0038

Canyon Fuel Company, LLC
Dugout Canyon Mine
P.O. Box 1029
Wellington, Utah 84542

Incoming
C/007/0039 gk
#2530

May 23, 2006

Ms. Pamela Grubaugh-Littig
Utah Division of Oil, Gas and Mining
1594 West North Temple, Suite 1210
Salt Lake City, UT 84114-5801

RE: Report of Projected Potentiometric Levels in Dugout Canyon Mine at Closure
Pace Canyon Fan Portal Amendment, Task #2104
Dugout Canyon Mine, Canyon Fuel Company, LLC, C/007/039, Carbon County, Utah

Dear Ms. Grubaugh-Littig:

Attached please find four copies of a report prepared by Petersen Hydrologic, LLC pertaining to the projected potentiometric levels in the mine at closure. This information was requested by the Division for the BLM.

A copy of this submittal has been delivered to the Price field office. In addition, we have forwarded a copy to Steve Rigby at the Price BLM office.

Thank you for your assistance and if you have any questions please call me at (435) 636-2869.

Sincerely yours,

Vicky S. Miller

Vicky S. Miller

cc: Dave Spillman
Pete Hess
Steve Rigby

File in:
C/0070039 Incoming
Refer to:
☐ Confidential
☐ Shelf
☒ Expandable
Date 052306 For additional information
0001

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SUFCO Mine ☐ Skyline Mines ☐ Dugout / Soldier Canyon Mines

Miller, Vicky

From: Spillman, David
Sent: Thursday, May 12, 2005 1:16 PM
To: Miller, Vicky; Hansen, Chris
Cc: Sass, Erwin; Heaps, Corey
Subject: Pace Canyon DOGM Stipulations

Vicky, Chris,

DOGM's No. 5 stipulation to the Pace Canyon approval reads as follows:

> Following completion of the Pace Canyon construction activities, the Permittee must provide a mine map showing the final piezometric water level in the mine workings. This will help determine and support whether or not a hydrostatic seal is necessary for the Pace Canyon intake portal. (BLM)

This is a BLM concern.....Stan Perkes to be specific.

APPLICATION FOR COAL PERMIT PROCESSING

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: Canyon Fuel Company, LLC
Mine: Dugout Canyon Mine **Permit Number:** C/007/039
Title: Addition of Information Pertaining to Projected Potentiometric Levels in Mine at Closure
Description, Include reason for application and timing required to implement:
Per a stipulation from the BLM for the approval of the Pace Canyon Fan Portal

Instructions: If you answer yes to any of the first eight (gray) questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes ☒ No 15. Does the application require or include soil removal, storage or placement?
☐ Yes ☒ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes ☒ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☐ Yes ☒ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes ☒ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes ☒ No 20. Does the application require or include subsidence control or monitoring?
☐ Yes ☒ No 21. Have reclamation costs for bonding been provided?
☐ Yes ☒ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☒ Yes ☐ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?

Please attach four (4) review copies of the application. If the mine is on or adjacent to Forest Service land please submit five (5) copies, thank you. (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

Erwin Sass
Print Name

Erwin - General Manager
Sign Name, Position, Date

Subscribed and sworn to before me this _____day of _____, 20_____

_____
Notary Public
My commission Expires: _____, 20____}
Attest: State of _____} } ss:
County of _____

VICKY SUE MILLER
NOTARY PUBLIC • STATE of UTAH
1776 KENILWORTH RD.
HELPER, UTAH 84526
COMM. EXPIRES 1-5-2008

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Form DOGM- C1 (Revised March 12, 2002)

APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

Permittee: Canyon Fuel Company, LLC
Mine: Dugout Canyon Mine **Permit Number:** C/007/039
Title: Addition of Information Pertaining to Projected Potentiometric Levels in Dugout Mine at Closure

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

			DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☒ Add	☐ Replace	☐ Remove	M&RP - Appendix 7-12
☐ Add	☐ Replace	☐ Remove	
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Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.

May 23, 2006
This information was requested by the BLM and was a stipulation for approval of the Pace Canyon Fan Portal.

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Projected Potentiometric Levels in the Dugout Canyon Mine after Mine Closure

3 April 2006

Canyon Fuel Company, LLC
Dugout Canyon Mine
Wellington, Utah

PETERSEN HYDROLOGIC, LLC
CONSULTANTS IN HYDROGEOLOGY

Mine # C/007/039
File Incoming
Record # 0038
Doc. Date 5·23·06
Recd. Date 5·23·06

Projected Potentiometric Levels in the Dugout Canyon Mine after Mine Closure

3 April 2006

Canyon Fuel Company, LLC
Dugout Canyon Mine
Wellington, Utah

Prepared by:

Erik C. Petersen, P.G.
Principal Hydrogeologist
Utah PG No. 5373615-2250

PETERSEN HYDROLOGIC, LLC
CONSULTANTS IN HYDROGEOLOGY

2695 N. 600 E.
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Projected Potentiometric Levels in the Dugout Canyon Mine after Mine Closure

1.0 Introduction

Canyon Fuel Company, LLC's Dugout Canyon Mine is located in the Book Cliffs coal field, approximately 10 miles northeast of the town of Wellington, Utah (Figure 1). Operations at the Dugout Canyon Mine commenced in 1998 and continue at present. The purpose of this investigation is to project the likely future potentiometric levels in the Dugout Canyon Mine workings after mine closure.

Including this introduction, this report contains the following sections:

- Introduction
- Overview of Mining Operations
- Topography
- Geology
- Description of Groundwater and Surface-Water Hydrology
- Projections of Likely Mine Potentiometric Levels
- Discussion
- References Cited

2.0 Description of Historic Mining Operations

The Dugout Canyon Mine is an underground longwall mining operation that currently produces approximately 4 to 5 million tons per year of low-sulfur bituminous coal. Mining operations at the Dugout Canyon Mine occur in the Rock Canyon and underlying Gilson coal seams. Groundwater intercepted in the Dugout Canyon Mine, which is intercepted in modest quantities, is temporarily held in underground sumps and subsequently used as mine process water or discharged to Dugout Creek.

Prior to the opening of the Dugout Canyon Mine, historic coal mining activities had occurred in both the Rock Canyon and Gilson seams (Figure 2). The most extensive mining took place in the Gilson Seam. Historic mining activities in the Dugout Canyon area began in the 1920's and continued through the mid 1960's. The old mines and their associated portals are located on both the east and west sides of Dugout Canyon (Figure 2). The abandoned Gilson Seam workings have been referred to in the past as the Knight Ideal Mine. For simplicity, they will hereafter be referred to as the old Gilson east workings and the old Gilson west workings. The historic east and west mine workings are not aerially extensive and are situated under relatively shallow cover, short distances laterally from the coal outcrop.

When historic mining activities in Dugout Canyon ceased, groundwater filled both the east and west workings to just below the elevation of the lowest portals. The time that elapsed from the cessation of mining operations to the complete filling of the old mine workings is not known. After the mine workings filled, the portal area at the old Gilson east workings was continuously damp, and minor amounts of groundwater discharge from the lowest mine

portal area was observed. This condition existed until the old Gilson Seam mine workings were drained in August 2002 by Dugout Canyon Mine for safety purposes.

3.0 Description of Topography

The Dugout Canyon Mine is situated in Dugout Canyon at the base of the Book Cliffs escarpment (Figure 1). The Book Cliffs are a steep erosional escarpment cut into the resistant bedrock formations in the area. Vertical relief in the Dugout Canyon Mine permit area exceeds 2,500 feet, ranging from about 6,500 feet in lower Dugout Canyon, to 9,057 feet at Soldier Peak. The Book Cliffs trend in a roughly northwest-southeasterly direction in the vicinity of the mine and are dissected by a series of steep, narrow canyons. At the base of the Book Cliffs escarpment extends a broad lowland region that includes plains and pediments developed on the rocks of the marine Mancos Shale. This region includes Clark Valley and the broad expanse of rolling flatlands that extends for many miles to the south and west (Figure 1).

The coal seams in the Dugout Canyon Mine area dip gently to the north beneath the Book Cliffs escarpment. Consequently, the depth of cover overlying the coal seams increases steadily as mining progresses to the north-northeast. As a result, although the coal seams are likely continuous to the north, coal mining operations are generally restricted to areas near the escarpment where the overburden thickness does not exceed reasonable mining depths. The depth of cover overlying currently mined areas ranges from near zero at the mine portals to approximately 2,000 feet in the northernmost portions of the mine.

4.0 Description of Geology

Seven bedrock formations are exposed in the Dugout Canyon Mine area. These include the Mancos Shale, Blackhawk Formation, Castlegate Sandstone, Price River Formation, North Horn Formation, Flagstaff Limestone, and the Colton Formation. Of these, only the Blackhawk Formation and the Mancos Shale outcrop in areas topographically below the Dugout Canyon Mine workings in the study area. The seven bedrock formations are shown on a geologic map in Figure 3. A geologic cross-section showing the locations of the old Gilson Seam workings and the Dugout Canyon Mine workings in Dugout Canyon is shown in Figure 4. The characteristics of these geologic formations are described below.

Mancos Shale (Upper Cretaceous)

The Mancos Shale is a gray to dark gray, slightly calcareous, gypsiferous, and carbonaceous marine shale. A few thin lenses of calcareous sandstone and limestone occur in the upper part of the formation. Regionally, the thickness of the Mancos Shale is greater than 4,000 feet. The Mancos Shale is exposed along the base of the Book Cliffs escarpment and forms the land surface in the expansive lowland areas of Clark and Castle Valleys to the south and west. In some areas, the mudstones and thin- to medium-bedded sandstones of the overlying Star Point Sandstone grade into the Mancos Shale. In other areas, these sandstones are absent.

Blackhawk Formation (Upper Cretaceous)

The coal seams at the Dugout Canyon Mine are contained in the Blackhawk Formation. The Blackhawk Formation, which is approximately 1,220 feet thick in the region, is continuously

exposed along the Book Cliffs escarpment. Regionally, the formation consists of five major tongues of generally similar lithologies representing the regressive littoral sequences of upward coarsening sediments (Anderson, 1978). The tongues, from top to bottom, are the Upper Sunnyside, Lower Sunnyside, Kenilworth, Aberdeen, and Spring Canyon. The lithologies of the tongues generally consist of massive mudstones at their base, grading to sandy siltstones with mudstone interlayers, which grade from fine to medium-grained, massive to thick-bedded sandstone at their tops.

Individual rock layers in the Blackhawk Formation (excluding the massive sandstone tongues described above) consist of interbedded sandstones, mudstones, claystones, and shales, which are generally discontinuous and lenticular in nature. It is usually not possible to trace these individual rock layers over significant lateral distances. Coal mining operations at the Dugout Canyon Mine are currently in the Gilson and Rock Canyon seams.

Castlegate Sandstone (Upper Cretaceous)

The Castlegate Sandstone is a cliff-forming sandstone unit that was deposited in a braided stream environment. The unit consists of fine- to medium-grained, medium-bedded to massive sandstones which grade to fine-grained sandstones with interlayers of mudstones towards the top. The Castlegate Sandstone is capped by about 35 feet of fine-grained, well-sorted, medium-bedded sandstone. The Castlegate Sandstone is approximately 140 feet thick in the Dugout Canyon area.

Price River Formation (Upper Cretaceous)

The Price River Formation consists of interbedded layers of massive, medium- to fine-grained sandstone, mudstones, and siltstones. Minor fine-grained sandstone layers are also present. The Price River Formation is about 350 feet thick in the Dugout Canyon area.

North Horn Formation (Upper Cretaceous, Tertiary)

The North Horn Formation is approximately 615 feet thick in the Dugout Canyon area. The lower half consists predominantly of mudstones interbedded with siltstones, and fine-grained, thin- to medium-bedded sandstones. In its upper half, the formation consists of interbedded siltstones, mudstones, marlstones, and limey mudstones in its upper half. Occasional sandstone lenses, 15 to 50 feet thick and 100 to 1,000 feet long also occur in the upper half.

Flagstaff Limestone (Eocene)

The Flagstaff Limestone consists of interbedded sandstone, mudstone, marlstone, and limestone. The unit forms a moderate slope at the top of the Book Cliffs. A 470-foot thickness of the Flagstaff Limestone was measured in the Dugout Canyon area. The Flagstaff Limestone is mapped together with the underlying North Horn Formation in Figure 3. The Flagstaff Limestone and North Horn Formation form the cap rock of the Book Cliffs in most parts of the Dugout Canyon area.

Colton Formation (Eocene)

The Colton Formation is exposed in the highland areas north of the Book Cliffs. The Colton Formation consists of mudstones and shaly siltstones interbedded with thin, fine- to medium-grained quartz sandstone beds. Sparse limestone beds also occur.

Geologic Structure

The structure in the Dugout Canyon area is controlled largely by the uplift of the San Rafael Swell. Rocks in the Dugout Canyon area strike approximately parallel to the trend of the Book Cliffs escarpment. Bedrock formations dip gently beneath the escarpment at an average dip of about 8° north-northeast. Bedrock in the Dugout Canyon area has some jointing, fracturing, and minor faulting. The area is not typified by faults with significant displacement, as is found in the Wasatch Plateau.

5.0 Description of Groundwater Systems

Two fundamental types of Groundwater systems occur in the Dugout Canyon Mine permit area. These include active-zone groundwater systems and inactive-zone groundwater systems. These types of systems have been described in detail by Mayo and others (2003) and Mayo and Associates (1996). The characteristics of these two types of groundwater systems are summarized below.

Active-zone groundwater systems

Active-zone groundwater systems are in good communication with shallow recharge sources and consequently, discharge rates from active-zone groundwater systems respond rapidly to annual recharge. Active-zone groundwater systems also respond to short-term and long-term climatic variability. Active-zone groundwater systems are characterized as having continuous flow paths from recharge areas to discharge areas. Active-zone groundwater systems commonly occur within approximately 500 feet of the ground surface or within approximately 1,000 feet horizontally of cliff faces where the cover exceeds 500 feet (Mayo and others, 2003). Active-zone groundwater systems can also extend deeper into the mountain where the rocks are intensely fractured. Active-zone groundwater systems in the Book Cliffs coal field most commonly occur as shallow, fractured-bedrock groundwater systems, alluvial groundwater systems, or colluvial groundwater systems. These groundwater systems are commonly perched above the deeper inactive-zone groundwater systems that are commonly intercepted by mining operations.

Inactive-zone groundwater systems

In contrast to active-zone groundwater systems, inactive-zone groundwater systems commonly occur where the depth of cover exceeds about 500 feet, or in areas more than 1,000 feet horizontally into cliff faces. Inactive-zone groundwater systems have little or no communication with annual recharge and, consequently, do not show seasonal or climatic discharge variability. Groundwater flow velocities in inactive-zone groundwater systems are commonly very slow as evidenced by radiocarbon ages of several thousand years and a lack of tritium. The absence of tritium in a groundwater system is indicative of groundwater that

has been isolated from shallow recharge sources for at least 50 years. Groundwater in the inactive zone also commonly occurs in isolated partitions that are not in good hydraulic communication with adjacent groundwater partitions. Inactive-zone groundwater systems in the Book Cliffs coal field commonly occur under perched conditions in sandstone paleochannel deposits in the Blackhawk Formation overlying mined areas. Groundwater flow directions within sandstone paleochannel deposits are constrained by the regional dip of the rock strata and by the geometry of the sandstone paleochannels. Sandstone paleochannels are typically sinusoidal in nature.

Groundwater in the Dugout Canyon Mine

Within the Dugout Canyon Mine, groundwaters intercepted in the mine workings under more than about 500 feet of cover are generally associated with inactive-zone groundwater systems. This is evidenced by the lack of seasonal variability in groundwater inflow rates in the mine (Personal communication, Dave Spillman, 2003), and by the lack of tritium in samples of in-mine groundwater. Radiocarbon dating of in-mine groundwater systems in the Dugout Canyon Mine has not been performed because of complexities in the carbon history of the groundwater associated with methane gas. However, the results of radiocarbon dating performed at other mines in the Book Cliffs and Wasatch Plateau coal fields indicates that the deep groundwater associated with coal mining in the Blackhawk Formation is typically about 2,000 to more than 20,000 years old (Mayo and others, 2003). Inactive-zone groundwater in the Dugout Canyon Mine is likely migrating very slowly down-dip in a northerly direction toward discharge locations north of the mine area.

In the mine development entries, groundwater commonly enters where mining intersects and exposes permeable, water-bearing sandstone paleochannels in the roof. In longwall gob areas, additional groundwater is sometimes released as a result of the fracturing of sandstone channels somewhat higher in the geologic sequence as a result of mining-induced fracturing of overlying strata. It is commonly estimated that mining-induced fractures overlying longwall panels typically propagate upward a distance of up to ten-times the coal mining height. Assuming a mining height of 8 to 10 feet, mining-induced fractures could be estimated to extend upward approximately 80 to 100 feet.

Sustained groundwater inflows into the Dugout Canyon Mine workings have not been encountered to date. Most groundwater encountered in the Dugout Canyon Mine originates from sandstone paleochannels in the mine roof (Personal communication, Dave Spillman, 2005). As discussed above, groundwaters in these paleochannels are not in good hydraulic communication with active recharge sources. Consequently, when these paleochannels are first intercepted by the mine workings, they typically drain rapidly. Within several weeks to several months after being intercepted, discharge from sandstone paleochannels typically ceases or declines to meager quantities. Because the groundwater in the sandstone paleochannels occurs under perched conditions and is hydraulically isolated from overlying horizons by interbedded low-permeability sediments, the hydraulic head on the groundwaters in the sandstone paleochannels is commonly only a few to a few tens of feet above the top of the coal seam locally.

Groundwater systems encountered in the mine are ancient in origin and are not in active communication with modern recharge. As discussed previously, inactive-zone groundwater systems occur primarily as isolated partitions that are not in hydraulic communication with adjacent strata. Groundwater conditions consistent with a regional type aquifer are not encountered in the Blackhawk Formation in the Dugout Canyon Mine area. Therefore, in the traditional sense, it is not possible to define a potentiometric surface in the area.

In the adjacent Soldier Canyon Mine workings, groundwater conditions were generally similar to those in the Dugout Canyon Mine. However, a water-bearing fault zone was intercepted in the Soldier Canyon Mine from which sustained groundwater inflows into the mine persisted throughout the life of the mine. In contrast, no significant water-bearing faults have been encountered in the Dugout Canyon Mine. An east-west trending fault was intercepted by the Dugout Canyon Mine workings beneath moderate cover in Pace Canyon (Figure 2). However, this fault did not contain significant water (Personal communication, Chris Hansen, 2006). Based on the projection of the fault trend, which is sub-parallel to the trend of Pace Canyon, it is likely that this fault will again be intercepted by the mine workings as mining operations progress eastward. However, because this fault did not contain water in the potential recharge area beneath the stream drainage, it seems likely this fault may not contain appreciable quantities of water in other locations.

Groundwaters encountered in the old Gilson east and Gilson west workings are likely from active-zone groundwater systems. Groundwater sampled from the old Gilson West workings contained appreciable tritium (20.8 TU), suggesting that the groundwater in the old works

was in good hydraulic communication with active recharge. This conclusion is also supported by the seasonal variability observed in potentiometric levels in the flooded mine workings, and by increases in the rate of inflow to the old workings during the high-flow season. The specific recharge location for the active-zone groundwaters contained in the old Gilson east and Gilson west workings is not known. However, the old mine workings are likely recharged from the downward migration of alluvial groundwater in the Dugout Canyon drainages that overlie the old mine workings under less than a few hundred feet of cover.

During the recent installation of the Pace Canyon portals, groundwater was not encountered in appreciable quantities in the alluvial/colluvial sediments in Pace Canyon. It is noteworthy that the installation of the portal facilities in Pace Canyon occurred during a very wet year.

Inactive-zone groundwaters intercepted in the Dugout Canyon Mine are intermittently discharged from the mine to Dugout Creek. Groundwater stored in the old Gilson east and Gilson west underground workings is also intermittently pumped through drill holes from the old workings into Dugout Canyon Mine and discharged to Dugout Creek.

6.0 Projections of Likely Future Mine Potentiometric Levels

A discussion of likely future potentiometric levels in the Dugout Canyon Mine workings after mining operations cease is presented below. It is acknowledged that in the absence of data on future mine inflow characteristics, it is not possible to precisely predict future mine groundwater potentiometric levels. However, based on our understanding of groundwater

systems in the mine environment, projections of approximate future potentiometric levels may be made. Projections have been made based on three different future mine-inflow scenarios as discussed below. The characteristics of these three scenarios are depicted schematically in Figures 5A through 5C.

Scenario 1

Assumptions:

- Future groundwater inflows into the mine will be similar to those encountered to date.
- The Dugout Canyon Mine workings will be hydraulically isolated from the old Gilson east and west workings and other potential inflows from active-zone groundwater systems near the surface.

Under Scenario 1, as illustrated in Figure 5A, it is anticipated that mining in the remainder of the Dugout Canyon Mine will progress under hydrogeologic conditions similar to those that have been encountered to date in the mine. Specifically, it is assumed that groundwater inflows will occur from perched Blackhawk Formation hydraulically isolated groundwater systems. Sustained groundwater inflows into the mine workings from faults will not occur.

Under the conditions of Scenario 1, it is anticipated that the mine workings will not fill with groundwater after mining operations cease and discharge from the Dugout Canyon Mine workings will not occur. Because the coal seams dip to the north, away from the mine

portals, discharge cannot occur until the mine workings fill to the level of the lowest mine portal. This condition will likely not occur for two reasons as discussed below.

Firstly, as discussed above, the potentiometric surface in Blackhawk Formation groundwater systems overlying the mine workings is likely only a few to a few tens of feet above the local elevation of the top of the coal seam. Blackhawk Formation groundwater systems in areas already mined near the mine portals have been drained and would thus not yield groundwater to the mine workings after mining operations cease. In deeper portions of the mine to the north, which are hydraulically further down-dip, the potentiometric surface on the sandstone paleochannels would likely be much lower than the portal elevation. Thus, there would not be sufficient hydraulic head on the potential groundwater pool in the mine workings to allow it to fill to the level of the mine portal.

Secondly, under this scenario, because there is no source of continuing recharge to the inactive-zone Blackhawk Formation groundwaters in contact with the mine workings, there would likely not be sufficient groundwater available to fill the Dugout Canyon Mine workings. As mining progresses, overlying groundwater systems are systematically drained. The only water available for filling the mine workings after mine closure under this scenario would be from the residual drainage of groundwater from those sandstone paleochannels intercepted by mining in the last months of operation of the mine that had not drained completely when pumping from the mine ceased. This would likely constitute only a *very* small fraction of the quantity of water that would be required to fill the entire mine volume.

It is noteworthy that in the four-year period from 2001 – 2004, the total discharge from the Dugout Canyon Mine was approximately 215 million gallons, or about 29 million cubic feet of water (including water pumped from the old Gilson Seam workings). There were no significant long-term sustained discharges encountered in the Dugout Canyon Mine workings during this time (i.e., the groundwater inflows that yielded this volume of groundwater were drained during that period and pumped from the mine). By comparison, the volume of mine void created by mining one million tons of coal is about 25 million cubic feet (assuming a specific gravity of 1.25), assuming no mine volume loss to subsidence. Assuming that subsidence reduces this volume by 50% (a conservative estimate), the volume of mine opening created by the mining of one million tons of coal is about 12.5 million cubic feet. Thus, the total quantity of water produced during this four-year period could be stored in the volume of mine corresponding to the mine production of about 2.3 million tons. Annual coal production at the Dugout Canyon Mine is currently between about 4 and 5 million tons.

Consequently, under Scenario 1, it is likely that the volume of water remaining in the mine workings after mine closure would be minimal. Assuming that at the time of mine closure the mine had pumped all intercepted water from the mine, there would be a very large volume of mine workings available to contain water that might continue to drip into the mine. Over time, minor additional amounts of groundwater could potentially discharge into the mine as the last residual groundwater held in storage in sandstone paleochannels slowly entered the mine. The quantity of this water would likely be meager and would pool in a small area in the lowest elevation portions of the mine workings.

Scenario 2

Assumptions:

- Future groundwater inflows into the mine will be different from those encountered to date. The mine will come into hydraulic communication with a fault-related groundwater system that yields sustained groundwater inflows into the Dugout Canyon Mine workings.

Under Scenario 2, as illustrated in Figure 5B, it is anticipated that the Dugout Canyon Mine will intercept a fault-related groundwater system that will yield sustained groundwater discharge into the mine workings. Under this scenario, groundwater will fill the mine workings to a level equal to that of potentiometric levels in the fault-related groundwater system or to the level of the lowest mine portal, whichever is lower. If the potentiometric level in the intercepted fault-related groundwater system is less than that of the lowest mine portal, mine inflows will continue until the elevation of the pool in the mine equals the hydraulic head in the fault-related groundwater system. At which time, inflow into the mine workings will cease and discharge from the mine portals will not occur. If the potentiometric head in the fault-related groundwater system is greater than the elevation of the lowest mine portal, discharge from the mine portals would be anticipated from the mine portal. The discharge rate from the mine portals when the mine fills would likely be less than that measured at the underground inflow source because of a decrease in the hydraulic gradient due to the increased hydraulic head on the groundwater pool impounded in the mine workings.

The time required to fill the mine workings is dependent on the mine inflow rate and the final volume of open mine workings below the elevation of the lowest mine portal at the time of mine closure.

Scenario 3

Assumptions:

- The Dugout Canyon Mine workings are left in good hydraulic communication with the old Gilson Mine workings at the time of mine closure.

Under Scenario 3, as illustrated in Figure 5C, it is anticipated that the Dugout Canyon Mine workings are left in good hydraulic communication with the old Gilson Seam workings at mine closure. As discussed above, based on tritium concentrations and seasonal discharge rates measured in the groundwater discharging from the old Gilson Seam workings, it is evident that the old workings are in good hydraulic communication with shallow, active-zone recharge. It has been estimated that recharge rates to the old workings range from about 0 – 50 gpm. Discharge rates also appear to be influenced by seasonal and climatic variability. If the Dugout Canyon Mine workings are left in good hydraulic communication with old Gilson Seam workings (possibly through unsealed drill holes), modern recharge will enter the Dugout Canyon Mine workings via the old Gilson Seam workings. Eventually the Dugout Canyon Mine workings would fill to the level of the lowest interconnected mine portal.

The time required for the Dugout Canyon Mine workings to fill would be a function of the climate-dependent recharge rate to the old Gilson Seam mine workings and the volume of open mine workings below the level of the lowest open mine portal in the Dugout Canyon Mine at the time of mine closure.

It should be noted that in each of the three scenarios described above, it has been assumed that active-zone recharge at the Pace Canyon Portal through the alluvial sediments in Pace Canyon will not occur. This conclusion is based on observations made by mine personnel during the installation of the Pace Canyon portal. It was noted that alluvial/colluvial sediments and shallow bedrock horizons in Pace Canyon adjacent to the portal did not contain appreciable quantities of groundwater (although some alluvial monitoring wells near the site did contain water). That the alluvial sediments and shallow bedrock adjacent to the portal opening were dry during a very wet year suggests that appreciable groundwater inflows will likely not occur at the Pace Canyon Portal in the future.

7.0 Discussion

As discussed above, it is currently not possible to determine with certainty which of the above scenarios will occur at the time of closure of the Dugout Canyon Mine, because mining operations are currently ongoing. However, based on the assumptions described above and on our current understanding of hydrogeologic conditions in the mine area, it is our best professional judgment that discharge from the Dugout Canyon Mine will not occur after mine closure. The conditions described in Scenario 1 will likely be most representative of actual conditions at the Dugout Canyon Mine.

Scenario 2 is considered unlikely primarily because mine workings have been driven through much of the future mine area along the trend of the Book Cliffs escarpment, and no major water bearing faults have been encountered. Being long linear features, if significant water-bearing faults were present in the Dugout Canyon Mine, it seems likely that these would have been intercepted in the Dugout Canyon Mine area during development work.

It is possible that the conditions outlined in Scenario 3 could occur if the Dugout Canyon Mine workings are not effectively isolated from the old Gilson Seam workings prior to closure of the mine. However, if care is taken to ensure the two mines are not interconnected, it is considered unlikely that the conditions outlined in Scenario 3 will occur.

8.0 References Cited

Mayo and Associates, 1996, Investigation of groundwater and surface-water systems at the Alkali Creek and Dugout Canyon areas, Utah, unpublished consulting report.

Mayo, A.L., Morris, T.H., Peltier, S., Petersen, E.C., Payne, K., Holman, L.S., Tingey, D., Fogel, T., Black, G.J., and Gibbs, T.D., 2003, Active and inactive groundwater flow systems: Evidence from a stratified, mountainous terrain, GSA Bulletin: December 2003: V. 115: no. 12; p. 1456-1472.

Figure1.cdr
Mayo and Associates, LC

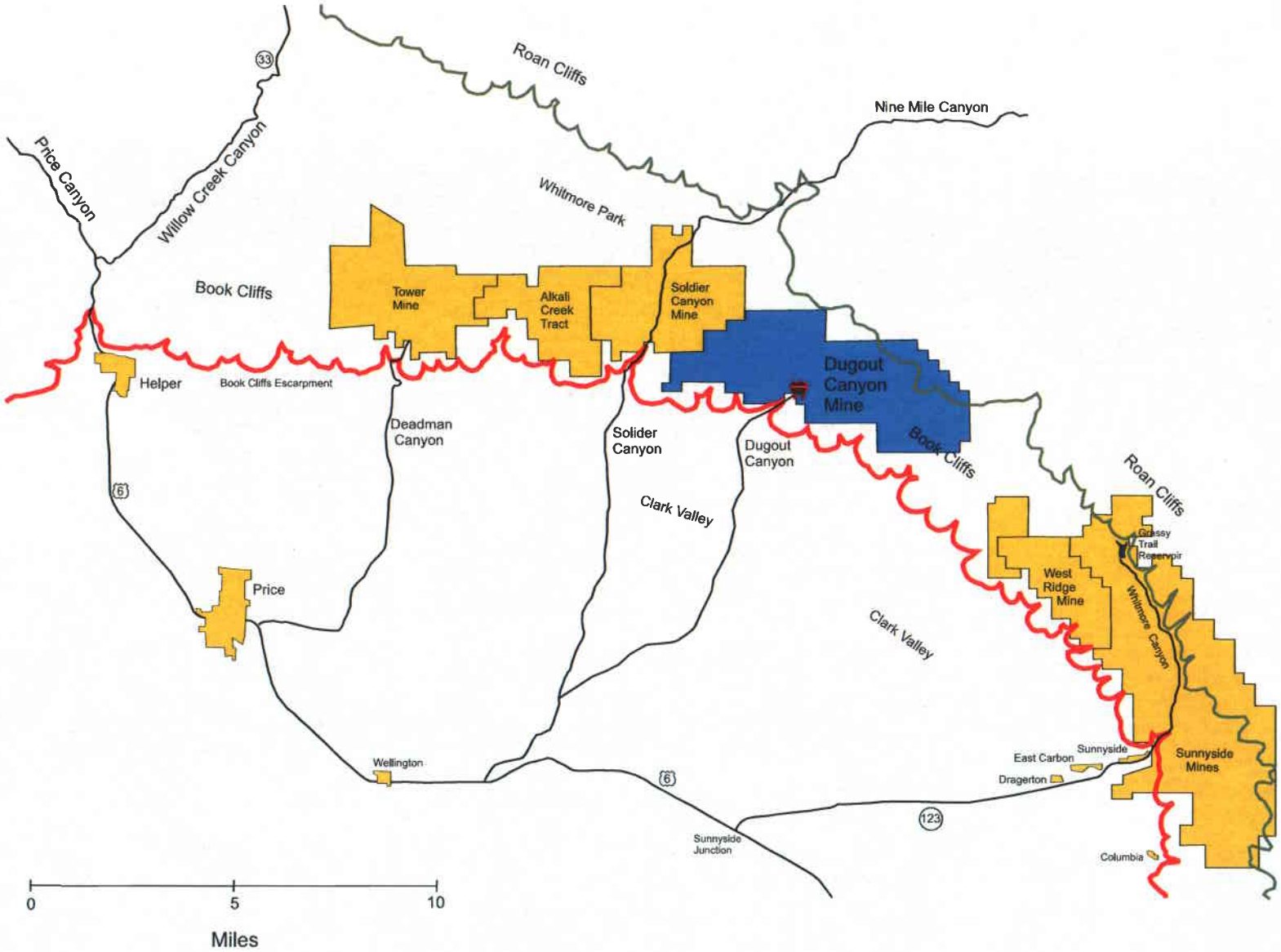


Figure 1 Location map for the Dugout Canyon area.

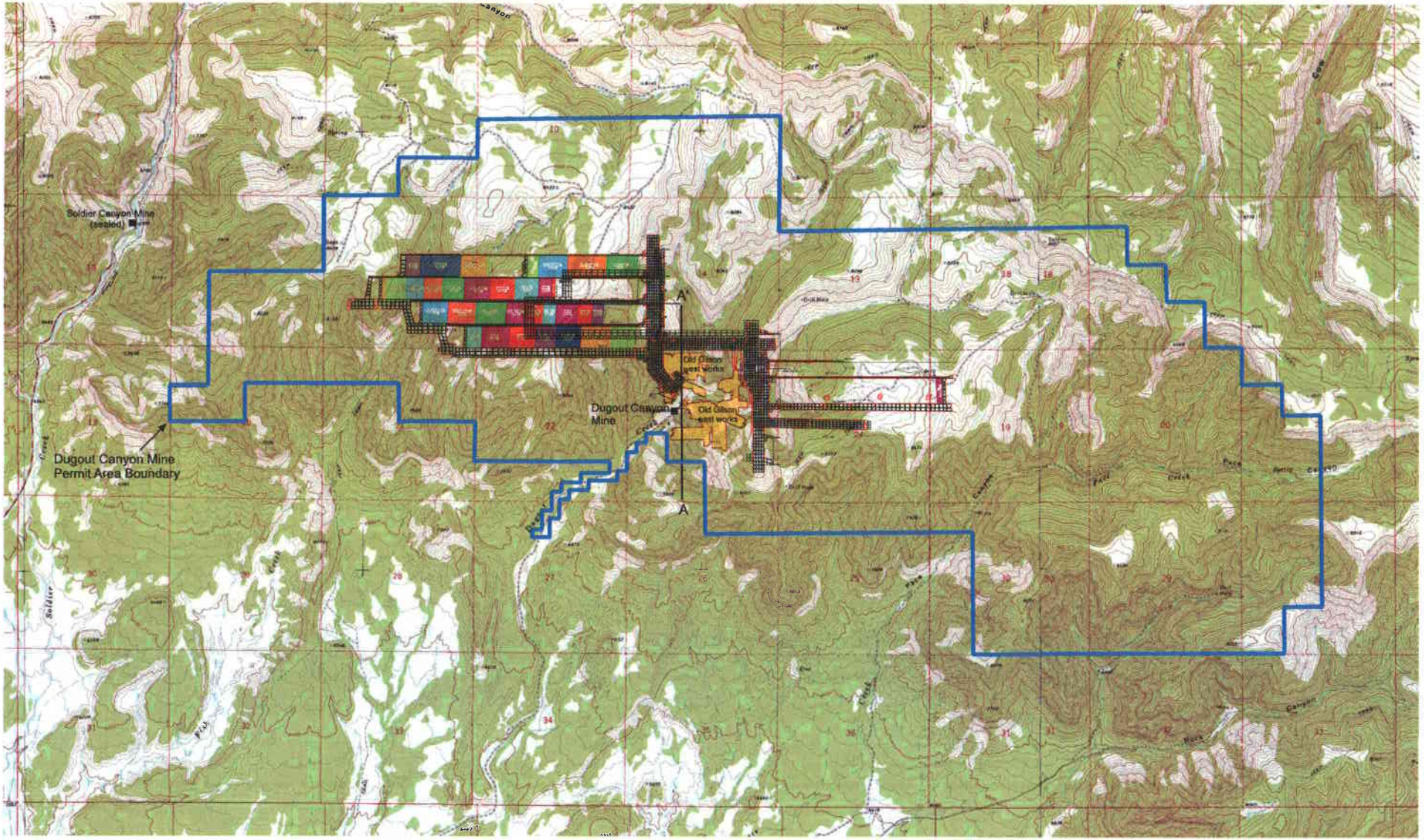
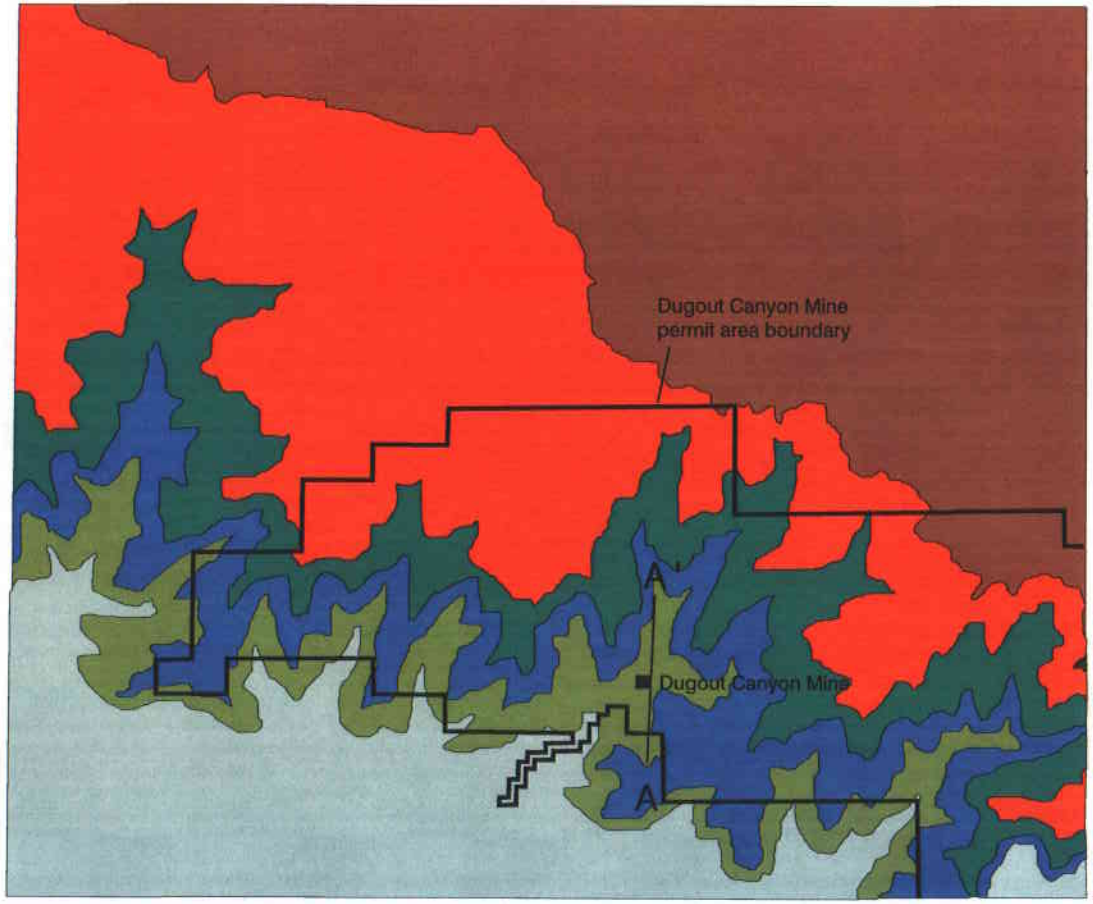


Figure 2 Dugout Canyon Mine study area map.



Colton Formation

Flagstaff and North Horn Formations (undivided)

Price River Formation

Castlegate Sandstone

Blackhawk Formation

Mancos Shale

N

1 Mile

Figure 3 Geologic map of the Dugout Canyon area.

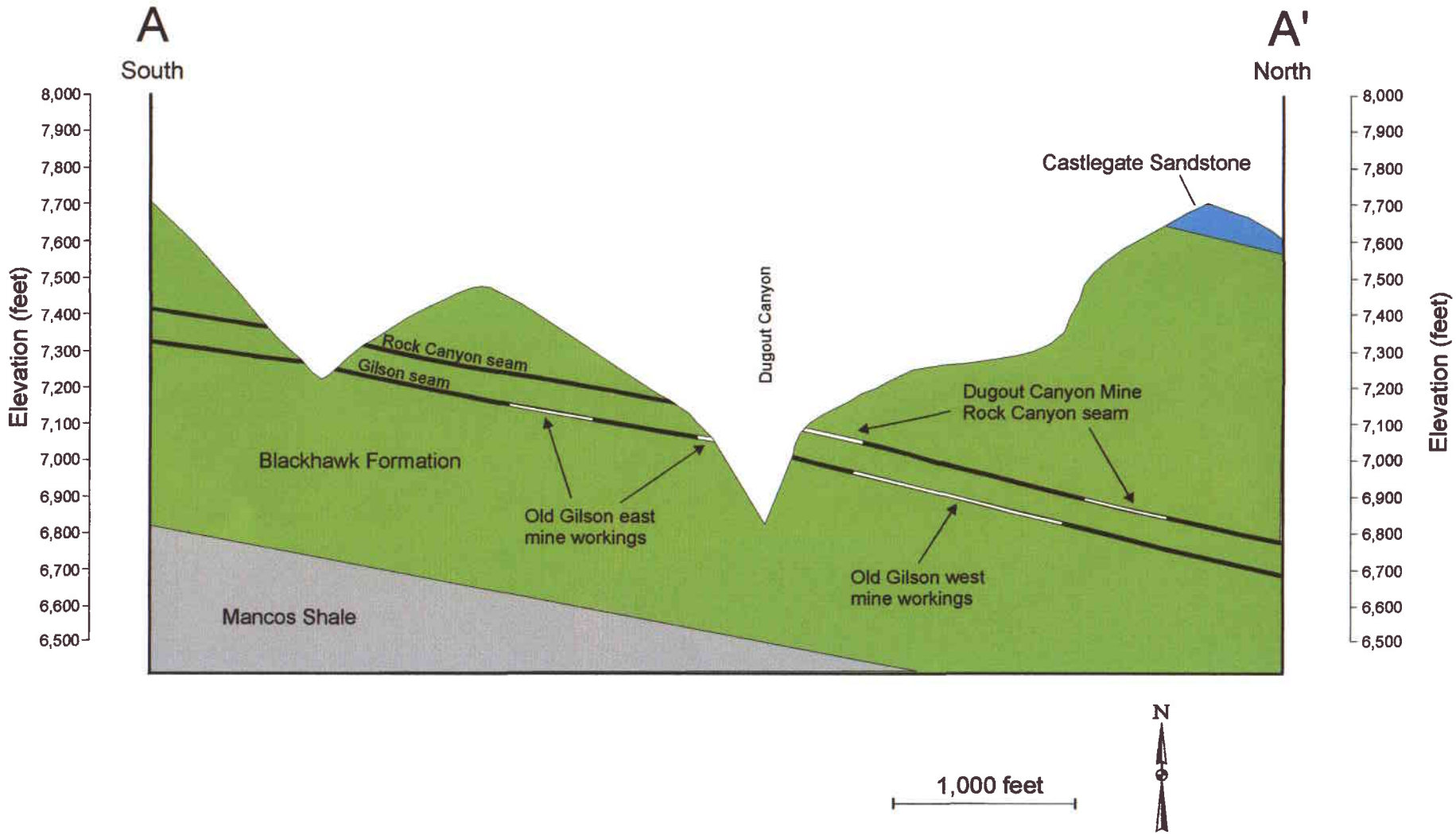


Figure 4 North-south cross-section showing locations of coal seam and mine workings in Dugout Canyon.

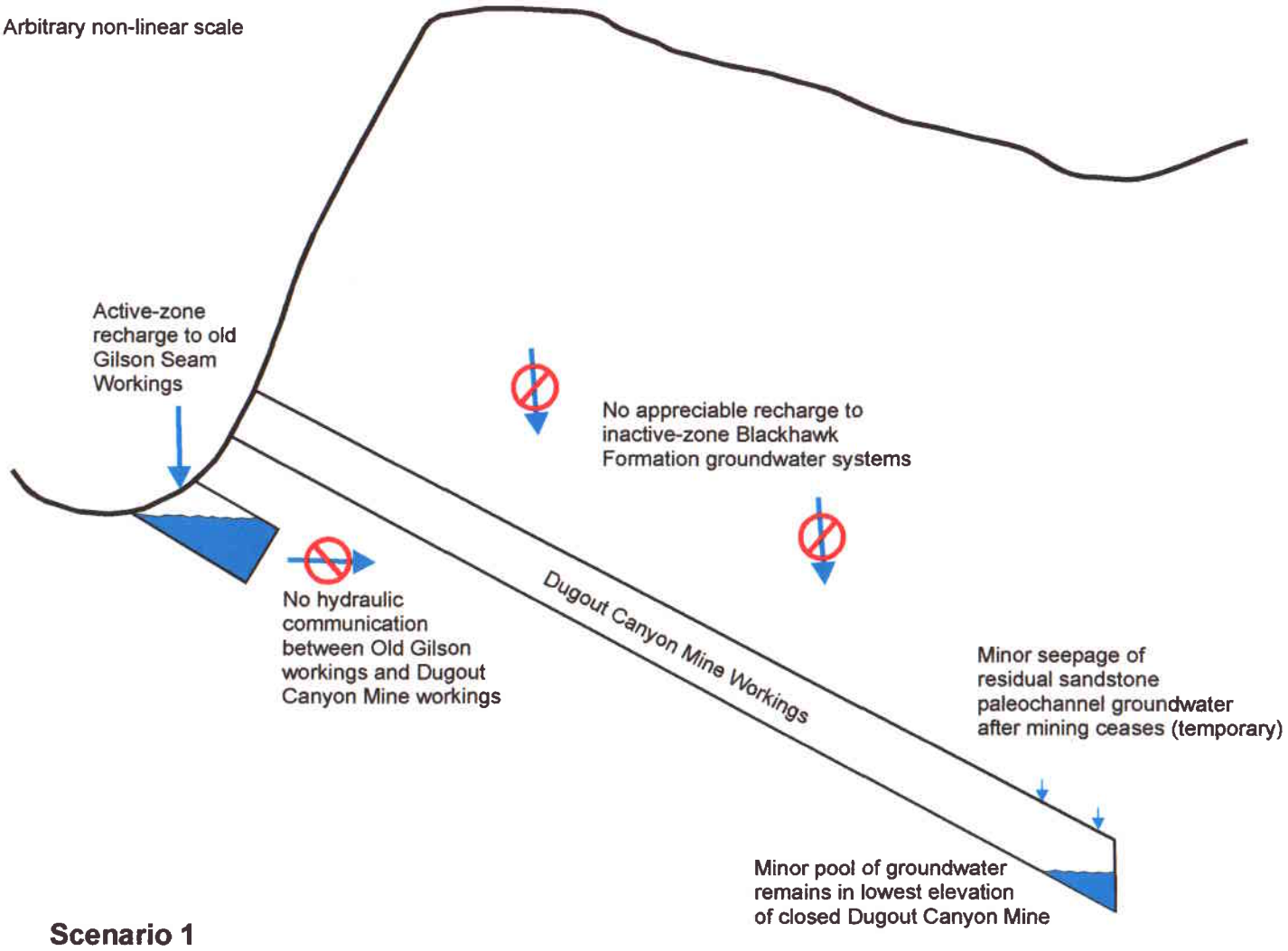


Figure 5A Schematic diagram showing conditions for Scenario 1.

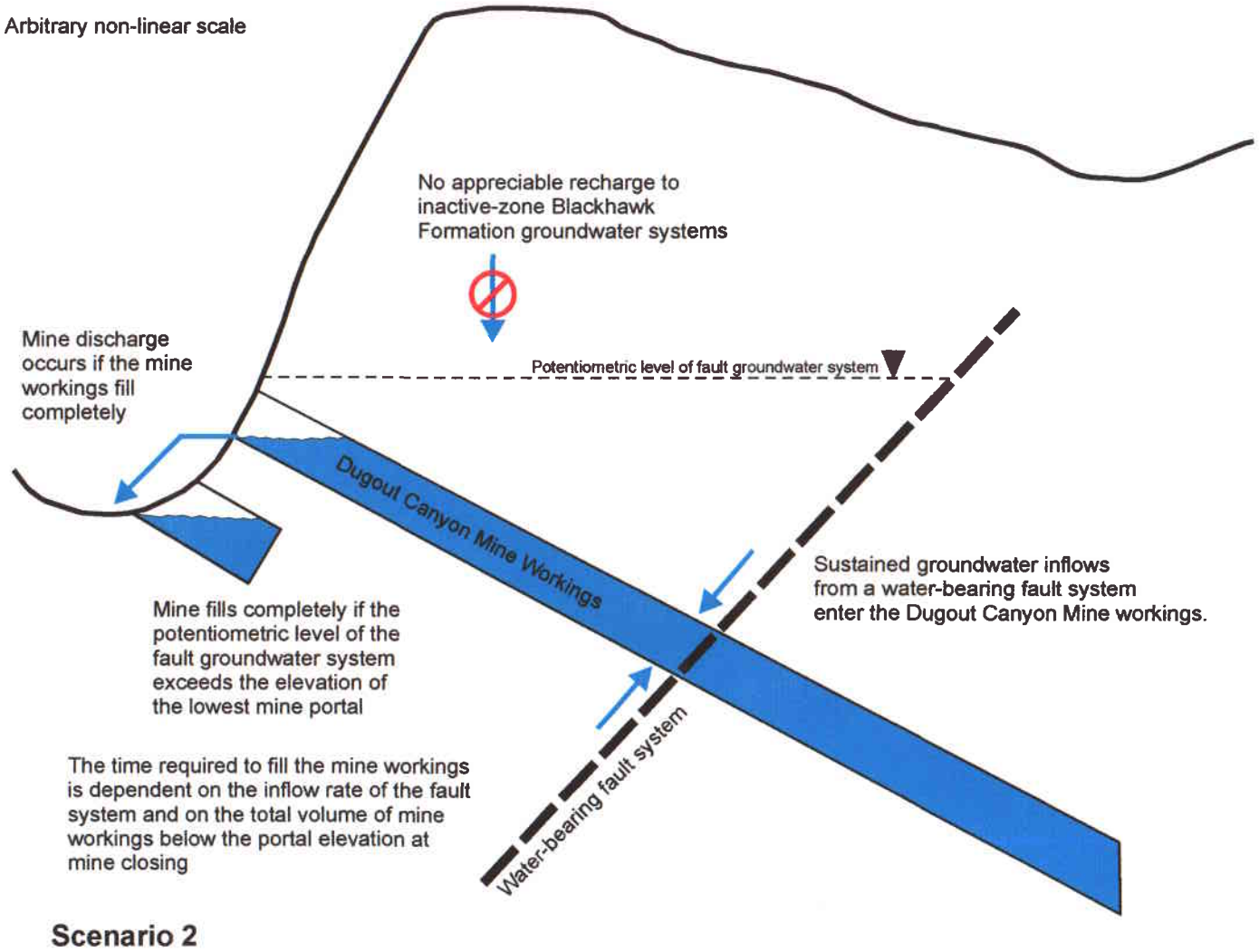


Figure 5B Schematic diagram showing conditions for Scenario 2.

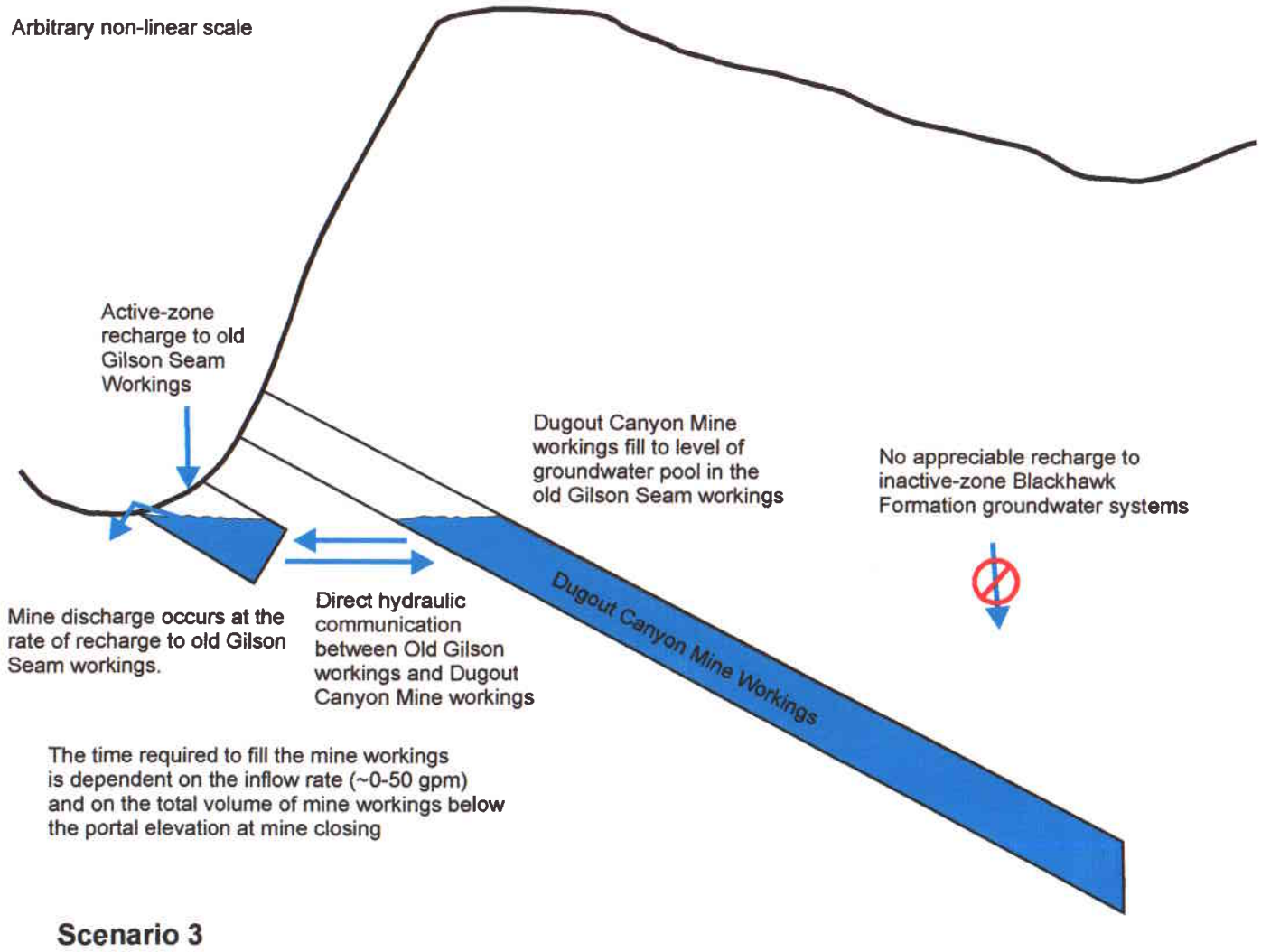


Figure 5C Schematic diagram showing conditions for Scenario 3.