliffs, up through littoral and lagoonal (Star Point Sandstone and lower Blackhawk Formation), to fluvial (upper Blackhawk Formation, Castlegate Sandstone, Price River Formation and North Horn Formation), and lacustrine (Flagstaff Formation and Green River Formation) depositional environments. The Colton Formation is a fluvial-deltaic sequence separating the Flagstaff and Green River deposits. The lower Blackhawk Formation is the major coal-bearing unit within the Book Cliffs Coal Field. Members of the Blackhawk Formation were deposited in an oscillating regressive seaway during the Cretaceous Period.

Range Creek is the closest perennial stream to the LCMA. The shortest distance between the planned mine workings and Range Creek is approximately four miles (Plate 2). Range Creek is in a broad, south-southeast oriented canyon that has been eroded into the West Tavaputs Plateau (Plate 1), leaving a segment of the Roan Cliffs along Patmos Ridge to separate Range Creek Canyon from Little Park Wash and the Book Cliffs (Plates 2 and 5).

Dutton (1880) named the Roan Cliffs (once also known as the Brown Cliffs) for the characteristic color of the Tertiary strata exposed along the escarpments (Plate 3). The mineable lower-Cretaceous Blackhawk Formation coal in the LCMA is stratigraphically well below the
Tertiary sediments of the Roan Cliffs and Range Creek Canyon (Plate 5). The lower Tertiary Colton Formation is exposed at the surface from Patmos Ridge eastward. It is exposed at the surface in some areas of the LCMA area, whereas, Range Creek has eroded into the upper Colton Formation, but not through the formation to the depth where it is exposed at the LCMA area (CHIA Plate 6, Plate 7-1B of MRP-Part B). Approximately 11 miles southeast of the LCMA and just upstream of Turtle Canyon, Range Creek has eroded through the Colton, Flagstaff, and North Horn Formations, but the stream reaches the Green River without having eroded through the Upper Price River Formation (Witkind, 1988). Other than along the west-facing escarpment of the Book Cliffs, the nearest Blackhawk Formation outcrop is over 10 miles south of the LCMA, along the Price River in the canyon that splits the Beckwith Plateau from the West Tavaputs Plateau. The MRP-Part B (Section 724.200) states that there was no collection of baseline data from Range Creek, because of the horizontal and vertical isolation from the Lila Canyon Mine workings.

As part of the CHIA, the Division also evaluated the elevation difference between the saturated ground-water zone in the Blackhawk Formation and streamflows in the Range Creek drainage, especially the reaches nearest the permit area, and the thick section of low-permeability strata between the Blackhawk and Colton Formations.

If the deeper ground water zone, in the Blackhawk Formation, were following either the gradient indicated by the piezometers or geologic dip, the water would flow well below Range Creek. The thick section of low-permeability strata between Range Creek and the coal seam will impede hydraulic interaction between that deeper ground water zone and the surface (Table 2 and Plate 5).

The Division reviewed U.S. Geological Professional Paper 332 by D.J. Fisher, C.E. Reeside and J.B. Erdman, 1960, *Cretaceous and Tertiary Formation of the Book Cliffs, Carbon and Emery Counties, Utah*. The paper evaluates the composite stratigraphy in Horse Canyon. The Division totaled the percentage of shale, siltstone and mudstone for each unit identified by the authors to get an idea of the amount of units that would restrict flow throughout the stratigraphic column.
### Table 2. Ratio of Fine Grain Strata in Geologic Formations in the CIA.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Unit</th>
<th>Fine Material</th>
<th>Thickness (feet)</th>
<th>% Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colton Formation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Sandstone Unit</td>
<td>Shale</td>
<td>1,300</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>Shale Unit</td>
<td>Mudstone</td>
<td>960</td>
<td>82.9</td>
</tr>
<tr>
<td></td>
<td>Lower Sandstone Unit</td>
<td>Shale, Mudstone</td>
<td>1,128</td>
<td>34.8</td>
</tr>
<tr>
<td>North Horn/Flagstaff Undifferentiated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shale Beds</td>
<td></td>
<td>237</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mudstone</td>
<td></td>
<td>181</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limestone</td>
<td></td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Siltstone</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clay</td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sandstone Beds</td>
<td>Shale, Mudstone, Siltstone, Clay</td>
<td>99</td>
<td>79.0</td>
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<tr>
<td>Price River Formation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Unit</td>
<td>Shale</td>
<td>299</td>
<td>43.8</td>
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<tr>
<td></td>
<td>Lower Unit</td>
<td>Shale, Mudstone</td>
<td>234</td>
<td>43.8</td>
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<tr>
<td>Castlegate Sandstone</td>
<td></td>
<td></td>
<td>160-180</td>
<td>0</td>
</tr>
<tr>
<td>Blackhawk Formation</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Upper Shale Unit</td>
<td>Shale</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Middle Sandstone Unit</td>
<td>Shale</td>
<td>0</td>
<td></td>
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<td></td>
<td>Middle Shale Unit</td>
<td>Shale</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lower Sandstone Unit</td>
<td>Shale</td>
<td>200</td>
<td>52.5</td>
</tr>
</tbody>
</table>

The ground-water gradient indicated by measurements from three piezometers constructed within the LCMA (IPA piezometers) might only be a local orientation rather than the overall direction of ground-water flow in the saturated strata. If so, then there might be discharge in lower Range Creek considerably downstream from the areas adjacent to the LCMA, where elevations are low enough for ground water to flow, through an indirect flow-path, from the deep saturated strata that are intercepted by the Lila Canyon Mine. Such flow would need to move stratigraphically upward through low-permeability strata.

Looking at a worst case scenario, by comparing the area potentially impacted by the Horse Canyon Mine and LCMA (6,032 acres in the combined permit area) to the area in the Range Creek drainage upstream of such a potential discharge point (approximately 50,000 acres upstream of or above the 5,900-ft elevation contour, and 85,000 acres for the entire drainage), and assuming total loss of all contributions from the Horse - Lila Canyon permit area and no contributions from similar areas outside the Range Creek drainage, potential impacts would be on the order of 12 percent loss of streamflow above 5,900 feet and 7 percent loss for the entire Range Creek basin. Standard deviation for streamflows in the Book Cliffs is typically on the order of 100 percent, and even with regular long-term monitoring, variation in flow of 15 percent or less is probably not detectable (Waddell and others, 1981). It is unlikely that mining at Lila Canyon will cause material damage to either the quality or quantity of water in Range Creek. It is unlikely that there will be a measurable change, and therefore unlikely there would be any impact at all (OSMRE, 1985).

If there is regional flow in the deep, saturated strata, it is most likely away from the higher elevations of the West Tavaputs Plateau and Range Creek, where precipitation is greater, and toward the dryer and lower-elevation Book Cliffs and the Price River, and would more likely be more southward rather than westward. If there were a westward component of such ground-water flow, it would pass deep beneath the perched local systems that sustain the springs in Little Park Wash. Plate 6, taken from Osterwald and others (1981) and Plate 7-1B of MRP-Part B, based on a USGS map (Witkind, 1988), show the relationship of the Blackhawk Formation to Range Creek and other overlying topographic features.

The potentiometric surface indicated by the three IPA piezometers is not necessarily an indication of regional ground-water flow. There is no recharge source at the Book Cliffs that could support such regional flow: it is unlikely that the dry and steep areas around Little Park Wash and Horse and Lila Canyons provide recharge adequate to generate regional flow towards Range Creek and other areas to the east. There is no discharge from the Blackhawk Formation or Star Point Sandstone in the direction indicated by the potentiometric surface. Rather than indicating regional flow, the water-level readings in the IPA piezometers are more likely from ground water in saturated zones in the coal seam and associated strata that have poor or no hydraulic interconnection. Elevations of the ground water in the piezometers indicate the elevations of these zones and broadly match the dip of the strata.
Dip is 8 to 12 degrees to the east-northeast at the Book Cliffs, but decreases eastward to as little as 4 degrees (Doelling, 1972). Strata in the Book and Roan Cliffs were tilted in response to the rise of the San Rafael Swell and the Socally and Farnam anticlines, and modified by subsequent erosional, tectonic and orogenic events.

The dip of the strata can be an important factor in ground-water flow. In some instances it can facilitate ground water flow. It can also impede groundwater flow, but cannot cause ground water flow. The dip of strata is neither a necessary condition for groundwater flow, nor a sufficient condition for ground water flow.

There is no evidence that water flows from the Lila side of Patmos Ridge towards Range Creek drainage through the Colton and North Horn - Flagstaff Formations, in spite of dip of the strata in that direction. The up-dip exposures of the Colton and North Horn - Flagstaff Formations along Little Park Wash are areas of ground-water discharge from local, perched, weathered bedrock and alluvial aquifers, as evidenced by springs, not areas of regional recharge. Examination of water rights and topographic maps, although not as comprehensive as a detailed seep and spring survey, nevertheless indicates that ground-water discharge on the Range Creek side of Patmos Ridge is much less than on the Lila side, and this limited discharge is most likely due to local, perched, alluvial systems similar to those on the Lila side of the ridge rather than west-to-east flow through bedrock beneath the crest of Patmos Ridge. The areas of upper zone ground-water recharge and discharge on the Little Park Wash side of Patmos Ridge are outside the limits of projected subsidence (MRP-Part B, Plate 7-1A), so probable impacts from mining have been minimized, and the probability of impacts on the Range Creek side is even less (MRP-Part B, Figure 7-4).

Faults can also be important factors in ground water flow. Both lateral and vertical flow may be channeled through faults and fractures, but plastic or swelling clays that can seal faults and fractures are abundant in the sequential sandstone-shale matrix in the Book Cliffs (Figure 2). The Sunnyside Fault Zone is a major north-northwest striking feature throughout much of the Sunnyside Mining District, extending from West Ridge to the Horse Canyon Mine (Osterwald and others, 1981). Extension of the Sunnyside Fault Zone south to the Horse Canyon Mine is uncertain (Osterwald and others, 1981; MRP-Part B, Plate 6-1), but it may continue to the east of the LCMA area (Dunrud and Barnes, 1972; MRP-Part B, Chapter 6). Faults that strike basically east-west were mapped by Osterwald throughout the Sunnyside Mining District, the Horse Canyon Mine and LCMA.

For many of these faults, stratigraphic separation is greatest at the Book Cliffs escarpment and decreases eastward. These faults have vertical offsets of 15 to more than 275 feet and divide the LCMA into several large blocks that vary from 3,000 to 12,000 feet in width. Mapping of these faults (Osterwald and others, 1981; Fisher and others, 1960; and Dunrud and Barnes, 1972) indicates they do not extend any great distance to the east of Patmos Ridge. This could be the result of the faulting occurring before deposition of the Colton Formation, decreasing offset from deeper to shallower strata, decreasing offset to the east, or any combination of these. Whatever the
reason, the potential for these faults as flowpaths between the surface and subsurface diminishes eastward and appears negligible in the Range Creek drainage.

Figure 2. Interbedded Sandstone and Shale. Photograph shows the distinct change and variability of bedding in the Blackhawk Formation above the coal seam. Water can be found in some fractures and sandstone units, but the shales can restrict vertical movement of ground water.

Ground water was monitored within the Horse Canyon Mine in several locations (MRP-Part A, Appendix VI-I). Generally, the small flows issued from rock slopes and gob areas (MRP-Part B, Chapter 7, Mine Inflow Information). Records do not indicate that these flows were excessive or sustained (MRP-Part B, Section 6.4.1). Unless a major fault is encountered, inflows of ground water into mines in the Book Cliffs Coal Field are small and decrease rapidly, indicating perched,
isolated sources. Geneva Mine records indicate that the mine was essentially dry until the Sunnyside Fault was intercepted, at which time water flows were encountered (MRP-Part B, Chapter 7, Mine Inflow Information). Lines and Plantz (1981) estimate discharge from the Horse Canyon Mine during this period was 0.2 cfs (90 gpm), but the amount attributable to inflow from the Sunnyside Fault is not known. The plan for the LCMA is to avoid the Sunnyside Fault (MRP-Part B, Plates 5-3 and 6-1).

The CIA boundary follows Patmos Ridge, which is as close as 1,600 feet to the Lila permit area boundary at one point and as close as 5,000 feet to projected mine workings at another. In the absence of contravening information or data, a ground water divide for shallow or local ground-water systems can be inferred to be coincident with a topographic divide such as Patmos Ridge. As discussed above, dip of the strata in this area is not a major influence on ground-water flow in the shallow, perched aquifers, and there is no evidence that any force other than gravity provides the gradient to drive ground-water flow in this region. If there is a distinct ground-water divide for the deeper saturated zones in the Blackhawk Formation and Star Point Sandstone, it is most likely beneath the headwaters areas of Range Creek and the Roan Plateau east of Range Creek. Ground water in this deeper system would flow south and west toward the Book Cliffs and the Price River rather than away from them, and would flow under the perched local systems that sustain the springs in Little Park Wash: Plate 6 shows the relationship of the Blackhawk Formation to Range Creek and other overlying topographic features.

ASSESSMENT OF RANGE CREEK

Based on the information provided above, the Division has determined that mining will not impact Range Creek and, therefore, did not include Range Creek within the Book Cliffs Area V CIA. The thickness of the upper Mesaverde Group, undifferentiated North Horn Formation/Flagstaff Limestone, and Colton strata that lie between Range Creek and the coal seam; the general low-permeability of these strata; and the capacity of clays in these formations to seal fractures will restrict vertical movement of water. The shortest distance ground water could travel laterally from the edge of the permit boundary to Range Creek is four miles, through very low-permeability rock. Likewise, perched aquifers in the Colton Formation and undifferentiated North Horn Formation-Flagstaff Limestone will not be impacted because the thick strata between these aquifers and the coal seam, the general low-permeability of the strata, and the capacity of clays in these formations to seal fractures will act as an aquitard to restrict vertical movement of water.

Lines’ model for Range Creek

Concerns were raised during the public comment period for the LCMA that the block-diagram in of Lines (1985,Figure 8) supports the hypothesis that there is discharge to Range Creek from a regional aquifer and is a model for interaction between the Lila Canyon Mine workings and Range Creek, also that it indicates that mining at Lila Canyon will disrupt flow in Range Creek. The Division does not dispute that the study by Lines provides valuable, although generalized, insight into ground-water systems in the Wasatch Plateau, specifically in the Trail Mountain area.
Much of the information can be applied to the Book Cliffs coalfield. However, the situation illustrated in Lines’ block-diagram differs from the reality of the hydrogeologic environment at Lila Canyon and Range Creek in at least four important aspects and does not adequately or realistically represent the hydrogeologic relationship between the Lila Canyon area and Range Creek.

- **Stratigraphic separation.** Range Creek has not eroded through the Colton Formation in the areas nearest the LCMA, and along its entire course, Range Creek has not eroded deeper than the upper Price River Formation, so a thick section of low-permeability rock vertically isolates the creek from the projected saturated zone in the lower Blackhawk Formation and Star Point Sandstone. In Lines’ diagram, the stream has eroded through the saturated Blackhawk, including the coal seam, and down into the Star Point.

- **Vertical separation.** In the reaches nearest Lila Canyon, Range Creek is significantly higher in elevation than the saturated Blackhawk strata, as illustrated on Plate 6.

- **Horizontal separation.** Lines’ block-diagram has no scale, but proximity of the stream to the impacted saturated strata is apparent, i.e., they are in direct contact. In contrast, the shortest horizontal distance between the planned LCMA boundary and Range Creek is at least four miles (Plate 2).

- **Lithology.** The Star Point Sandstone, the stratum with perhaps the best, but nevertheless limited potential as an aquifer in the Wasatch Plateau, thins eastward and pinches out in the vicinity of the Dugout Canyon Mine, so it is not present in the Horse Canyon or Range Creek areas. The IPA piezometers at Lila Canyon were completed beneath the coal seams in a sandstone tongue of the Sunnyside Sandstone Member of the Blackhawk Formation. The Sunnyside Member sandstones were deposited in environments similar to those of the Kenilworth Member of the Blackhawk Formation, and hydraulic characteristics are probably very similar (Table 4); however, the sandstone units in these Blackhawk sandstone members are not as extensive or thick as the Star Point Sandstone.

Lines also created a very simple 3-dimensional model of ground-water flow from a Blackhawk – Star Point aquifer into a mine in the Blackhawk Formation, and comments were received from the public as to the applicability of that model to the Lila Canyon Mine. Conclusions drawn by Lines from the model are very general, even for the Wasatch Plateau and Trail Mountain Mine. The maximum mine inflow, calculated for steady-state conditions (approximately 10,000 years) for a mined-out area 10,000 ft by 5,000 ft, was just under one cfs or approximately 450 gpm (UEI used 500 gpm in calculating effects of the Lila Canyon Mine discharge on channels). Lines’ (Figure 23) indicates that if the mine were to pump and discharge water for more than 5 years, some drawdown of the saturated zone might be expected 25,000 ft from the mine, approximately the distance from the Lila Canyon Mine to Range Creek.

**SCOPE OF MINING**
The Sunnyside coal-mining district of the Book Cliffs Coal Field, as defined by Osterwald (1981), includes the Horse Canyon Mine, the Sunnyside Mine, the Columbia Mine, and the Book Cliffs Mine. Of these old operations, only the Horse Canyon and Book Cliffs Mines are entirely within the CIA (Plate 2).

Horse Canyon Mine

Coal mining in Horse Canyon is thought to have begun in the late 1800's or early 1900's. Prior to that, Horse Canyon was used as a cattle trail. In 1936, the Cedar Ridge Coal Company was formed and operated a mine in Horse Canyon.

Operation of the Horse Canyon Mine was taken over by the Defense Plant Corporation (a United States Government Agency) in 1942 to supply metallurgical grade coal for the Geneva Steel Works in Orem, Utah. In December 1943, the Geneva Steel Company began operating the mine for the Defense Plant Corporation. On June 16, 1946, the mine was purchased from the War Assets Administration by United States Steel Corporation, and was operated by the Geneva Steel Company until January 1, 1952, when the Geneva Company became a part of the Columbia-Geneva Steel Division of United States Steel. U. S. Steel operated the mine until 1982, and then sold it to Kaiser Steel Corporation in 1984. Kaiser Steel never produced coal from the mine. There were eleven portals in the area. After exploring the old workings, Kaiser sealed the portals and began interim reclamation in 1986.

In 1990, IPA acquired the Horse Canyon Mine and the areas south of Horse Canyon that had belonged to Kaiser Steel Corporation. The Division approved transfer of the permit rights. During 1990 and 1991, IPA reclaimed the majority of the surface disturbance, leaving only a main facilities pad with buildings essential for future mine operations. Phase I bond release was approved in 1997 and Phase II was approved in 2002.

BXG explored the Horse Canyon Mine to evaluate the feasibility of utilizing the mine to access the adjacent South Lease Reserve. The exploration commenced in August 1992 with the breaching of the Horse Canyon and Lila Canyon portal seals. The underground evaluation of the mine began in January 1993, was completed in March 1993, and the mine was resealed.

In the LCMA, UEI currently holds six federal leases covering 5,544.01 acres. UEI subleased these federal coal lease tracts from IPA in August 1998 and purchased them in June 2000. These leases are in the South Lease - North Block LMU. There is additional federal coal south of the LCMA area that has been leased in the past as the South Block of the South Lease LMU (Plate 2). This South Block is not currently under lease but it could be leased again in the future.

Plate 2 shows the extent of past and projected mining operations at the Horse Canyon Mine, including the LCMA. Past operations mined some 3,500 acres in and adjacent to the Horse Canyon Mine permit area. The abandoned workings are approximately 3 miles in length, roughly along
strike and parallel to the escarpment, and extend approximately one mile down-dip to the east. Overburden thickness was up to 2,000 feet. Mining was done in the Lower Sunnyside Coal Seam.

**Book Cliffs Mine**

The Book Cliffs Mine operated from 1938 to 1966. Coal was mined in the area between the Book Cliffs escarpment and the abandoned workings in the north part of the Horse Canyon Mine. The Prentiss, Utah Blue Diamond, Blue Diamond, and Heiner Mines were either alternative names for the Book Cliffs Mine or were smaller mines incorporated into it as it expanded.

**Other**

Doelling (1972) presented coal characteristics information from the area near Lila Canyon. Coal samples were collected near the site of the old Book Cliffs Mine from the lower Sunnyside Coal Seam. Coal characteristics are favorable for production, however overburden becomes extensive to the east and south of the proposed site.
III. HYDROLOGIC SYSTEM and BASELINE CONDITIONS

Elevations range from approximately 6,000 to over 9,000 feet in the CIA. Predominant features are cliffs, narrow canyons, valleys, and pediments. Drainage in the CIA is characterized by a system of ephemeral washes draining the southwest-facing Book and Roan Cliffs escarpments.

GEOLOGY

Plate 3 shows the surface geology of the Book Cliffs Area V CIA.

Stratigraphy

The stratigraphy of the CIA consists of strata ranging in age from Late Cretaceous to Tertiary (Eocene) plus unconsolidated Quaternary deposits (Figure 3). There are no major disconformities in the area. The oldest exposed rocks include the upper members of the Mancos Shale. The Cretaceous Mesaverde Group, which in the Book and Roan Cliffs consists of the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, and Price River Formation, overlies the Mancos Shale: the Star Point Sandstone thins eastward and pinches out in the vicinity of the Dugout Canyon Mine so it is not present in the Horse Canyon area. Overlying the Mesaverde Group are the North Horn Formation, Flagstaff Limestone, Colton Formation, and Green River Formation, which in the Book and Roan Cliffs constitute the Wasatch Group of Paleocene to Eocene age. The Eocene Green River Formation is the uppermost, consolidated formation in the vicinity of the CIA. Unconsolidated deposits exist as soils, terrace deposits, alluvium in canyons and along washes, and pediments at the base of escarpments.

The rock record displays an overall regressive sequence from marine (Mancos Shale) through littoral (Star Point Sandstone) and lagoonal (Blackhawk Formation) to fluvial (Castlegate Sandstone, Price River Formation and North Horn Formation) and lacustrine (Flagstaff Limestone) depositional environments. Oscillating depositional environments within the overall regressive trend are represented by lithologies such as the Sunnyside Sandstone Member within the Blackhawk Formation. The major coal-bearing unit within the Book Cliffs Coal Field is the Blackhawk Formation.

Coal

The Sunnyside Member of the Blackhawk Formation contains the primary economic coal resource in the Book Cliffs Coal Field. The lowest coal seam is the Kenilworth. Doelling (1972) indicates an average thickness of two feet in the vicinity of Horse Canyon, with the seam probably missing in areas. The Gilson and Rock Canyon Seams that lie above the Kenilworth throughout much of the Book Cliffs Coal Field, and that are mined in the Dugout and Soldier Canyon Mines to
the north, are not mentioned by Doelling or others for the Horse Canyon area and are either missing or very thin.

The Lower Sunnyside Coal Seam is the only seam in the area that can be mined economically. In the abandoned sections of the Horse Canyon Mine, the Lower Sunnyside Coal Seam was uniformly 10 to 16 feet thick. Measurements indicate it is 4 to more than 18 feet thick in the LCMA: UEI has determined the Upper and Lower Seams are merged into one seam in the Lila Canyon area and split again into two seams to the south. Where separate from the Lower Seam, thickness of the Upper Seam never exceeds 4 feet in the Lila Canyon area (MRP-Part B, Section 6.4.1). Doelling (1972) stated his expectation for the upper coal seams to be thin and inconsequential in this area.

In most of the LCMA, the lower coal seam lies below 1,500 feet of strata. Mining will take place in a small area where strata above the Lower Sunnyside Coal Seam are thicker than 2,500 feet (MRP-Part B, Section 6.4.2 and Plate 6-2). Average overburden thickness is about 2,000 feet in the abandoned area of the Horse Canyon permit area.

Structure

Strata in the Book and Roan Cliffs were tilted in response to the rise of the San Rafael Swell and the Socally and Farnam anticlines, and modified by subsequent erosional, tectonic and orogenic events. Strike of the beds at the Horse Canyon Mine is roughly north-south, generally parallel to the face of the Book Cliffs. Dip is 6 to 12 degrees to the east at the Book Cliffs but decreases eastward to as little as 4 degrees (Doelling, 1972).

Joints occur in two principal and two secondary orientations, although orientations are more accurately related to the local strike of the strata rather than to a specific direction. All joints tend to dip steeply. Retreat type erosion of the Book and Roan Cliffs escarpments have probably been facilitated significantly by blocks of rock breaking from the cliffs along joints. Soils and vegetative cover develop in large troughs formed as these blocks pull away. Northwest to north-northwest joints tend to be the most variable in orientation. They generally are parallel to strike of the strata and at right angles to the canyons and ridges of the escarpment. Locally they occur as little as 1 foot apart in zones a few feet wide, zones being a few feet to 20 feet apart. There has been vertical movement on some of these joints and some are coated with gypsum or calcite. Northeast to north-northeast joints are generally normal to the northwest to north-northwest joints and tend to be parallel to dip. The secondary joint-sets trend west-northwest and northeast (Osterwald and others, 1981, p. 45).

The Sunnyside fault zone is a major north-northwest striking feature throughout much of the Sunnyside Mining District, extending from West Ridge to the Horse Canyon Mine (Osterwald and others, 1981). Average stratigraphic separation across the zone is 30 feet at Sunnyside and 40 to 60 feet at Horse Canyon, but offset on individual faults may be small. There has also been some horizontal displacement, but the amount is undetermined. Most faults within the zone are parallel
to the trend of the zone. The faults dip steeply. Faults are detectable from surface mapping between West Ridge and upper Horse Canyon but not farther south. Extension of the Sunnyside Fault Zone south of the Horse Canyon Mine is uncertain, but it is believed to continue to the east of the LCMA.

Figure 3. General Stratigraphy of the Book Cliffs Coal Field (after Doelling, 1972).

<table>
<thead>
<tr>
<th>System</th>
<th>Series</th>
<th>Stratigraphic Unit</th>
<th>Thickness (feet)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary</td>
<td>Eocene</td>
<td>Green River Formation</td>
<td>-</td>
<td>Greenish-gray and white claystone and shale, also contains fine-grained and thin-bedded sandstone. Shales often dark brown, containing carbonaceous matter. Full thickness not exposed.</td>
</tr>
<tr>
<td></td>
<td>Colton Formation</td>
<td></td>
<td>300-2,000</td>
<td>Colton consists of brown and dark-red lenticular sandstone, shale, and siltstone; thins westward and considered a tongue of the Wasatch.</td>
</tr>
<tr>
<td></td>
<td>Flagstaff Formation</td>
<td></td>
<td>3,000</td>
<td>Wasatch - predominantly sandstone with interbedded red and green shales with basal conglomerate. Found in east part of field and equivalent to Colton and Flagstaff in west.</td>
</tr>
<tr>
<td></td>
<td>North Horn Formation</td>
<td></td>
<td>0 – 500</td>
<td>Flagstaff - mainly gray and cream colored limestone, variegated shale, and fine-grained, reddish-brown sandstone.</td>
</tr>
<tr>
<td></td>
<td>Tucher Formation</td>
<td></td>
<td>350 – 2,500</td>
<td>North Horn Formation - Gray and gray-green calcareous and silty shale, tan to yellow-gray fine-grained sandstone, and minor conglomerate. Unit thickens to the west.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tucher Formation - Light gray to cream-white friable massive sandstone and subordinate buff to gray shale that exhibits light greenish east. Contains minor conglomerate and probably represents lower part of North Horn; only present in east part of coal field.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 – 200</td>
<td></td>
</tr>
<tr>
<td>Danian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Maestrichtian</td>
<td>Price River Formation</td>
<td>500 – 1,500</td>
<td>Yellow-gray to white medium-grained sandstone and shaley sandstone with gray to olive green shale. Contains carbonaceous shale with minor coal and thickens along east edge of field.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MINOR COAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Castlegate Formation</td>
<td></td>
<td>100 – 500</td>
<td>White to gray, fine-grained sandstone; argillaceous massive resistant sandstone thinning eastwardly with subordinate shale. Carbonaceous east of Horse Canyon but coal is thin and lignitic.</td>
</tr>
<tr>
<td>Formation</td>
<td>Member</td>
<td>Age</td>
<td>Description</td>
<td></td>
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<td>-------------------------</td>
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<td></td>
</tr>
<tr>
<td>Blackhawk Formation</td>
<td>MAJOR COAL SEAMS</td>
<td>600 – 1,100</td>
<td>Cyclical littoral and lagoonal deposits with six major cycles. Littoral deposits mainly thick-bedded to massive cliff-forming, yellow-gray, fine- to medium-grained sandstone; individual beds separated by gray shale. Lagoonal facies consist of thin- to thick-bedded yellow-gray sandstones, shaley sandstones, shale, and coal. Coal beds of Wasatch Plateau and Book Cliffs Coal Fields. Unit thins eastward, grading into the Mancos Shale.</td>
<td></td>
</tr>
<tr>
<td>Star Point Sandstone</td>
<td></td>
<td>0 – 580</td>
<td>Yellow-gray, massive, medium- to fine-grained littoral sandstone tongues projecting easterly, separated by gray marine shale tongues projecting westerly.</td>
<td></td>
</tr>
<tr>
<td>Santonian</td>
<td>Masuk Tongue</td>
<td></td>
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<tr>
<td></td>
<td>Emery Sandstone</td>
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<td></td>
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</tr>
<tr>
<td>Coniacian</td>
<td>Garley Canyon Sandstone</td>
<td></td>
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<tr>
<td></td>
<td>Blue Gate Shale</td>
<td>Mancos Shale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turonian</td>
<td>Ferron Sandstone</td>
<td>MINOR COAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tununk Shale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cenomanian</td>
<td>Dakota Sandstone</td>
<td>2 - 126</td>
<td>Heterogeneous sandstone, conglomerate, and shale, thin resistant cuesta former.</td>
<td></td>
</tr>
</tbody>
</table>

Faults that strike basically east-west were mapped by Osterwald throughout the Sunnyside Mining District but they are more numerous in the Horse Canyon Mine area. Dips are generally vertical, but in the vicinity of Horse Canyon some of these faults dip 45 degrees or less. For many of these faults, stratigraphic separation is greatest at the cliff-face and decreases eastward. Several additional faults with this orientation have been mapped in the LCMA. These faults, which have vertical offsets of 15 to more than 275 feet, divide the Lila Canyon addition into several large blocks that vary from 3,000 to 12,000 feet in width.

Osterwald identified two other groups of faults that are not prominent in or around the Book Cliffs Area V CIA. A group of east-northeast and northeast trending faults are located mainly in Whitmore Canyon near the Sunnyside Mine, and a belt of west-northwest trending faults that extends from the Book Cliffs out into the San Rafael Swell are located south of the CIA.
CLIMATOLOGIC INFORMATION

The permit area is located in the northwestern portion of the Price River basin in eastern Utah. The basin is surrounded almost completely by mountains, with elevations of over 9,000 ft. in the CIA. The mountains greatly influence local weather, inhibiting cold arctic air masses from penetrating into the region and acting as a barrier to storms approaching from every direction except south.

Daily climatic information is collected at a National Weather Service station in Sunnyside, Utah. Mean monthly precipitation at Sunnyside is shown in Figure 4. Average annual precipitation is 13.53 inches. The area typically receives the greatest quantity of moisture from thundershowers in the late summer and early fall (August-October). The driest months at Sunnyside are November to February. Figure 4 provides the accumulative amount of snow that can be expected at the surface facility. Average snow accumulation at the Sunnyside mine, during 1973 to 1983, ranged from 1.35 inches to 9.86 inches during the winter months (Table 3).

The Palmer Hydrologic Drought Index (PHDI) indicates long-term climatic trends for the region (Figure 5). The PHDI is a monthly value generated by the National Climatic Data Center (NCDC) that indicates the severity of a wet or dry spell. The PHDI is computed from climatic and hydrologic parameters such as temperature, precipitation, evapotranspiration, soil water recharge, soil water loss, and runoff. Because the PHDI takes into account parameters that affect the balance between moisture supply and moisture demand, it is a useful for evaluating the long-term relationship between climate and ground-water recharge and discharge. Figure 5 shows the Palmer Hydrologic Drought Index for Utah Divisions 6 and 7: the permit area lies in Division 7, but near Division 6. These graphs indicate wet years between the late 1970's and late 1980's, followed by several years of drought in the late 1980's and early 1990's. Shorter wet and dry cycles alternated from 1993 to 1999, then 2000 to 2004 was another extended period of drought.

Wind data were collected during 1982 and 1983 (1993 Sunnyside Coal Company MRP, Appendix 7-2). The data, collected near East Carbon from atop a 45-meter tower, show that the majority of the winds are from the north-northeast through the south-southwest (clockwise) with an average annual speed of 6.2 mph.

Upper level winds, over 1,600 feet above the ground level, are generally from the southwest during most of the year. The wind tends to be strong high in the atmosphere, but weakens toward the surface where obstructions and surface friction come into play. During the winter, airflow from the northeast is common. Local night airflow patterns, which are induced by decent of colder air, primarily follow canyon bottoms from the mountains down to the valleys, and wind speed resulting from this decent of colder air is generally light. Daytime flow is strongly influenced by surface heating effects that result in mixing between the surface and upper flows. There is a general airflow toward the north and northeast (to higher elevations) during the day, and toward the southwest (toward lower elevations) during the night. Winds are usually light to moderate (below 20 mph) unless influenced by localized thunderstorms or moving frontal systems. Higher wind
speeds are generally associated with storm systems and higher elevations such as ridge tops and plateaus (West Ridge MRP, Chapters 4 and 7).

Figure 4 - Precipitation at Sunnyside.
SNOW ACCUMULATION IN INCHES, 1973-1983
SUNNYSIDE MINE
(approximately 6,800 feet elevation)

<table>
<thead>
<tr>
<th></th>
<th>Maximum</th>
<th>Mean</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td></td>
<td>Daily</td>
</tr>
<tr>
<td>October</td>
<td>6.5</td>
<td>1.35</td>
<td>0.73</td>
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<tr>
<td>November</td>
<td>6.0</td>
<td>1.69</td>
<td>0.28</td>
</tr>
<tr>
<td>December</td>
<td>14.00</td>
<td>4.42</td>
<td>1.73</td>
</tr>
<tr>
<td>January</td>
<td>21.00</td>
<td>9.86</td>
<td>4.01</td>
</tr>
<tr>
<td>February</td>
<td>21.00</td>
<td>6.44</td>
<td>2.84</td>
</tr>
<tr>
<td>March</td>
<td>15.00</td>
<td>5.30</td>
<td>0.60</td>
</tr>
</tbody>
</table>


HYDROLOGY

Ground Water

The ground-water regime in the LCMA consists of two different multi-layered zones. The upper zone, or Wasatch Group consists of the Colton Formation and undifferentiated Flagstaff Limestone-North Horn Formation. The Wasatch Group covers the eastern half of the LCMA, where it dips a little north of east. Some saturated zones of the Wasatch Group are classified as perched, local aquifers because they supply ground water in sufficient quantities for a specific use (as specified by the definition for "aquifer" in R645-100-200). Low-volume springs flow from up-dip exposures of bedrock and overlying alluvium. Some spring discharges from this shallow zone have been developed to supply water for livestock during the summer months, and it is assumed that the developed water is also used by wildlife.
The Mesaverde Group consists of the Blackhawk Formation, Castlegate Sandstone and the Price River Formation. No formation or unit in the Mesaverde Group in the CIA is considered an aquifer as defined by the Utah Coal Regulations R645-100-200 because, although a considerable volume of water may be stored, the water is not developed for a specific use, the strata do not transmit ground water to supply any water sources, and the water has no potential to be used or developed nor is it elemental to preserving the hydrologic balance in the permit and adjacent areas. It has no observable discharge points within the LCMA or adjacent areas or down-dip from those areas. It does not discharge along any faults or fractures or in adjacent canyons. The impermeable Mancos Shale underlies the Blackhawk Formation. Although ground water in the Mesaverde Group is overlain by perched aquifers in the upper Wasatch Group, these two saturated zones are

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Figure 5 – PHDI for Horse Canyon Region.
separated by clay layers in the upper Blackhawk, Price River, and undifferentiated North Horn-Flagstaff Formations that contain approximately 80% clays, siltstones, mudstones and shales, all highly restrictive to ground-water movement (Fisher and others, 1960). Detailed surface mapping by Dunrud and Barnes (1972) at Horse Canyon clearly showed the intricate and extensive interfingering of sandstones, siltstones, shales, and mudstones in the Blackhawk and Price River Formations.

Hydraulic conductivities indicate very low vertical movement within the Mesaverde Group. It is sound and common practice to use information from adjacent, analogous areas in evaluating or predicting conditions in a new area. There is nothing in the LCMA that indicates depositional environments and resulting strata in the Mesaverde and Wasatch Groups are in any substantial way different from nearby areas. Table 4 lists hydraulic conductivities and transmissivities in strata of the Mesaverde Group at distant and nearby localities in the Wasatch Plateau and Book Cliffs coal fields. The wide variability of these values is indicative of the variability of the depositional environments and lithologies. A similar range of permeabilities is expected at Lila Canyon because the depositional environments and lithologies are similar.

It would be unreasonable to expect to detail all hydrologic variables in strata with multiple, interfingering layers such as the Mesaverde Group. Deposition occurred in and adjacent to an oscillating seaway in a variety of environments, and beds consist of beach sands, stream channels, delta deposits, shales, mudstones and swamp environments. Individual beds can change quickly from one point to the next, but when viewed over a larger area the same lithologies are repeated and general characteristics are definable. Similarly, the hydrologic characteristics of the beds can change rapidly within a few meters, both vertically and horizontally, but the overall hydrologic properties remain consistent.

The Mesaverde Group is likely saturated in isolated perched zones in some areas away from the escarpments. The IPA piezometers, open to the Sunnyside Sandstone that underlies the Sunnyside Coal Seam, indicate confined conditions, with hydrostatic heads several hundred feet above the coal zone. Saturation does not mean the ground water is readily available. The texture of the formations and beds ranges from course sandstone to very-fine mudstone. Movement and storage of water in the formations is related to porosity and permeability of the beds. Lateral movement of ground water is more likely than vertical movement, however any movement is very slow, and no discharge is occurring from the Mesaverde strata anywhere in the CIA.
## Table 4
**HYDRAULIC PROPERTIES of STRATA in the BOOK CLIFFS COAL FIELD, UTAH**

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>FORMATION</th>
<th>Hydraulic Conductivity in cm/sec</th>
<th>Transmissivity in cm²/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Price River</td>
<td>Castlegate</td>
<td>Blackhawk (Kenilworth Ss. Member)</td>
</tr>
<tr>
<td>Soldier Cyn. Mine</td>
<td>SC-11G</td>
<td>2x10⁻⁷ cm/sec*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC-12G</td>
<td>1.5x10⁻³ cm/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SC-13G</td>
<td>10⁻⁶ cm/sec</td>
<td></td>
</tr>
<tr>
<td>USGS (Waddell, 1986)</td>
<td>G95.5</td>
<td>7.5x10⁻⁴ cm²/sec**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G93.5</td>
<td>2.1x10⁻⁴ cm²/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G100.4</td>
<td>3.2x10⁻⁵ cm²/sec</td>
<td></td>
</tr>
</tbody>
</table>

* cm/sec = hydraulic conductivity
** cm²/sec = transmissivity

## Table 5
**HYDRAULIC PROPERTIES of the STAR POINT SANDSTONE at BEAR CANYON MINE WASATCH COAL FIELD, UTAH**

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>Star Point Sandstone</th>
<th>Hydraulic Conductivity in cm/sec</th>
<th>Transmissivity in cm²/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Panther Tongue</td>
<td>Storrs Tongue</td>
<td>Spring Canyon Tongue</td>
</tr>
<tr>
<td></td>
<td>2.6x10⁻⁴</td>
<td>1.1x10⁻⁵</td>
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<td>1.1x10⁻⁵</td>
<td>5.1x10⁻⁵</td>
<td>3.2x10⁻²</td>
</tr>
<tr>
<td></td>
<td>8.8x10⁻⁶</td>
<td>2.7x10⁻²</td>
<td>2.4x10⁻²</td>
</tr>
<tr>
<td></td>
<td>3.4x10⁻⁵</td>
<td>4.2x10⁻⁶</td>
<td>89.3</td>
</tr>
<tr>
<td></td>
<td>7.4x10⁻²</td>
<td>2.0x10⁻⁵</td>
<td>1.5x10⁻²</td>
</tr>
<tr>
<td></td>
<td>7.5x10⁻⁴</td>
<td>5.7x10⁻⁵</td>
<td>4.0x10⁻²</td>
</tr>
<tr>
<td></td>
<td>3.1x10⁻¹</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 6

**HYDRAULIC PROPERTIES of STRATA in the WASATCH COAL FIELD, UTAH**

<table>
<thead>
<tr>
<th>Core</th>
<th>Price River</th>
<th>Castlegate</th>
<th>Blackhawk</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.3×10⁻⁶ cm/sec (ss)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>3.3×10⁻¹¹ cm/sec (silt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.9×10⁻⁶ cm/sec (ss)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.9×10⁻¹² cm/sec (shale)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7.0×10⁻¹¹ cm/sec (silt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.1×10⁻⁵ cm/sec (ss)</td>
<td>5.3×10⁻⁶ cm/sec (ss)</td>
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</tbody>
</table>

**USGS Lab Measurements on Cores (Lines, 1985)**

<table>
<thead>
<tr>
<th>Core</th>
<th>Price River</th>
<th>Castlegate</th>
<th>Blackhawk</th>
<th>Star Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17-6 27bda Horizontal</td>
<td></td>
<td>1.3×10⁻⁶ cm/sec (ss)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.2×10⁻¹¹ cm/sec (silt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td>1.4×10⁻⁶ cm/sec (ss)</td>
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<td></td>
<td></td>
<td></td>
<td>Not measured</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7.8×10⁻¹⁰ cm/sec (silt)</td>
<td>3.9×10⁻⁷ cm/sec (ss)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.3×10⁻⁶ cm/sec (ss)</td>
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</tr>
</tbody>
</table>

**USGS Recovery or Drawdown Test (Lines, 1985)**

<table>
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<tr>
<th>Core</th>
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<th>Castlegate</th>
<th>Blackhawk</th>
<th>Star Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17-6 24dcd</td>
<td></td>
<td>3.9×10⁻⁶ cm/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17-6 27bda</td>
<td></td>
<td>4.8×10⁻⁶ cm/sec</td>
<td>2.64×10⁻⁶ cm/sec</td>
</tr>
<tr>
<td></td>
<td>17-6 28bd</td>
<td>5.6×10⁻⁶ cm/sec</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>17-6 34dda</td>
<td></td>
<td>7.8×10⁻⁵ cm/sec</td>
<td>1.6×10⁻⁵ cm/sec</td>
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<tr>
<td></td>
<td>18-6 4bac</td>
<td></td>
<td>5.8×10⁻⁵ cm/sec</td>
<td></td>
</tr>
</tbody>
</table>

**Genwal Mine Slag Tests**

<table>
<thead>
<tr>
<th>Core</th>
<th>Price River</th>
<th>Castlegate</th>
<th>Blackhawk</th>
<th>Star Point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW-1 (1987)</td>
<td></td>
<td>3.5×10⁻⁴ cm/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MW-4 (1992)</td>
<td></td>
<td>2.1×10⁻⁴ cm/sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MW-5 (1992)</td>
<td></td>
<td>8.8×10⁻⁴ cm/sec</td>
<td></td>
</tr>
</tbody>
</table>

In the CIA, the Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, Flagstaff Limestone, Colton Formation and Quaternary deposits all contain potential reservoirs or conduits for ground water. Reservoir lithologies are predominately sandstone and limestone. Sandstone reservoirs occur where there is sufficient intergranular porosity and permeability in lenticular fluvial-channel and tabular overbank deposits, whereas limestone reservoirs have developed through dissolution and fracturing of tabular lacustrine deposits. Shale, siltstone, and cemented sandstone beds act as aquatards or aquicludes to impede ground-water movement. The Mancos Shale is a regional aquiclude that limits downward flow. More localized aquatards occur within the North Horn, Price River, Castlegate and Blackhawk.
Ground water in the CIA, as is typical of ground water throughout the Price River basin, occurs under both confined and unconfined conditions.

Recharge in the Wasatch Plateau and Book Cliffs Coal Fields has been estimated to be 3 to 8% (Danielson and Sylla, 1983) and 9% (Waddell and others, 1986) of the average annual precipitation. Snowmelt provides most of the ground-water recharge. In the Book and Roan Cliffs the recharge rate is generally greatest where limestones of the Flagstaff Formation are exposed as dip-slopes at the higher elevations. The Flagstaff is thin and not exposed on dip slopes in the Book Cliffs Area III (West Ridge) CIA just to the north, and thins and interfingers with the North Horn and Colton Formations to the south, in the Horse Canyon area (Osterwald and others, 1981, p. 22 and Plate 2).

Recent studies in Australia (Barnes and others, 1994) and at the Nevada Test Site (French and others, 1996) indicate that recharge is not a linear process in arid and semi-arid environments, but rather there are threshold conditions involving the soil and the amount, rate, and timing of precipitation that must be met before recharge occurs; therefore, average annual precipitation alone may not accurately predict recharge and there may be years with precipitation but no recharge.

Ground-water quality varies greatly, depending on geology, physiography, and elevation. Waddell and others (1986) indicate that TDS concentrations range from 250 to 2,000 mg/L in the Book Cliffs area. The best quality occurs in or near mountain recharge areas and the poorest quality in lowland areas. The chemical characteristics of the ground water vary vertically from formation-to-formation and areally within each formation. TDS in water from the Flagstaff Limestone ranges from 250 to 500 mg/L, whereas TDS in the Blackhawk and North Horn Formations range from 500 to over 1,000 mg/L. The principal chemical constituents in Flagstaff water are calcium and bicarbonate. Water from the Blackhawk Formation is of variable chemical composition with no single dominant cation or anion. Where dissolved solids concentrations in water of the Blackhawk Formation are affected by Mancos Shale, sulfate and sodium increase significantly. Water from two springs that issue near the contact between the Blackhawk Formation and the Mancos Shale near Soldier Canyon have specific conductivities equivalent to TDS concentrations of 1,600 and 2,000 mg/L.

Water samples collected from several sump locations inside the Sunnyside Mine consistently had TDS levels in excess of 1,200 mg/L. Samples from two shafts averaged approximately 700 mg/L (Mayo & Associates, 1998, Appendix A), which is probably more representative of the ground water above the coal seam. Waddell and others (1981, p. 41) suggest water from the Sunnyside Mine is highly mineralized because of it may be derived from the Mancos Shale, the Mancos commonly intertonguing with the Blackhawk in this area of the Book Cliffs. Waddell also noted that, except for the Sunnyside Mine, water from mines and springs discharging from the Blackhawk Formation had dissolved-solids concentrations ranging from about 60 to 800 mg/L, the principal dissolved constituents being calcium, magnesium, bicarbonate, and sulfate.
Drill hole DH-86-1 is located in Whitmore Canyon, near the Sunnyside Mine and north of Horse and Lila Canyons. It is open to the Bluecastle Sandstone Tongue of the Castlegate Sandstone. With the exception of one sample with 1,264 mg/L, TDS levels in the other 23 samples ranged from 282 to 720 mg/L and averaged 564 mg/L. Magnesium, calcium, and carbonate were the dominant ions. Waters from springs SP-6, SP-8, and PC-1 also are high in TDS. Located in the same general area, DH-86-2 is open to the Sunnyside Sandstone. TDS in 14 samples averaged 1,244 mg/L, and sodium, magnesium, and sulfate were the dominant ions (Mayo & Associates, 1998, pp. 66, 69, Appendix A).

Water samples were collected by Kaiser, both inside the Horse Canyon Mine and as water was discharged from the mine. Analyses indicate that Blackhawk Formation ground water has a mean TDS concentration range of 1,400 to 2,400 mg/l and is calcium – sodium – sulfate type water (MRP-Part A, Appendix VI-1; MRP-Part B, Sec 724.100, Mine Inflow Information, Appendix 7-1). Lines and Plantz (1981) analyzed mine water after it had been discharged to Horse Canyon, and snowmelt runoff was included in some samples; still, based on 12 samples, TDS ranged from 953 to 4,220 mg/L and averaged 1,960 mg/L; sodium and sulfate were the predominant ions. Lines and Plantz suggested that the water in and adjacent to the coal seam is so mineralized because, as at Soldier Creek, the lower Blackhawk Formation and Mancos Shale are interbedded.

Saturation indexes indicate that most ground waters in the Blackhawk Formation in the Book Cliffs are at saturation with respect to calcite and dolomite. Ground waters are generally undersaturated with respect to gypsum and anhydrite (Waddell and others, 1986, Table 8).

Once recharge enters the ground, the rate and direction of ground-water flow is governed mainly by gravity and geology. Lateral ground-water flow dominates in the alluvium, colluvium, and weathered rock overlying gently-dipping Tertiary and Cretaceous strata of the Book and Roan Cliffs. Layers of low-permeability rock impede downward movement of water that has seeped into the ground.

Both lateral and vertical flow may be channeled through faults and fractures, but plastic or swelling clays that can seal faults and fractures are abundant (Figure 2, Table 2). Typically, ground-water flow in the Book and Roan Cliffs continues both laterally and downward until it intercepts the surface and is discharged as a spring or seep, enters a stream as baseflow, is transpired by vegetation, or simply evaporates. Ground water tends to flow more readily through shallower systems because the hydraulic conductivities are commonly larger than those of deeper systems, but some of the ground water will follow slower, deeper flow-paths.

Permeabilities and hydraulic conductivities of strata have not been measured above the proposed minesite, however reports produced by the USGS and mining companies indicate that low hydraulic conductivities in the strata can be expected to restrict ground-water movement (Tables 2 and 2b).
A discussion of the type of hydraulic conductivities expected in the Sunnyside Sandstone Member of the Blackhawk Formation below the coal seam is indicated in the following paragraph from the Soldier Canyon CHIA, which describes homologous sandstone beneath the Gilson Seam, probably part of the Kenilworth Sandstone Member of the Blackhawk Formation:

In August 1986 bore holes SC-11G, SC-12G, SC-13G were drilled from the Rock Canyon Seam workings of the Soldier Canyon Mine down through the Gilson Seam and a 13- to 20-foot thick, clean sandstone located approximately 40 to 50 feet below the Gilson Seam. Hydraulic conductivities of $2 \times 10^{-7}$ to $10^{-6}$ cm/sec were measured in SC-11G and SC-13G, but hydraulic conductivity was $1.5 \times 10^{-3}$ cm/sec in SC-12G. The tests measured the hydraulic conductivity of the entire stratigraphic sequence. Ground water was under confined conditions in all three boreholes, but in SC-12G the measured head was 250 feet above the floor of the mine and water flowed into the mine until the hole was capped. The gradient determined from the three boreholes was 1,800 ft/mile (approximately 12°) in a direction N 11° E.

Even assuming the boreholes measured the hydraulic properties of the same stratigraphic sequence at three different locations, the range of hydraulic conductivities shows great inhomogeneity, and the true potentiometric surface is almost certainly not planar with a uniform dip to the north-northeast. No further measurements have been reported for these wells and they are no longer usable as far as is known. Information on these three boreholes, including driller's logs, is in Appendix 7-I of the Soldier Canyon Mine MRP.

Springs in the Book Cliffs and Wasatch Plateau Coal Fields are often associated with contacts between zones or strata of differing permeability, such as at the base of sandstone lenses in the Colton and Green River Formations or fractured limestone beds in the Flagstaff and tight mudstones of the North Horn Formations (Osterwald and others, 1981). In many areas, such as the Soldier and Dugout Canyon area northwest of Horse Canyon, the contact between the Flagstaff Limestone and the North Horn Formation is the preferred location for springs; however, in the Book Cliffs Area III (West Ridge) and Book Cliffs Area V CIAAs there are only a few springs at this contact because the Flagstaff Formation is thin or absent and the contact between the Flagstaff Limestone and North Horn Formations is transitional (Osterwald and others, 1981), and in addition the overlying Colton Formation is relatively thick.

UEI submitted an initial inventory of seeps and springs in and adjacent to the LCMA. The inventory included sites identified by Kaiser Coal and consultant companies JBR and EarthFax. The data were collected between 1981 and 1995. Many of these seeps and springs have very low flow and flow for only a short period. For initial baseline ground-water monitoring, UEI selected 6 springs (including Redden Spring), plus the three IPA piezometers for water level measurements only. Since initiating monitoring, UEI has replaced 2 ground-water monitoring sites with offsetting sites (L-6-G with L-11-G and L-10-G with L-12-G) and added 2 sites below the coal seam (L-16-G and L-17-G). The Division has used information on these seeps and springs to help characterize the hydrologic regime for the CIA, in and adjacent to the permit area. Some of the seeps and
springs were not considered useful because of insufficient information on location or water quality and quantity. Plates 3 and 4 show locations for all known seeps and springs, washes and streams, surface-water monitoring sites, and piezometers.

The paucity of perennial springs and flows in the area results from both the geologic characteristics and arid climate. There are no perennial water sources at the base of the Book Cliffs escarpment near the proposed Lila Canyon surface facilities, only the two perennial seeps (L-16-G and L-17-G) exist in Stinky Spring Wash south of the Lila Canyon permit area, which flow near the contact of the Mancos Shale. They appear fault-related. Redding Spring is the only continuous source in Horse Canyon (outside the Lila Canyon Mine permit area) below the Book Cliffs escarpment. It flows from near the boundary between the Price River Formation and North Horn-Flagstaff Formation at a rate of about 8-20 gallons per minute (gpm) throughout the year. All other spring sources in and adjacent to the proposed LCMA are located above the escarpment. Monitoring Spring L-10-G, which has removed from the monitoring plan, flows from the upper Price River Formation in Little Park Wash, near the Williams Draw Fault. The remainder of springs on and adjacent to the proposed LCMA are associated with the undifferentiated Flagstaff-North Horn and lower Colton strata and do not appear related to any of the identified fault systems. These springs typically appear to be associated with separate, isolated sandstone units within the formations. Springs in the headwaters of Little Park Wash, monitoring data shows the flows are very low reflecting the small recharge areas.

On July 2, 2001, UEI conducted a spring survey that included springs L-9-G and L-7-G. The main channel of Little Park Wash and its tributary channels are typically dry. Spring L-9-G is accessed through a narrow draw, accessible by vehicle only in the lower part. The survey team hiked up the draw and eventually ran into wet alluvium. 100 meters farther up the draw there was a small flow in the channel, and flow was 5 gpm at Spring L-9-G (Figure 7). A hike up the channel from spring L-9-G located a similar spring site and flow situation only with less flow. Flow along the channel was discontinuous downstream of the springs. Flows were observed where bedrock was exposed in the channel and were reduced when alluvial gravels filled the channel.

Temperatures for the springs monitored July 2, 2001 ranged in the high 50's °F. Specific Conductance was between 700 to 780 micromhos, indicating relatively good water quality.
Figure 6. Watering Trough at Spring L-7-G. The spring emanates in the channel above the fence. Water is diverted into a plastic pipe and into the trough. Spring flow was measured at 2 gpm.

Most of the springs on the escarpment are within a mile of the ridgeline that divides Little Park Wash from Range Creek Canyon; this ridge is a southern continuation of Patmos Ridge, a western extension of the Roan Cliffs (Van Cott, 1990; Osterwald and others, 1981). The stratigraphy in this area consists of the Upper Colton Formation, which is the recharge zone for the springs. The Colton Formation is a multi-layered formation having very low hydraulic conductivity\(^1\) in some of the strata. It consists of interbedded siltstones, sandstones and mudstones deposited in a terrestrial/paludal environment. The limited recharge area and low hydraulic conductivities of the same rock units within the Colton Formation account for the very low volumes of discharge from the springs.

The undifferentiated Flagstaff Limestone – North Horn Formation underlies the Colton Formation. The Flagstaff Limestone is the ground-water (spring) producing formation near Soldier Canyon, northwest of the proposed LCMA area. The fracture system that is usually associated

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\(^1\) Hydraulic Conductivity replaces the term "coefficient of permeability" and should be used in referring to the water transmitting characteristics of material in quantitative terms, or the ability of rock to transmit water, 1989, Heath, Ralph C., U.S. Geologic Survey Water Supply Paper 2220.
with the limestone forms good conduits for transmitting ground water. As ground water flows through the Flagstaff Limestone it comes in contact with interbedded mudstones and shales of the North Horn Formation, which act as an aquitard, so that springs often form near the contact. The undifferentiated Flagstaff Limestone – North Horn Formation is not extensively exposed in the Horse Canyon Mine - LCMA.

The springs are about 1,000 to 2,400 feet above the coal seam to be mined for the proposed Lila Canyon Extension (Table 7 and 8). It is very unlikely that subsidence or subsidence fractures would reach the springs or recharge sources to cause any impacts.

The interbedded claystones, siltstones, and sandstones of the Mesaverde and Wasatch Groups are rich in swelling clay minerals of the montmorillonite or smectite group. Swelling clays absorb water and expand to as much as 150 percent of their dry volume. These swelling clays reduce the hydraulic conductivity of the rock or soil that contains them and contribute to the rapid closing or sealing of fractures that result from subsidence. Genwal examined 6 shale and siltstone samples from the Blackhawk Formation from the Wasatch Plateau by X-ray diffraction and cross-polarized light microscopy and found the samples contained 3 to 34 percent smectitic clays, with an average of 24 percent. Siltstones and shales in the Castlegate (3 samples) averaged 19 percent smectitic clay, and the Price River Formation (3 samples) 15 percent. Non-swelling clays, which also inhibit ground-water flow, constituted an additional 1 to 6 percent of the rock volume (Crandall Canyon Mine MRP, App. 7-41).

Observations at numerous mines in both the Wasatch Plateau and Book Cliffs coal fields support the conclusion that, when ground water is present, shale layers in adjacent formations tend to swell and seal fractures that are created by subsidence. This swelling and sealing phenomenon restricts movement of water through conduits created by subsidence; it also explains in part why the flow of water intercepted during mining often diminishes gradually over time.

Table 7  Elevation of Lower Sunnyside Coal Seam, Spring Resources, and Thickness of Strata

<table>
<thead>
<tr>
<th>SURFACE ELEVATION</th>
<th>COAL ELEVATION</th>
<th>OVERLING STRATA THICKNESS</th>
<th>COVER THICKNESS from MRP-Part B, PLATE 6-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-6-G / H-18</td>
<td>7500</td>
<td>5700</td>
<td>1800</td>
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<tr>
<td>L-7-G</td>
<td>7400</td>
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<td>2500</td>
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<td>L-8-G</td>
<td>7400</td>
<td>5000</td>
<td>2400</td>
</tr>
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<td>L-9-G</td>
<td>7300</td>
<td>5000</td>
<td>2300</td>
</tr>
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<td>L-10-G</td>
<td>6700</td>
<td>5500</td>
<td>1200</td>
</tr>
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<td>L-11-G / H-18-A</td>
<td>7500</td>
<td>5600</td>
<td>1900</td>
</tr>
<tr>
<td>L-12-G / 11</td>
<td>6750</td>
<td>5600</td>
<td>1150</td>
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<td>1655</td>
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<td>IPA-2</td>
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<td>5895</td>
<td>970</td>
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<td>IPA-3</td>
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<td>5764</td>
<td>1046</td>
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<tr>
<td>RS-2, Redden Sp.</td>
<td>6600</td>
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</table>
Three piezometers, IPA-1, IPA-2 and IPA-3, are used to monitor the potentiometric surface in the Sunnyside Sandstone Member of the Blackhawk Formation, just below the coal seam. Completion information for these three piezometers is in Appendix 6-2 of MRP-Part B. The boreholes were originally drilled in 1993 and 1994 to assess the thickness and quality of the coal, so they penetrate only 100 to 200 feet below the lower Sunnyside Coal. To complete the boreholes as piezometers, 2-in diameter steel casing was cemented from the surface to below the coal seam, and 20 feet of slotted screen was installed in the Sunnyside Sandstone interval. Since the initial water-level measurements in July 1994, the potentiometric surface has remained well above the coal seam. Because of the water levels measured in these piezometers and because ground water frequently flows into other mines in the Book Cliffs Coal Field, it is expected that development of the Lila Canyon Extension will also result in flow into the mine. UEI has made plans to use, store and treat any ground water intercepted in the mine and to ensure it meets Utah Pollutant Elimination Discharge System (UPDES) standards before any water is discharged from the mine.

Water levels were measured in the piezometers 1994 through 1996. There was a hiatus in monitoring after 1996 until late 2000, when UEI began work to permit the LCMA. Water depth could be measured only at IPA-2 in December 2000. The measured depth, 899 feet from the surface, closely matched the levels taken at the same piezometer in 1994-1996. All three piezometers were used to measure water levels in 2001 through 2003 and 2005, and are included in MRP-Part B. Depths in wells IPA-2 and IPA-3 in 2001, respectively 901 and 839 feet, were similar to earlier measurements. IPA-1 has shown a steady rise (decrease in depth) over the years, from 1,134 in July 1994 to 1,128 in April 1996 to 1,111 in March 2005. IPA-2 and IPA-3 are in the same fault block, and their almost static levels are a good indication of stability in the water level of this area.

The rise in water level at IPA-1 is not completely understood. A fault separates IPA-1 from the other two piezometers, and the throw on the fault ranges about 50 feet up on the north block at the western end of the fault to an unknown displacement on the eastern end. The bedding dips to the northeast. The Horse Canyon Mine is over a mile to the north, but an exploration tunnel that was developed for the mine (1957 to 1962) was driven south through Section 14, a mile west of IPA-1. It is not known if the development of this tunnel has any connection with the rise of the water level in the piezometer. Other possible factors producing this slow rise could be:

- A leaky annular seal that is allowing surface water to reach the monitored zone and slowly raise the water level;
- Very low hydraulic conductivity in the surrounding rock so that the water level in the bore hole has not yet reached equilibrium; and
- Debris, damaged screen or other well construction factors that have delayed the water level in the borehole from reaching equilibrium.
A suggestion was also made that the casing has deteriorated, allowing material to slough in and raise the water level; however, it does not seem likely this could account for a seemingly steady rise in water level since the piezometer was completed.

Mining may eventually undermine these IPA piezometers and render them useless, but combining information from these piezometers with monitoring of flows into the mine and mine discharges will provide a good picture of the effect mining is having on the deep saturated zones near the coal seam.

Most water entering mines in the Wasatch Plateau and Book Cliffs Coal Fields comes through leaks in the mine roof as water in storage in the interstices of the rock matrix seeps into the mine. The amount of ground water that is contacted depends on the porosity and permeability of the surrounding rock that is penetrated during mining. Sometimes mining intersects faults that produce in-mine flows.

Historically, mine water has been discharged from the nearby Soldier Canyon, Sunnyside, and Horse Canyon Mines. Some discharges have been as high as several hundred gallons per minute. This information provides a basis for expecting mine water discharge from the proposed Lila Canyon Extension.

UEI cannot predict how much water will be encountered during mining at the Lila Canyon Extension, but have made plans to discharge mine water if the amount exceeds the what is needed during mining operations. Regardless of how much water is encountered during mining, natural flow from the mine portals is not expected. UEI bases this on the elevation of the potentiometric surface, from measured water levels in the piezometers, relative to the coal seam elevation (MRP-Part B, Plate 7-1, Figures 7-1 and 7-2). The highest water elevation measured (which is the head of water in the lower Sunnyside Coal Seam) as of 2005 is 5,973 feet in Well IPA-3. The elevation of projected interception of the coal seam with the rock slope tunnel is 6,300 feet, over 300 feet higher than water in IPA-3. The tunnels will angles upward at about 12° to the east northeast. The proposed mine will extend down-dip 3,530 feet from the tunnel intercept before the water table is contacted. Mine plans indicate that, if needed, any mine water discharges would be pumped from the mine via the coal loadout entry, then transported through a pipe to the ephemeral Right Fork of Lila Canyon channel, a tributary to Grassy Trail Creek.

**Surface Water**

The CIA is drained mainly by Horse Canyon Wash, Lila Canyon Wash, Stinky Springs Wash, the Right Fork of Lila Wash, and Little Park Wash. Table 8 provides information related to the drainages in the CIA. Topography in the area varies from vertical cliffs to slopes less than 5° in the Grassy Wash valley, before the Book Cliffs and Little Park wash Valley before the Roan Cliffs. Some of the draws that supply these stream channels contain springs, which flow perennially for short distances then filter into the channel deposits. All the springs on the CIA flow less than 10 gpm and most flow only one or two gpm. There is no baseflow sustained in any CIA
stream channels far from any springs because spring discharge infiltrates into the deep alluvium of the channels. Snowmelt is the major source of water for the springs. Intense summer thunderstorms may cause short-term flooding. Water use of the springs is for wildlife and stock. There are no major reservoirs located within the CIA.

During warm snow melts and heavy rain storms erosion takes place and the streams become loaded with sediments especially in the lower reaches where vegetation is sparse and hillsides of the Blackhawk Formation and Mancos Shale are exposed.

Vegetation is mainly pinion/juniper with grass undercover to sagebrush with grass undercover. Soil cover varies with slope. Soil is sparse on cliffs and outcrops. Soils are several inches deep over most of the flatter areas of the CIA and are very soft. Vegetation matter from the covers the ground where forests of pinion/juniper exist. Soils are classified under hydrologic soils group B through D.

Watersheds of the CIA

Price River

The Price River is perennial throughout its length. It begins at Scofield Reservoir where its flow is regulated. It joins the White River then flows down Price Canyon. Its discharge is measured at several locations both upstream and downstream of the confluences with Deadman, Coal, Soldier, and Grassy Trail Creeks. The area of the Price River drainage is 455 square-miles above USGS gauging station 09313000 near Helper, and 1,540 square-miles above USGS streamflow gauging station 09314500 near Woodside, about 10 miles below the confluence with Grassy Trail Creek. Between these two stations water is taken from the river and its tributaries for irrigation.

Snowmelt is the major source of water for the streams of the Price River basin. Intense summer thunderstorms cause short-term flooding, but not large volumes of runoff. Water use in the higher elevations of the Price River basin is initially for wildlife and stock watering purposes. Storage reservoirs are common at higher elevations for stock watering.

In general the quality of water in the headwaters of the Price River basin is very good. Waddell and others (1981) report that the Price River and its tributaries generally have a TDS concentration of between 250 to 500 mg/L upstream from Helper, and the water type in this area is calcium bicarbonate. However, the quality of water in the Price River rapidly deteriorates down gradient. Below the town of Helper, Utah, most flows originate on Mancos Shale or are irrigation return flows from lands situated on Mancos-derived soils (Price and Waddell, 1973). The Price River near the confluence with Soldier Creek has an average TDS content of about 1,700 mg/L, including sulfates of calcium, magnesium and sodium. At USGS station 09314500, the weighted average TDS content is between 2,000 and 4,000 mg/L, with the water type being strongly sodium sulfate (Mundorff, 1972).
Soil cover varies with slope, with bare sandstone cliffs along the upper portions of the canyons, shallow silty soils on the milder slopes, and shallow sand-gravel alluvium in the channel bottoms. Soils in the CIA are dominantly in hydrologic soils groups B to D (Wilson, 1975), having infiltration rates that are moderate to very slow.

The average annual sediment yield is 0.5 to 1.0 ac-ft/mile²/yr across most of the CIA, so the estimated average annual sediment yield of the Horse Canyon CIA is 57 to 114 ac-ft/yr for undisturbed conditions. (The expected sediment yield from the Lila mine disturbed area is 0.3090 ac-ft/yr.) The higher elevations of the Book and Roan Cliffs, where limestone and dolomite are exposed on steep slopes, have the lowest sediment yield, 0.1 to 0.2 ac-ft/mile²/yr. On lower, flat areas developed on the more erosive sandstones and shales of the Mancos Shale, sediment yield is 0.5 to 3.0 ac-ft/mile²/yr (Waddell and others, 1981, Plate 6).

USGS water discharge data are available for station 09314500 for water years 1946 to 1992, and 2001 to 2004. Records are fair except for estimated daily discharges, which are poor. Maximum-recorded discharge was 6,180 cfs on September 7, 1991. Periods of no flow were recorded in 1960, 1961, 1992, 2002, 2003, and 2004. The mean annual flow volume (1946 to 1992) was 120 cfs or 87,000 acre-ft/year. Limited water quality data are available for 1946 to 1949, 1951 to 1988, and 1991 to 1996.

Discharge of the Green River has been measured at USGS gauging station 0931500 at Green River, Utah, about 12 miles below the confluence of the Price and Green Rivers (Table 9). For water years 1894 to 1899 and 1905 to 2004 flow ranged from a minimum of 380 cfs on December 5, 1934 to a maximum of 66,700 cfs on June 27, 1917. Average annual discharge is 6,132 cfs or 4,440,000 acre-ft/year. Fontenelle and Flaming Gorge Reservoirs have regulated flow in this reach of the Green River since 1964 and 1962, respectively. Records are good except for estimated daily discharges, which are poor. Water quality data are available for 1928 to 1996 (Table 8).
Figure 7 Daily Mean Flow of Price River at Woodside, Utah.
### Table 8. SUMMARY OF SELECT WATER QUALITY DATA FROM USGS STATIONS

#### PRICE RIVER AT WOODSIDE AND GREEN RIVER AT GREEN RIVER UTAH

<table>
<thead>
<tr>
<th>STATION</th>
<th>WATER YEAR</th>
<th>SPECIFIC CONDUCTANCE (Microhos)</th>
<th>pH (units)</th>
<th>TEMPERATURE (deg C)</th>
<th>CALCIUM (mg)</th>
<th>MAGNESIUM (mg)</th>
<th>SODIUM (mg)</th>
<th>POTASSIUM (mg)</th>
<th>CHLORIDE (mg)</th>
<th>SULFATE (mg)</th>
<th>BICARBONATE (mg)</th>
<th>IRON (mg)</th>
<th>MANGANESE (mg)</th>
<th>SUSPENDED SOLIDS (mg)</th>
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**Note:** ppm = parts per million; mg/L = milligrams per liter; Fe = iron; Mn = manganese; Mg = magnesium; Ca = calcium; Na = sodium; K = potassium; Cl = chloride; SO4 = sulfate; HCO3 = bicarbonate; pH = potential hydrogen; Temp = temperature; Temp unit = deg. C; **Min.** = minimum; **Max.** = maximum; **Fe** = iron; **Mn** = manganese; **Suspended Sediment** = total dissolved solids.
<table>
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Notes:  Station locations:  See 4 (Price River Drainage Basin.  Constituents :  in mg/L, except manganese and iron, which are in micrograms/L.  Specific Conductance:  field determinations.  pH:  field determinations.
Grassy Trail Creek

According to Mundorff (1972), Grassy Trail Creek has the largest drainage area of any tributary to the Price River. The headwaters of Grassy Trail Creek are in the area between the Book Cliffs and the Roan Cliffs, at altitudes ranging from approximately 7,000 ft. to over 9,000 ft. Whitmore Canyon, a steep, deep, narrow valley, has been eroded through Tertiary and Cretaceous strata. At the mouth of Whitmore Canyon, Grassy Trail Creek crosses a large alluvial fan, and then meanders across a gently sloping plain on the Mancos Shale to its confluence with the Price River. The lower portion of Grassy Trail Creek forms the southwestern boundary of the CIA.

Grassy Trail Creek is perennial in Whitmore Canyon to just below Grassy Trail Reservoir. Water is usually only released from the reservoir in the spring if water levels in the reservoir are high. The stream is usually ephemeral in the canyon below the reservoir, but picks up some runoff from Water Canyon in the spring and from the towns of Sunnyside and East Carbon as storm drainage. The stream provides characteristic water quality and quantity found along the Book Cliffs, even though the upper portion of Grassy Trail Creek is not part of the CIA.

When Sunnyside Mine was operating, ground water was pumped from the mine to Grassy Trail Creek. The creek became perennial below the mine for several miles, supporting aquatic life. The Sunnyside Mine was reclaimed in 1996. Mine portals were backfilled and mine discharges ceased. Grassy Trail Creek changed from a perennial to an ephemeral stream because no water was being pumped from the mine.

For water years 1979 to 1985, during the period when water was being pumped from the mine to the stream, the USGS measured discharge of Grassy Trail Creek at station 09314340 located approximately half way between the town of Sunnyside and the Sunnyside Mine (Figure 8). Record quality was good. Grassy Trail Creek average daily mean discharge for the seven-year period was 9.9 cfs. Maximum daily mean flow was 349 cfs on May 28, 1983 and maximum measured flow was 631 cfs on May 31, 1983. Minimum daily mean flow was 0.04 cfs on February 22, 1981, and no flow was observed on several days in February 1981.

Water quality was measured in samples from station 09314340 during water years 1979 to 1984 (Price and Plantz, 1987). TDS ranged from 330 to 1,900 mg/L, with a mean value of 988 mg/L. In general, dominant cations were calcium and magnesium and dominant anions were bicarbonate and sulfate; however, there were seasonal variations that related directly to TDS, which was related to streamflow and mine discharges.
Suspended sediments in 25 samples ranged from 4 to 1,640 mg/L. The largest calculated instantaneous sediment load was 518 tons/day. The sampled sediments were about 17% coal, with water discharged from the mines being the probable source (Price and Plantz, 1987).

Price and Plantz (1987) reported good benthic-invertebrate diversity in Grassy Trail Creek. In the five phytoplankton samples collected in 1981, green algae had a uniform distribution but blue-green algae had relatively larger numbers in three of the samples.

Monitoring of Grassy Trail Creek by Sunnyside Mines showed that from 1989 through 1992, when sampling ceased, TDS consistently exceeded 1,200 mg/L between the Sunnyside Mine and the town of Sunnyside. During this same period, TDS concentrations also increased at monitoring sites upstream of the main mine area. This does not appear to have been solely due to
road salting, because concentrations of all ions increased more-or-less uniformly.

**Horse Canyon**

Horse Canyon originates at an altitude of approximately 9,600 feet and flows into Grassy Trail Creek. Data is available in the Division database for monitoring site B-1 (HC-2) from April 1981 to recent. The USGS maintained gauging station 09314374 just below the Horse Canyon Mine during the 1979 to 1981 water years (USGS, 2001 and, 1987) (Figure 9). The watershed area of the drainage above this station is 12.5 square-miles. No water flows from the LCMA to the Horse Canyon drainage.

Horse Canyon is an intermittent stream at the gauging station. Flow data was quite variable during the two years when monitoring was conducted by the USGS. Mean annual discharge at the gauging station was 170 gpm (0.43 ft³/sec) and discharge from the mine probably accounted for half of that, based on observations in 1979. According to Lines and Plantz (1981), an average of 89.6 gpm (0.2 cfs) may have been discharged intermittently from the Horse Canyon Mine. U.S. Steel also reported (Section 6.2.2.1.) that inflow to the mine from ground water was not precisely known, the average mine water discharge was estimated to be 0.2 cfs. Greatest daily discharge was 1,080 gpm (2.4 ft³/sec) in May 1980; however, a storm in November 1979 produced a flow of 940 gpm (2.1 ft³).

The USGS performed seven sets of base-flow measurements in Horse Canyon between August 1978 and August 1981, at stations above and below the mine discharge. The channel was dry at least once at each site, but average values indicated that baseflow was entering the channel somewhere between the upper Price River and upper Blackhawk Formations (Price and Plantz, 1987).

Flow levels dropped to no-flow since 1989 after mining had discontinued (no data for 1983 to 1988). Flows in the two forks above the mine site (HC-1 and RF-1) have been fairly consistent during and after mining. Flows in the forks have generally been low except in response to storms. A flow of 654 gpm was recorded in the Left Fork on May 1, 1993, but there was no-flow reported in the Right Fork that usually has flow, and no flow below the mine on that day. The 654 gpm data point is thought to be in error.
Figure 9. Daily Mean Flow of Horse Canyon Wash near Sunnyside, Utah.

Water samples were collected and analyzed from August through September 1979 (Lines and Plantz, 1981) and during water years 1979 to 1981 (Price and Plantz, 1987). Most of the water sampled was discharged from the mine just upstream of the monitoring station. TDS averaged approximately 1,900 mg/L, with a low of 953 mg/L and a high of 4,220 mg/L. Sodium and sulfate were the main dissolved ions. Suspended sediment was measured in twenty-seven samples: concentrations ranged from 2 to 2,278 mg/L. Suspended-sediment discharge ranged from less than 0.01 to 2.0 tons/day and was greatest during spring snowmelt.

Benthic invertebrates were sampled during the summers of 1978 and 1979. The small diversity of organisms reflected the poor water quality and intermittent flow (Lines and Plantz, 1981).

Redden Spring is located in the South Fork of Horse Canyon, approximately 0.5 mile above the confluence with the North Fork of Horse Canyon. The spring was developed to supply some of the domestic use at the mine. Water was piped from the spring to a pump that filled the water tank. UEI continues to monitor the spring, however it is no longer used for mining. It now flows down the channel at an initial rate between 8 to 20 gpm before it seeps into the alluvium, no more than 3,000 feet downstream of the spring.
Grassy Wash

Grassy Wash (not to be confused with Grassy Trail Wash) is ephemeral. It receives flow during large snowmelt or rainstorm events from its tributaries that drain the Book Cliffs escarpment south of Horse Canyon to just south of Stinky Springs Wash. Grassy Wash is just over 12 miles in length from its confluence with Marsh Flat Wash to an unnamed tributary south of Horse Canyon. Lila Wash, the Right Fork of Lila Wash, and Stinky Springs Wash are the largest tributaries that contribute to Grassy Wash. These tributaries have headwaters that begin above the escarpment between 7000 ft. and 9000 ft. elevation; they too are ephemeral functioning, except for the very headwaters of Lila Wash where springs sustain some perennial flow.

There are a myriad of small ephemeral drainages along the escarpment and piedmont supply ephemeral flows to Grassy wash. The lands below the escarpment the area is made up of alluvial deposits and soils washed down from the formations above and bare surfaces of Mancos shale. The BLM and ranchers have dammed some of the small drainages to capture the ephemeral flows for stock ponds. None of these drainages lie within the disturbed area or maximum zone of subsidence of the proposed Lila mine permit area.

UEI reports there was once a diversion on the Right Fork of Lila Wash that delivered flow to a stock pond adjacent to Grassy Wash, but now confirms that the diversion is breached and flow no longer is transported to the stock pond. It was also found that the stock pond was damaged and did not have a water right.

Grassy Wash joins with Marsh Flat Wash then flows to the Price River about 2 miles northwest of Woodside, Utah.

Lila Canyon

Lila Canyon drains an area of approximately 1,317 acres (Table 9). It begins as a narrow steep drainage above the escarpment. Small perennial and intermittent springs, including L-6-G and L-11-G flow then vanish into the channel bottom. The channel is ephemeral functioning at the Little Park county road above the escarpment. One snowmelt sample was taken from the stream on March 29, 2005, below L-11-G (see data in the Division database).

Most of the Lila Canyon drainage has been undermined by the Horse Canyon Mine. The only mining planned in Lila Canyon will take place in two 10-acre areas. One area has previously been undermined. The other will be undermined by entries for the Lila Canyon Extension. Cover ranges between 500 feet to 1,000 feet.

There are two water rights (91-617 - Leslie Spring, and 91-618 - Mont Spring) located in the proposed Lila Canyon Extension permit area, in the upper part Lila Canyon, Section 11. They are designated for stock watering directly on the spring. The springs have already been
undermined by the Horse Canyon Mine. They will not be undermined by the Lila Canyon Mine and both springs lie outside the area of maximum subsidence (21.5 % angle of draw).

The channel drains the canyon, and runs along the north site of the proposed mine facilities on a 12-degree slope before it crosses a lower county road. Monitoring site L-S-1 is located in the channel above the county road. The channel runs another 1.9 miles before it drains into Grassy Wash. That confluence is over 10 miles above the Price River.

The unmaintained county road runs along the valley at the foot of the Book Cliffs escarpment, west of the mine facilities site, then to the Horse Canyon road. A 60-inch culvert once transmitted flow under the county road at the mouth of Lila Canyon, but is now buried under 20 feet of sediment.

Surface flows on the proposed facilities area will be directed away from Lila Wash. Stream buffer zone markers will be placed along the channel to mark the 100 ft zone and alert personnel that the channel is to be protected. There will be no discharges to the channel. There are no drinking water sources or state appropriated water resources of the surface waters on or downstream of the drainage, below the escarpment.

**Right Fork of Lila**

The Right Fork of Lila Wash drainage is ephemeral. It begins above the escarpment, flows south then west where it will pass along the south side of the Lila Canyon Mine and surface facilities. Average, channel gradient adjacent to the facilities is 8%. The drainage is 278 acres at the county road that crosses the drainage. The channel runs another three miles before it empties into Grassy Wash. A 60-inch culvert will replace the existing culvert then extended up the channel (approx. 500 ft) to divert the drainage beneath the facility sedimentation pond. The pond was designed to contain and treat the total runoff and sediment load of the disturbed area and some undisturbed areas. Discharge from the pond will be to the Right Fork of Lila Wash in accordance with requirements of a UPDES permit.

Two surface water sites (L-S-2 and L-S-3) monitor the stream flow above and below the facilities. Two UPDES sites are established: UTG040024-001 (L-4-S) for the sedimentation pond discharge, and UTG040024-002 (L-5-G) for mine water discharge.

Mining will occur under the parts of the drainage above the escarpment. Subsidence can occur. No springs or functioning water right exist along the channel. The channel below the facilities was surveyed for baseline channel shape. Inspections will take place to assess any impacts.

There are no drinking water sources or State-appropriated water resources of the surface waters on or downstream of the drainage.
Stinky Springs Wash

Stinky Springs Wash is an ephemeral drainage covering an area of 850 acres. The drainage begins above the escarpment. Two water rights (91-4648 and 91-4649) are listed for stockwatering and wildlife use from reservoirs along the Stinky Wash drainage within the proposed permit area. The reservoirs are not maintained and do not appear to be functioning. There are no springs in the headwaters of the drainage. There are two springs, L-16-G and L-7-G, below the escarpment. The springs are associated with the small fault and emit a hydrogen sulfide odor and are surrounded by a dark precipitate. The surface runoff is monitored at L-18-S. No flow has been monitored.

Mining is planned beneath the drainage. Cover ranges from 400 to 700 feet. Mining the western most longwall panel under Stinky Springs Wash may cause parallel fractures in the channel. Although there will be relatively little subsidence in the channel it is expected that fissures could develop from strain. The eastern side of the canyon is could subside. Mining should not impact the springs, because the coal seam is higher than the springs.

Little Park Wash

Little Park Wash and its tributaries, Figure 10, are ephemeral functioning drainages. They drain the dipslope of the Book Cliffs and escarpment of the Roan Cliffs that form the mountainous region above the minesite. Little Park Wash drains an area of 5,822 acres above the southern boundary of the Lila Canyon Mine permit area, most of the surface area above the mine site. The channel runs another 12 miles before it drains into Trail Canyon Wash, then into the Price River. Four springs L-7-G, L-8-G, L-9-G and L-12-G and two surface monitoring sites (L-13-S and L-14-S) are monitored. Springs flow perennial and intermittent in the upper drainages near the Colton and undifferentiated North Horn-Flagstaff formations contact. Springs have been shown to flow a short distance down stream 200 to 500 yards before they seep into the alluvium of the channels.

The channels below the springs (and piezometers) have been observed each time sampling was conducted and found to contain no flow. There are no springs along the main drainage of Little Park Wash or downstream of surface monitoring site L-13-S, which monitors the flow near the southern boarder of the permit area.

Cover between the coal seam and surface ranges from 600 feet in the southern part of the permit to over 2,500 feet in the northeast part of the permit. As the coal seam dips northeastward between 8 to 12 degrees, the topography increases, so that all of the spring and upper channels of Little Park Wash lie above 1,500 feet of cover.

There are no drinking water sources or state appropriated surface water resources immediately downstream of the permit area in Little Park Wash. There is small spring (91-237) located in the stream channel 7.5 miles downstream of the southern permit boundary. Mining
should not affect the recharge source to the spring. A water rights search shows no downstream surface water rights.

Figure 10. Tributary to Little Park Wash. Typical ephemeral nature of channels in Little Park Wash drainage. Occasional high flows from seasonal surface runoff carries high volumes of sediment down the channel. The survey team drove 4-wheel vehicles up the tributary to Little Park Wash to access Spring L-7-G, Figure 6. The spring flowed about 2 gpm and had a specific conductance of 789 micromhos and a temperature of 56 degrees F.

Little Park Wash Tributaries

No Name Wash has an area of 993 acres. The slope of the channel averages 14 percent. The coal seam is 1,300 to 2,500 feet beneath the drainage. Site L-14 –S monitors the flow from drainage below the permit area. No flow has been recorded at the surface site during the monitoring period of two years. Spring site L-12-G lies outside the permit area and subsidence zone. Its use is cattle and wildlife. Longwall panels extend underneath the length of the drainage.

Pine Spring Wash has an area of 605 acres. The slope of the channel averages 14 percent. The coal seam is 1,000 to 2,000 feet beneath the drainage. Longwall panels will extend underneath the length of the drainage and channel. Three springs are located in the drainage within the projected zone of subsidence. Water right 91-2517 has the same name on the water right as 91-2539 (L-9-G), Pine Spring. UEI owns the water right 91-810 for mining. Mining will occur 1,900 feet below spring L-9-G. The spring L-9-G has been used for cattle and wildlife in the past. During a field visit on September 14, 2006, it was found that the metal spring box had been washed downstream and was all but buried. Supply structures are in disrepair. All other springs in the
drainage lie upstream, outside of the permit area. There were no other springs downstream of L-9-G.

IPA #1 Wash has an area of 1,066 acres. Three springs have been identified within the drainage upstream and outside of the proposed permit area. One spring is monitored as site L-8-G. Depth of cover over the drainage ranges from 1,500 to over 2,200 feet. The slope of the channel averages 12 percent. Longwall panels will extend underneath the length of the drainage.

Cottonwood Spring Wash has an area of 421 acres. Eight springs have been identified within the drainage upstream and outside of the proposed permit area, but outside the projected zone of subsidence. One spring (Cottonwood spring) is monitored in this drainage as site L-7-G. Depth of cover over the drainage ranges from 1,900 to over 3,000 feet. The slope of the channel averages 17 percent.

Upper drainage consists of all the drainages above Cottonwood Spring Wash that flow into Little Park Wash, an area of 2,732 acres. There are several springs in the upper tributaries. There are no springs or water rights within the projected zone of subsidence. There are no springs on the west side, dipslope, of the drainage. Cover ranges from 1,900 feet to 2,250 feet where mining will occur under the drainage. The channel slope averages 14 percent. The north ends of the longwall panels run perpendicular to Little Park Wash. There are no monitoring sites in this section of the drainage. Springs are undeveloped and used for cattle and wildlife. Mining will take place more than ½ mile from the northern permit boundary.

The lower drainage has an area of 1,226 acres and drains the western side of the channel from the south permit area to the confluence of Cottonwood Wash. There are no springs or water rights within the projected zone of subsidence. Surface monitoring site L-13-S is located where the Little Park Wash county road crosses Little Park Wash. Cover ranges from 400 feet to 1,900 feet for these tributaries. Longwall panels and entries extend underneath the length of the drainage. The channel slope averages 3 percent.

Williams Draw is located south of the permit area. The tributary is 6.2 square miles has several springs, which are used for cattle and wildlife. The slope of the channel averages 10 percent. Monitoring site L-10-G is a developed spring with a trough. Use is for cattle and wildlife. Surface water site L-15-S is located ½ mile below the spring.
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<th>Tributary</th>
<th>Area (acres or mi²)</th>
<th>Channel Length</th>
<th>Monitoring Site</th>
<th>Slope %</th>
<th>To be undermined</th>
<th>Cover (feet)</th>
<th>Elevation near CIA (feet)</th>
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* Upper Lila Wash is the drainage above the Little Park Wash county road above the escarpment. Lower Lila Wash is that part of Lila Canyon next to and above the surface the surface facilities to the Little Park Wash county road.
** Upper Little Park Wash consists of tributaries above the confluence of Cottonwood Spring Wash and Little Park Wash. Lower Little Park Wash consists of the western drainages that flow into Little Park Wash below the confluence of Cottonwood Spring Wash.
- Not applicable to Lila Canyon Extension
IV. IDENTIFY HYDROLOGIC CONCERNS

General hydrologic concerns include changes of flow rates and chemical composition that could physically affect the off-permit hydrologic balance. Changes to the existing hydrologic regime or balance need to be limited in order to prevent economic loss to existing agricultural and livestock enterprises, prevent significant alteration to the channel size or gradient, and maintain adequate capacity for existing fish and wildlife communities. The basis for the limiting value of a parameter may differ according to specific site conditions.

The remoteness and dry conditions of the Lila Canyon permit area eliminate some of the concerns expressed above. UEI has provided information in their MRP-Part B showing stream channels on the permit area are ephemeral functioning, through monitoring and a stream characterization study. They have also shown that there are no local fisheries or agricultural enterprises that require protection. The only used water resources on the mine permit area are low flowing perennial and intermittent springs in the headwaters of Lila Wash and Little Park Wash, some of which have water rights.

SUBSIDENCE

The greatest mining-related potential for impacting from the Lila Canyon Mine is from subsidence. Subsidence impacts are largely related to extension and expansion of existing fracture systems and upward propagation of new fractures. Inasmuch as vertical and lateral migration of water appears to be partially controlled by fracture conduits in most ground water systems, readjustment or realignment in the conduit system will inevitably produce changes in the configuration of ground-water flow. Potential changes include increased flow rates along fractures that have "opened", and diverting flow along new fractures or within permeable lithologies. Subsurface flow diversion may cause the depletion of water in certain localized aquifers and potential loss of flow to springs that will be undermined.

Mining methods at the Lila Canyon Mine will be room-and-pillar in the entries and mains and longwall methods in the panels. Subsidence affects can occur over longwall panels, over second mined room-and-pillar areas, and in surrounding areas within the expected angle-of-draw.

Mine panel alignment and surface topography play a significant role in the amount and type of fracturing and/or movement that takes place. When subsidence occurs, there is a concentric lowering of the ground above the mined area. The ground becomes compressed in the center of the panel, while tensile stresses occur along the boundary of the panel, which can cause fractures. If fracturing extends over a long distance, recharge and storage areas can be intercepting and surface and ground water can be diverted away from its original flow path, which could result in desiccation of springs, and vegetation. If cover is shallow, surface cracks can appear above the mine. Fracturing of strata in the interbedded sandstone and shales, rich in clays, siltstones and mudstones, have potential to be self-healing, because they are more plastic and mobile and move
into fractures. Montmorillonite and bentonitic clays will absorb water and expand in volume, as much as 50 percent, even when they are associated with other soil and rock. Fractures at the surface are prone to heal rapidly, because during natural erosion process, there is a high amount of fine soils that are washed over the surface during some of the larger rain storms and snowmelt events. The expanding nature of the clays and natural erosion will help fill and seal surface fractures, if any develop.

Table 9 provides information showing which stream channels on the Lila Canyon Mine permit area will be undermined and the depth of cover of stream channels between the coal seam and surface.

ACID AND TOXIC FORMING MATERIALS

Acid and toxic forming material can occur at coal mine sites from constituents in groundwater, coal and coal refuse, disturbed area drainage, storage of chemical, fuels and emulsions and use of equipment.

DEWATERING

Underground mining removes the support to overlying rock causing caving and fracturing of the overburden. If fracturing is extensive, it can intercept the surface or aquifers located above the workings. Dewatering caused by fracturing may decrease aquifer storage and ground-water flow to streams and springs.

Ground Water

UEI concluded that there are two ground-water zones in the CIA, an upper zone containing perched springs and a lower saturated zone. The upper zone consists of the Colton Formation and Undifferentiated North Horn/Flagstaff Formations. The upper and lower zones are separate and disconnected from that of the Castlegate Sandstone and each other. Considering the amount of shales, siltstones, and mudstones and thickness of strata between the zones, Table 2, UEI’s conclusion has substantial basis. The potential recharge source for springs is reported to be local and very small. The springs above the minesite are perched and emit very low flows throughout the year. The small annual flow of the springs is a good indicator that the springs are perched and have a small local recharge area. The upper zone exists above 2,500 feet of cover on the permit area.

The deep saturated zone consisting of strata in the Blackhawk Formation is not identified as an aquifer, because it does not discharge or have any specific use, or have a potential future use. Underground mining in the Lila Canyon permit area can fracture and subside the surrounding rock creating conduits for water stored in the strata. Any potential flow volume is unknown, but could be similar to the rates of intercepted ground water at the Horse Canyon Mine, which were estimated to average 90 to 200 gpm.
In a phone conversation with Paul Clark (November 17, 2006), a former mine employee who resides in Sunnyside, Utah, Mr. Clark stated he didn’t remember a time the mine did not pump water between 1955 and 1982, when the mine shut down. No more water was pumped from the mine after shut down. He stated that pumping was infrequent. The mine acquired a large pump between 1974-1975, which eliminated the intermediate pumps and allowed pumping directly from the slope extension to the portal. Sometimes discharges were near 500 gpm.

The Lila Mine mains will be developed first, driven deep into the mountain at a 12 percent grade following the coal seam. All roofs will remain supported. Longwall panels will be developed off the mains at the deepest section, where cover is 2,500 feet. Panel development will begin in the farthest section of the mine then move progressively back toward the mine entry. As panels are mined and collapsed voids will be left that will store water downdip of the mining operations. No subsidence or fracturing will occur until longwall mining begins.

Upon termination of mining operations, any discharge of ground water from the mine should cease, because the dip slope is away from the mine entry and the pre-mining saturation level in the mine is shown to be far down dip of the entries. The time required for mine flooding will depend not only on the rate of water inflow, but also on the amount of caving and the void space remaining after caving.

**Water Rights**

Following spring and seep inventory surveys and baseline studies, prior to mine permitting, representative springs and seeps are chosen for a mine’s monitoring plan to aid in the determination of mining-related impacts to the hydrologic balance and water rights. Seven springs were monitored for baseline conditions within and adjacent to the Lila Canyon Mine permit area.

Two water rights (91-617 and 91-618) are identified in upper Lila Canyon drainage. They have been undermined by the in the past and lie outside the projected maximum area of subsidence of the Lila Canyon Mine.

Three spring sites located within the area of the maximum subsidence zone (21.5 degrees) are shown to have water rights (91-2517, 91-2539, and 91810). All are located in Pine Spring Wash (tributary to Little Park Wash) identified in the permit area (Plate 5). According to the Utah Division of Water Rights database, two of the springs share the name Pine Springs (91-2517 and 91-2539). Water monitoring site L-9-G is for water right 91-2539. The specified use for both springs is stock watering, directly on the spring. The third spring, 91-810 (located in Section 24), is owned by UEI, and the use is specified for coal mining. It is possible that the water rights for all three springs are the same source, but filed at different dates. There are no observations of a spring sources in Section 24, below the spring L-9-G.
There are two water rights (91-4648 and 914649) identified in the upper reach of Stinky Springs Wash. The water rights are designated for stockwatering ponds. Evaluation by UEI found the ponds no longer exist.

Several water rights are identified in the lower Grassy Wash drainage system. The water rights were evaluated by UEI and Division personnel on December 18, 2006. It was found that none of the water rights were associated with stream channels draining the Lila Canyon Mine permit area.

**DISCHARGE TO STREAMS**

Discharges of mine water and disturbed area runoff can affect the quality and shape of the receiving streams and any downstream use. The only discharge within the CIA will be from the proposed Lila Canyon Mine into the Right Fork of Lila Wash during operations.

Intercepted groundwater will be stored in sumps underground and used in the mining process. It is unknown how much water will be produced during mining. Piezometer levels indicate there is a level in the Blackhawk Formation where saturated conditions should produce water in the mine. A saturated zone does not mean that ground water flows freely from the surrounding rock. From other minesites, it has been identified that transmissivities in the Blackhawk Formation are very low. The lithologies vary and are discontinuous. Excess water encountered during mining will be discharged into the Right Fork of Lila Wash and monitored as UPDES outfall 002.

Potential discharge from the sedimentation pond into the Right Fork of Lila Wash will be monitored as UPDES outfall 001.

**FLOODING**

Flooding of the mine could result if excessive mine water is encountered, beyond the predicted amount. Mine water would have to be pumped to a stream channel that could result in the higher water levels, displacement of fines on the channel bottom and widening of the channel. Extensive, continuous discharge might have affects to perennial streams that contain fisheries.

The Right Fork of Lila Wash is the only channel that has a potential of flooding due to mining, because it has the potential to receive water from mine discharge and disturbed area runoff. UEI has evaluated potential discharges of 500 gpm (1.1 cfs) from the Lila Canyon Mine into the Right Fork of Lila Wash. The discharge was compared to the bankfull channel level. It was found that the mine discharge is significantly less than the bankfull level and that a continuous discharge would not reach a perennial stream.
WATER QUALITY

The quality of the local surface waters can be affected by four processes on and adjacent to the Lila Canyon Mine permit area controlled runoff from the disturbed lands and waste piles, mine water discharge, spring contamination from subsidence and fracturing on the ground surface. These functions could increase sediment concentrations and alter the distribution and concentration of dissolved solids in the receiving streams. The potential for inducing water quality changes to streams has been fully recognized by UEI for the Lila Canyon Mine. UEI will develop a surface facilities area below the Book Cliffs escarpment where only a county road exists. Disturbed areas can contribute many times the normal amount of runoff and sediment loads that can affect the downstream morphology and use. Disturbed area drainage will be minimized by the use of sediment control structures.

Water quality changes to surface water from subsidence are difficult to measure for ephemerally functioning stream channels, but can be measured on perennial springs. No flow is the normal condition of the streams on and adjacent to the Lila Canyon permit area, with infrequent flows during storms and snowmelt events. UEI states that changes in gradient in stream channels will cause some erosion on the downhill slope of the subsided area, but pond or reduce flows on the uphill side, causing flows to reduce and sediments to settle. During larger event there are high volumes of sediments generated during storms events from turbulent activity in the stream. Ephemeral functioning stream do not form the cohesive armored bottom that perennial and intermittent streams form. Measurements of these flows would not provide useful information for impacts or mitigation. UEI has proposed to minimize impacts from subsidenceby surveying the surface after full extraction is conducted, identifying impacts, then implementing needed mitigation using the best technology available.

Water not used or stored in the Lila Canyon Mine, or lost to evaporation will have to be discharged to the Right Fork of Lila Wash via UPDES 002. Discharge rates have increased over the life of the mine. Ongoing monitoring will indicate total ground-water discharge due to mining.

Rule R645-301-751 require that a coal mine discharge must meet state and federal water quality and discharge standards.
BOOKCLIFFS V CHIA  IDENTIFY HYDROLOGIC CONCERNS
V. IDENTIFY RELEVANT STANDARDS

RELEVANT STANDARDS

Water quality standards for surface waters in the State of Utah are found in R317-2, Utah Administrative Code (UDWQ, 2006).

It shall be unlawful and a violation of these regulations for any person to discharge or place any wastes or other substances in such manner as may interfere with designated uses protected by assigned classes or to cause any of the applicable standards to be violated, except as provided in R317-1-3.1.

The standards are intended to protect the waters against uncontrolled discharges and pollution. Waters, and the applicable standards, are grouped into classes based on beneficial use designations. The Utah Division of Water Quality of the Department of Environmental Quality has classified surface waters in the Book Cliffs Area V CIA. Tributaries of the Price River drainage within the CIA are classified 1C, 2B, 3A, 3C and 4 according to the use and category information listed below.

1C Protected for domestic purposes with prior treatment by treatment
2B Protected for secondary contact recreation uses except swimming,
3A Protected for cold water species of game fish and other cold water aquatic life.
3C Protected for nongame fish and aquatic life, and
4 Protected for agricultural uses.

<table>
<thead>
<tr>
<th>Grassy Trail Creek and tributaries, from Grassy Trail Creek Reservoir to headwaters</th>
<th>Stream Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1C, 2B, 3A, 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Price River and tributaries, from confluence with Green River to Carbon Canal Diversion at Price City Golf Course</th>
<th>Stream Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2B, 3C, 4</td>
</tr>
</tbody>
</table>

Table 10 identifies parameter limits for Utah’s stream standards in the CIA. Utah water quality standards exist for numerous parameters other than those already mentioned above, but at this time there is no evidence indicating they are of concern or have a reasonable probability of affecting the hydrologic balance in the CIA. However, because there remains some possibility that
those parameters could indicate impacts to the hydrologic systems, they are included in routine water quality monitoring of the mine operations.

<table>
<thead>
<tr>
<th>Stream Classification</th>
<th>1C</th>
<th>2B</th>
<th>3A</th>
<th>3B</th>
<th>3C</th>
<th>3D</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Domestic Source</td>
<td>Recreation and Aesthetics</td>
<td>Aquatic Wildlife</td>
<td>Agriculture and Stockwatering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS – mg/L</td>
<td>3000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Price River and tributaries</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH (range)</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td>6.5-9.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/L) Minimum</td>
<td>6.5</td>
<td>5.5</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 day average</td>
<td>6.5</td>
<td>5.5</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 day average</td>
<td>9.5-5.0</td>
<td>6.0-4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day average</td>
<td>8.0-4.0</td>
<td>5.0-3.0</td>
<td>3.0</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (µg/L)</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrate as N (mg/L)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Phosphorus as P (mg/L)</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Review of monitoring results by the mine operators and the Division will identify concerns or problems and generate revisions of the mine operations to mitigate those problems.

The Utah Department of Environmental Quality, Division of Water Quality can authorize a coal mine to discharge into surface waters under the Utah Pollutant Discharge Elimination System (UPDES). The UPDES permits for the Horse Canyon and Lila Canyon Mines provide some basic standards for quality of waters in the area around Horse and Lila Canyons. The Lila Canyon Mine has a UPDES permit to discharge to the Right Fork of Lila Canyon wash from two points. UPDES point 001 will be located at the principal spillway of the sedimentation pond (L-4-S). UPDES
point 002, the mine-water discharge site, will be located near the mine portals (L-5-G). Mine water will be held in sumps in the mine before being discharged. If discharges occur, water will flow through a 4-inch pipe and discharge to the Right Fork of Lila Wash (MRP-Part B, 731.513 and Plate 7-5). Water will be sampled prior to discharge to ensure compliance with UPDES water quality standards (MRP-Part B, 728.333).

The Lila Canyon Mine UPDES permit (MRP-Part B, Appendix 7-5) contains specific water-quality limitations so that the discharges from the mine and pond will meet applicable federal and state water quality standards. Additionally, there can be no more than a trace amount of visible sheen, floating solids, or foam and no discharge of sanitary waste or coal process water.

Flow

There is no standard for flow in the Utah water quality standards. The Horse – Lila Canyon Mine UPDES permits contain no limit on flow. Discharge is to be measured monthly, and the duration of intermittent discharge is to be reported along with flow.

Characteristics such as stream morphology, vertebrate and invertebrate populations, and water chemistry can be affected by changes in flow and therefore can provide an indirect standard for flow. Prior to discharging and at least quarterly during discharge, receiving-channel morphology and erosion impacts will be evaluated to determine the extent of streamflow alteration (MRP-Part B, Section 728.333).

Oil and Grease

There is no State water quality standard for oil and grease, but the Horse Canyon – Lila Canyon Mine UPDES permit limits are a daily maximum of 10 mg/L, which is typical of UPDES permits for coal mines in the Wasatch Plateau and Book Cliffs Coal Fields. Only one grab-sample a month is required to measure oil and grease routinely, but any observation of visual sheen requires a sample be taken immediately.

Total Dissolved Solids (TDS) concentrations

TDS is commonly used to indicate general water quality with respect to inorganic constituents. There is no state water quality standard for TDS for Classes 1, 2, and 3. State standards for irrigation of crops and stockwatering (Class 4) are normally 2,000 and 1,200 mg/L. Studies conducted by the Utah Division of Water Quality found natural occurring waters in the area of the CIA have higher background levels of TDS. A higher TDS level has been designated to more accurately reflect natural conditions. The Price River from the confluence with the Green River upstream to Soldier Creek has a standard TDS level of 3,000 mg/L for all agricultural and stockwatering use (UDWQ, 2006). This level will not impair downstream water use.


The Horse – Lila Canyon Mine UPDES permits allow up to one-ton per day limit for TDS, to be determined by one grab sample per month.

**pH**

Allowable pH ranges are 6.5 to 9.0 under State water quality standards for all Classes, and also under the Horse – Lila Canyon Mine UPDES permits.

**Total Suspended Solids (TSS) and Settleable Solids**

The Horse – Lila Canyon Mine UPDES permits have the following allowable limits on TSS: 30-day average, 25 mg/L; 7-day average, 35 mg/L; daily maximum, 70 mg/L. TSS is to be determined by a monthly grab sample.

There is no State water quality standard for solids in the water, but an increase in turbidity is limited to 10 NTU for Class 2A, 2B, 3A, and 3B waters and to 15 NTU for Class 3C and 3D waters.

Under the current Horse – Lila Canyon Mine UPDES permits, all samples collected during storm water discharge events are to be analyzed for settleable solids. Samples collected from increased discharge, overflow, or bypass that is the result of precipitation that does not exceed the 10-year, 24-hour precipitation event may comply with a settleable solids standard of 0.5 mL/L daily maximum rather than the TSS standard. If the increased discharge, overflow, or bypass is the result of precipitation that exceeds the 10-year, 24-hour precipitation event, then neither the TSS nor settleable solids standard applies.

**Iron and Manganese**

The Horse – Lila Canyon Mine UPDES permits allows a daily maximum of 1.0 mg/L total iron, determined by a monthly grab sample. State water quality standards allow a maximum of
1,000 µg/L dissolved iron in Class 3A, 3B, 3C, and 3D waters, with no standard for Class 1, 2, and 4 waters.

Monitoring of total manganese is required by SMCRA and the Utah Coal Mining rules, but there is no established UPDES or Utah water quality standard for either total or dissolved manganese.

**Macroinvertebrates**

Macroinvertebrates are excellent indicators of stream quality and can be used to evaluate suitability of a stream to support fish and other aquatic life. Surface-water drainages on and adjacent to the LCMA function as ephemeral streams. Aquatic macroinvertebrates have not been identified in the channels (MRP-Part B, Appendix 7-7).

**MATERIAL DAMAGE**

Material damage to the hydrologic balance would possibly manifest itself as an economic loss to the current and potential water users, would result in quantifiable reduction of the capability of an area to support fish and wildlife communities, or would cause other quantifiable adverse change to the hydrologic balance outside of a permit area. The basis for determining material damage may be found to differ from site-to-site within the CIA depending upon specific site conditions. Surface water and ground water concerns have been identified for CHIA evaluation.

The Division received a letter from Mr. Josiah Eardley, a landowner, on March 30, 1999. Mr. Eardley asked the regulatory authority to ensure protection of water rights he owns in Sec. 11, T. 16 S., R. 14 E., near the proposed Lila Canyon Mine permit area. Mr. Eardley's water rights, as well as all water rights on the proposed permit area were evaluated during the review process to ensure the utmost protection.

Mining has been conducted directly underneath or adjacent to springs H-18, H-18A, H-18B, H-19, H-20, H-21, H-21A, H-21B, H-22 and H-92 in the upper portion of Lila Canyon Wash. No more mining will be conducted to affect these springs (MRP-Part B, Plates 5-5 and 7-1). The area already undermined includes water rights 91-617 (Leslie Spring) and 91-618 (Mont Spring), totaling 0.022 cfs, in Sec 11. According to information from the Utah Division of Water Rights, these water rights belong to Mont Blackburn, but presumably these are water rights Mr. Eardley has acquired and refers to in his letter. Lila Canyon Mine will not mine near any listed water rights in Section 11. All of the spring sources mentioned above flow down Lila Canyon Wash and none flow down Little Park Wash. The BLM holds two surface-water rights and one ground-water right and UEI holds one ground-water right in the zone of potential subsidence (MRP-Part B, Plate 5-3). Remaining water rights are outside the zone of potential subsidence.
Parameters for surface-water quantity and quality

The potential material-damage concerns this CHIA focuses on are changes of surface flow rates and chemical composition that would physically affect the off-permit stream channel systems as they presently function and affect aquatic and wildlife communities. There is no farming in the CIA, however there is livestock production. Therefore, criteria are intended to identify changes in the present discharge regime that might be indicators of economic loss to the livestock enterprise, or significant alteration to the channel size or gradient, or of loss of capacity to support existing fish and wildlife communities within the CIA. In order to assess the potential for material-damage to these elements of the hydrologic system, the following indicator parameters were selected for evaluation at each evaluation site: low-flow discharge rate, TDS, and sediment load.

The surface-waters have been evaluated at L-1-S, L-2-S, L-3-S, L-18-S, RF-1, HC-1 and B-1 in the drainages below the escarpments. Generally, these sites have been dry and receive flow only during rapid snowmelt and heavy rainstorms. L-13-S, L-14-S, and L-15-S have been used to characterize Little Park Wash and tributary washes.

Low-Flow Discharge Rate

Measurements provided by mine operators are generally of instantaneous flow and provide some indication of long-term trends, but are probably no more accurate either individually or as a whole than the “poor” USGS measurements. In the Wasatch Plateau, Waddell and others (1981, p. 13) found that correlating three years of low-flow records (September) at stream sites against corresponding records from long-term monitoring sites would allow the development of a relationship that could be used to estimate future low-flow volumes at the stream sites within a standard deviation of approximately 20 %. Ten years of measurements reduced the standard deviation to 16 - 17 % and 15 years of data reduced it to about 15 %. This relationship has not been demonstrated for streams in the Book Cliffs; however, it indicates that a change in low-flow rates of less than 15 to 20 % probably would not be detectable. A 20 % decrease in the low-flow rate will provide a threshold indicator that decreased flows are persisting and that an evaluation for material damage is needed. However, because flows in Horse and Lila Canyons and Little Park Wash are intermittent, material damage due to loss of flow is very unlikely: no-flow is the normal condition for these drainages. The ephemeral nature of the flow will also make any such loss almost impossible to detect.

Monitoring of mine-discharge rates will provide a means to evaluate effects of the mine discharge on the receiving streams. The potential for material damage by mine discharge water is tied to the effect of that discharge on the flow in the receiving streams, and that effect will be most pronounced during low-flow, which at Lila and Horse Canyons is no-flow. Water from the LCMA disturbed area will be monitored at the discharge from the sedimentation pond (L-4-S). Direct discharge from the mine will be monitored near the mine portal (L-5-G). UEI obtained a UPDES permit to discharge from these two locations.
Sediment Load

Sediment is a common constituent of ephemeral streamflow in the western United States. The quantity of sediment in the flows affects stream-channel stability and most uses of the water. Excessive sediment deposition is detrimental to existing aquatic and wildlife communities. Large concentrations of sediment in streamflow may preclude use of the water for irrigating crops because fine sediment tends to reduce infiltration rates in the irrigated fields, and the sediment reduces capacities of storage facilities and damages pumping equipment. Sediment load measurement uncertainty is, at a minimum, the same as the flow measurement uncertainty because sediment load is directly dependent on flow and in practice cannot be measured more accurately than the flow.

TSS is the indicator parameter initially chosen for evaluating the sediment hazard to stream-channel stability and irrigation. Threshold values have initially been set as the greater of 1 standard deviation above the baseline mean TSS value or 120% of the baseline mean TSS value (by analogy with the accuracy of low-flow discharge rate measurement and assuming that any change in TSS will contribute equally with any change in flow when determining sediment load). If TSS concentrations persistently exceed these threshold values, it will be an indication that evaluation for material damage from sediment load in the streams might be needed.

Parameters for Ground-Water Quantity and Quality

The potential material-damage concerns of this CHIA are intended to limit changes in the quantity and chemical composition of water from ground-water sources to magnitudes that: will not cause economic loss to existing or potential agricultural and livestock enterprises; will not degrade domestic supplies; would not cause structural damage to the aquifers; and will maintain adequate capacity for existing fish and wildlife communities.

To assess the potential for material damage to these elements of the ground-water hydrologic system, the following indicator parameters were selected for evaluation: seasonal flow from springs and TDS concentration in spring and mine-discharge water.

Ground-water concerns will be monitored at eight springs, three piezometers, and the mine-water UPDES discharge point at the Lila Canyon Mine portals. Locations are identified on Plate 4. If the Division finds that inflow to the mine is significant or persistent, monitoring of mine inflow will be required.

Seasonal Flow from Springs

Seasonal spring flow will be monitored to determine if potentiometric heads that sustain average spring discharge rates, on a seasonal basis, are equal or greater than 80% of the mean seasonal baseline discharge, or in other words baseline minus 20% probable measurement uncertainty. The 20% measurement uncertainty is based on an analogy with the accuracy of
measuring low-flow surface discharge rates. A 20% decrease in flows, determined on a seasonal basis, will indicate that decreased flows are probably persisting and that an evaluation for material damage is needed.

**TDS from Springs**

The quality of water from underground sources reflects the chemical composition of the rocks the water passes through. Ground-water quality may be degraded by intrusion of poorer quality water from wells or mines, by leakage from adjoining formations, or by recharge through disturbed materials. Ground water discharging from seeps and springs is used by wildlife and livestock during operational and post-mining land uses. There is no water quality standard for TDS for aquatic wildlife. The state standard for TDS for irrigation of crops, and for stockwatering it is 3000 mg/L. If TDS concentrations persistently exceed 3000 mg/L it will be an indication that evaluation for material damage is needed.
VI. ESTIMATE PROBABLE FUTURE IMPACTS OF MINING ACTIVITY

The CHIA should address the cumulative impacts for all mining in the CIA. Of the three mines associated with the Book Cliffs V CIA, part of the Columbia Mine, Horse Canyon Mine and Proposed Lila Canyon, only the Lila Canyon Mine has the potential for future impacts. There has been some effort to initiate another mine at the Columbia site, but latest reports indicate plans have stalled. The Horse Canyon Mine was officially closed in January 1984. Operations had shut down almost two years earlier. Some of the areas were reclaimed and some turned over to the college. At this point in time all areas effected by mining at the Horse Canyon Mine including subsidence and ground water levels, have stabilized to a degree that is reflected on the surface today.

SUBSIDENCE

No adverse impacts due to subsidence have been identified from past mining at the Horse Canyon Mine. No further subsidence is expected in the future.

Subsidence at the Lila Canyon Mine is expected to take place at some time during the mining process where cover is low. Effects in the form of cracks, fissures and slope distortion are the most common could cause vertical migration of surface flows of seeps and springs.

There is a higher probability of subsidence occurring in areas where cover is less than 1300 feet. Subsidence has a good chance of happening in the lower reach of Little Park Wash, and in the upper reaches of Stinky Springs Wash and the Right Fork of Lila Wash. There is a lower chance that subsidence will occur in areas in the tributaries and upper reaches of Little Park Wash. The Castlegate Sandstone is a massive, rigid, and brittle sandstone unit that exists over the permit area. It is thought that this unit will help reduce the amount of subsidence by sustaining most of the stress, as it apparently has in the Soldier Canyon and Horse Canyon Mines, which show no identified subsidence impacts and have cover similar to Lila Canyon Mine that ranges between 500 to 2500 feet.

If fracturing does take place in a stream channel the fracture will likely fill with sediments washing down the stream channel. If natural healing does not happen the operator has presented and committed to implementing a subsidence monitoring, control and mitigation plan, Section 525.400. The Permittee has also addresses water replacement and mitigation in Section 727 of the MRP.

UEI has committed to survey surfaces after second or full extraction mining occurs, and mitigate any impacts using the best technology available at that time. The stream channels are dry most of the time so surveying them for impacts will be easier.
ACID AND TOXIC FORMING MATERIALS

Contamination should not take place from acid or toxic materials during or after mining. All disturbed area runoff will be contained, monitored, and treated if required before discharge to ensure water quality standards are met. Surrounding soils and bedrock contain buffering compounds of calcium carbonates and bicarbonates.

A Spill Prevention Control and Countermeasure (SPCC) Plan will be implemented. Potentially acid- or toxic-forming materials will be identified by use of Material Safety Data Sheets (MSDS), or by direct sampling and analysis in the case of underground development waste. Such waste will be tested for acid- or toxic-forming potential, and if found to be acid- or toxic-forming, the waste site will be protected from surface runoff by the use of earthen berms. Any material which exhibits acid- or toxic-forming characteristics will be properly stored, protected from runoff, removed to an approved disposal site or buried on site beneath a minimum of 4' of non-acid, non-toxic material. Underground development waste (if any) will also be stored in a designated area. Upon reclamation the surface will be shaped to drain overland flow and prevent long-term exposure to groundwater thus, preventing chemical reactions that cause acidic drainage.

No acid or toxic discharges are intended. The potential for acid mine drainage was evaluated for the mine by the Division. There is a potential that mine water will be discharged based on water levels in piezometers. Also, other mines in the Book Cliff mines have intercepted and discharged mine water. UEI has committed to monitor and treat all discharges of water from the mine to keep in compliance with all Utah and federal water quality laws and regulations. They have submitted plans to comply with effluent limitations for coal mining promulgated by the U.S. Environmental Protection Agency set forth in 40 CFR Part 434. Uncontrolled mine water discharge should not take place, because the formations slope down-dip, away from the mine portals.

Non-coal waste (garbage) will be stored in a designated location, in dumpsters, and removed to an approved landfill (East Carbon Development Contractors - ECDC) on a regular, as-needed basis. Unused or obsolete equipment or supplies will be stored in a designated area. Drainage from the storage area will be directed and contained in the sedimentation.

MINE DISCHARGE

No impacts are expected if mine water is discharged. Groundwater intercepted in the mine will be stored in sumps and treated prior to any discharges. Any discharges will be monitored under the UPDES program.

UEI evaluated the potential of a continuous flow rate, at 500 gpm (1.1 cfs), reaching the Price River (9.5 miles away), and found it would only flow 3.4 miles before it completely infiltrates into the alluvium.
UEI compared the mine discharge value of 500 gpm with flow depth of the bankfull channel (2.55 feet) and found it flowed significantly less, showing that there would be no impacts to the channel from mine discharge. The results show that mine discharge would only reach a flow depth of 0.8 feet, significantly less than the bankfull conditions.

UEI showed the culvert in the Right Fork of Lila Wash could handle the total runoff from the undisturbed channel (UA-1), undisturbed area (UA-5), the discharge from the sedimentation pond for a 25 yr-6 hr precipitation event, plus the mine water discharge.

As mining continues to advance to deeper sections of the mine, the operator will be able to determine future discharge requirement by the amount of water entering the mine.

Disturbed area runoff has been addressed. All runoff will be controlled and contained on site from the proper design storm.

DEWATERING

There are no indications that dewatering of the mine water or springs will have a potential for future impacts.

No impacts are expected from dewatering, unless an exceptional volume of ground water is contacted. Evaluating the amount of mine water inflow during main development should provide UEI with an understanding of the potential for discharging mine water. If volumes look larger than planned, UEI should make alternative plans to treat water that will not meet UPDES standards.

Dewatering of any springs in the upper zone is unlikely, because the springs are separated from the mine by extensive cover or lie outside the zone of subsidence.

FLOODING

Potential impacts from mine-water discharge into the Right Fork of Lila Wash have been identified and analyzed. They include the displacement of fines on the channel bottom and widening of the channel. Flooding impacts from mine and sediment pond discharges are not expected to occur. Assumptions and calculations have been provided.

WATER QUALITY

Plans have been submitted to minimize disturbance and impacts to water quality of surface waters or ground waters on or off the permit area from mining. Diminution of water quality should not occur.

The potential for water quality impacts are not likely in any of the channels. No uncontrolled surface disturbance will take place in or adjacent to Lila Wash, the Right Fork of Lila
Wash, Little Park Wash or Stinky Wash. Although flows have not been sampled, several USGS reports show that high volumes of runoff from adjacent areas contain high volumes of suspended and dissolved sediments, Waddell, 1981, USGS Professional Paper 2068.

Sediment will be controlled at the Lila Canyon surface facilities. Undisturbed runoff will be routed around the disturbed area. The MRP describes construction methods to be used to control runoff and sediment. A sedimentation pond is to be used throughout mining and Phase II reclamation periods. Runoff control will need to be implemented using alternative methods (i.e. silt fences, berms, straw bales) during installation of the 60-inch undisturbed culvert and upon its removal and restoration of the natural channel through the site.

Alternate sediment control areas (ASCA) will be used in areas where the surface disturbance is minor and sediment control can be restored effectively with surface roughening and revegetation. At the topsoil stockpiles, ditches will divert undisturbed area runoff away from the stockpiles, silt fencing will be placed around the stockpiles to minimize siltation from the stockpile, the surface of the stockpiles will be pocked and roughened to retain moisture and minimize runoff, and the surface of the piles will be revegetated to minimize surface erosion. The office and parking lot area below the mine yard facility area will slope to one end, where silt fencing will be used to control sediment. The slopes and embankment of the office pad will be revegetated to control sedimentation and erosion.

Plans have been submitted to treat mine water or disturbed area drainage prior to discharge. Any discharge will go into the Right Fork of Lila Canyon Wash. Discharged water will be subject to monthly monitoring stipulated by a UPDES permit. Water quality analyses will be conducted according to the methodology in the current edition of "Standard Methods for the Examination of Water and Wastewater" or the methodology in 40 CFR Parts 136 and 434.

The expected sediment from the Lila mine disturbed area is 0.3090ac-ft/yr. The sedimentation pond at Lila Canyon is designed for the complete retention of the 10-year, 24-hour storm event plus three years of sediment storage. This will effectively reduce the sediment yield from the disturbed area to an insignificant amount during the operational and reclamation phase of the mine. Drainage from undisturbed areas will, for the most part, be carried under the mine site through a bypass culvert.

The UPDES permits for Lila Canyon Mine places limits on: TDS (one-ton/day), total suspended solids (30-day average, 25 mg/L; 7-day average, 35 mg/L; daily maximum, 70 mg/L), total settleable solids (0.5 ml/L for storm-water discharges), total iron (1.0 mg/L), oil and grease (10 mg/L), and pH (between 6.5 and 9.0). There is no limit on flow, but it is to be measured and reported monthly. Additionally, there can be no more than a trace amount of visible sheen, floating solids, or foam and no discharge of sanitary waste or coal process water. Monitoring is to be by monthly grab samples.
PROBABLE FUTURE IMPACTS

Upon termination of mining operations, if there has been any discharge of ground water from the Lila Canyon Mines, discharge will be discontinued and the mine will begin to flood. There will be a reduction in surface flow, because of the loss of the mine discharge. Because the drainages function ephemeral, there is no baseflow in the streams, and surface flow will probably be unaffected by a return to pre-mining conditions as the mine floods. The time required for mine flooding will depend not only on the rate of water inflow but also on the amount of caving and the void space remaining after caving. Complete flooding of the mine may never occur because flow out of the mine through the roof, floor, and ribs and into the surrounding rock will increase as flooding increases the hydraulic head within the abandoned workings.

STREAM BUFFER ZONES

The Permittee meets the requirements for establishing stream buffer zones during mining and reclamation work. Stream buffer zone markers will outline the limits of mining activity adjacent to Lila Canyon Wash and parts of the Right Fork of Lila Wash. Undisturbed areas between the wash and surface facilities will be lined with boulders and signs to alert equipment operators of disturbed area boundary limits. There will be no diversion of Lila Canyon Wash and no runoff from the disturbed area will enter the drainage. No spoil will be placed the drainages. The channel will be monitored below the buffer zone at site L-1-S.

The Permittee has committed to meeting applicable Utah and federal water quality standards and will not adversely affect the water quantity and quality or other environmental resources of Lila Canyon Wash. The Division, therefore, has authorized the Permittee to conduct the planned coal-mining and reclamation activities within 100 feet of Lila Canyon Wash.

ALLUVIAL VALLEY FLOORS

An evaluation was conducted for the soils and hydrology conditions required to define an alluvial valley floor (AVF). No conditions were found within, adjacent to, or downstream of the mine permit area.
VII. ASSESS PROBABLE MATERIAL DAMAGE

The probable hydrologic impacts are summarized below under the headings entitled First Five Year Permit Term and Future Mining.

FIRST FIVE YEAR PERMIT TERM - Horse Canyon - Lila Canyon Mine Area

The Lila Canyon Mine is expected to be dry initially as the main entries are being driven. All pillars will remain intact and the roof will be supported. Any water generated during mining will be used in the coal mining process to cool equipment and maintain dust suppression. Initially, driving of the entries will provide a good opportunity to evaluate the amount of water being produced at different levels and if a discharge might be necessary. At that point any discharge plans can be updated.

According to the mining plan, there should be no subsidence for the first five years. During the first two to five years, the mine portals and rock tunnels will be constructed, and a continuous miners will be used to develop, mine entries, room and pillar panels and gate entries, leaving supports for the roof. Longwall mining will only take place if demand requires it. Longwall mining will first take place where overburden thickest is 2500 feet. No impacts to stream channels or springs are anticipated because of the thick amount of cover buffering subsidence. Subsidence surveys will be conducted to identify potential impacts where mining takes place.

During the first year culvert UC-1 will be installed and the sedimentation pond and diversion structures will be constructed. The initial disturbance will be contained by silt fences or straw bales. The facilities area will be constructed according to plans, and all flow will be routed to the sedimentation pond. Lila Canyon Wash will be protected with a stream buffer zone. The operational water monitoring program will be implemented to check any diminution to water quality.

There should be no flooding in channels from either mine discharge or surface disturbance. The sedimentation pond is designed to store more than the required 10 yr-24 hr runoff event.

FUTURE MINING

If no changes take place as identified in the Future Impact Section, there should be no impacts from mining. The mine is projected to operate approximately 20 years. Changes in mining, to the mining area or the disturbed area, or methods of mining are some of the variables that can change the type of impacts mining can take in the future. A mid-term mine permit review is conducted every 2 ½ years to check changes in bonding, ownership and mining protocols. A 5-year mine plan review is conducted to ensure the mine plan is current and mine activities are
following the plan. Annual reports are submitted, which summarize activities for the year. Water monitoring data is reviewed and summarized in a quarterly water monitoring report. Monthly inspections are conducted at the minesite to check mining activities and inspection required by the operator, and to ensure the operator complies with the terms of the mine permit. Any changes to the mine plan require an assessment of the change in accordance with the coal mining regulations. These reviews and inspections are required to ensure the Permittee is conducting mining and reclamation operations in a manner to protect the public and environment. These checks will continue into the future to ensure UEI operates the Lila Canyon Mine in accordance with the rules and laws governing coal mining.
VII. STATEMENT OF FINDINGS

Based on the information presented in this CHIA, the Utah Division of Oil, Gas and Mining finds that the proposed coal mining and reclamation operations of the Horse Canyon Mine, including the proposed Lila Canyon Extension, have been designed to prevent material damage to the hydrologic balance outside the permit areas. No evidence of material damage from actual mining operations in the CIA has been found. No probability of material damage from existing and anticipated mining operations in the CIA has been found.
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**ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AVF</td>
<td>Alluvial Valley Floor</td>
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<tr>
<td>BLM</td>
<td>Bureau of Land Management</td>
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<td>BTCA</td>
<td>Best Technology Currently Available</td>
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<td>CEU</td>
<td>College of Eastern Utah</td>
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<td>CIA</td>
<td>Cumulative Impact Area</td>
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<td>DWR</td>
<td>Utah Division of Wildlife Resources</td>
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<td>FEIS</td>
<td>Final Environmental Impact Statement</td>
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<td>Lila Canyon Mine Area</td>
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<td>LMU</td>
<td>Logical Mining Unit</td>
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<td>mg/L</td>
<td>milligrams per liter</td>
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<td>Mining and Reclamation Plan</td>
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<td>Mine Safety and Health Administration</td>
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<tr>
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<td>Nephelometric Turbidity Units</td>
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<tr>
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<td>Probable Hydrologic Consequences</td>
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<td>Post Mining Land Use</td>
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<td>Record of Decision</td>
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<td>United States Geological Survey</td>
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<td>Waste Rock Disposal Site</td>
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Cumulative Impact Area
Book Cliffs Area V
Plate 2
Workings Map
Apr. 2007

Proposed Workings
Workings
Drainage
Stream and localized streams, river banks
Ditch or canal
Wash or ephemeral drain
Aqueduct
Intermittent streams/Graded stream (subset of above)
Drain or well
Tunnel
Water Body
CIA Boundary
Cumulative Impact Area
Book Cliffs Area V
Plate 3
Geology Map
Apr. 2007
File: N:/gis/coal/damaps/BookCliffs5/Plate03-Geology.pdf
Plate 6. Illustration of coal zone, Sunnyside member (Kbs), and undifferentiated Flagstaff Limestone and North Horn Formation (TKfn) aquatard which separates the coal zone from Range Creek.