C/015/032 Incoming
#4206
ok

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January 7, 2013
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DIV. OF OIL, GAS & MINING

Mr. Daron Haddock
Coal Program Manager
Utah Division of Oil, Gas & Mining
1594 West North Temple
Salt Lake City, Utah 84116

RE: Revised Probable Hydrologic Consequences Chapter 7, Appendix 7-15 – Genwal Resources, Inc., Crandall Canyon Mine, C/015/0032, Task ID #4206

Dear Daron:

On behalf of Genwal Resources, Inc. ("**Genwal**"), and in response to the Division's conditional approval letter dated December 18, 2012, enclosed are two copies of the modifications to Chapter 7 of the MRP, including replacement text of the Probable Hydrologic Consequences Determination ("**PHC**"), Appendix 7-15, of the Crandall Canyon Mine, Permit No. C/015/0032. Also enclosed are application forms C-1 and C-2, executed by Jay Marshall, requesting processing of the permit change.

Please update of Chapter 7 of the MRP as follows:
Crandall Canyon Mine PHC: replaces the entire text of Appendix 7-15;
Chapter 7 Table 7-4(A): replaces the old Table 7-4(A);
Chapter 7 Surface water monitoring summary page: replace the old page.

Finally, we understand that the new monitoring requirements will be effective following final approval upon the Division's receipt of the enclosures.

Thank you for your approval of this permit change.

Very truly yours,

Denise A. Dragoo

DAD:jmc
cc: David Hibbs
Jay Marshall
J. D. Leonard
Erik Petersen

16389924.1

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

Permittee: Genwal Resources, Inc.
Mine: Crandall Canyon Mine
Permit Number: 015/032
Title: Response to Division Task ID #4194

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.

Add	Replace	Remove	DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☐	☒	☐	Chapter 7, Appendix 7-15, Probable Hydrologic Consequences Determination
☐	☒	☐	Chapter 7, Table 7-4(A) Appendix 7-66
☐	☒	☐	Chapter 7, Surface water monitoring summary page
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Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.	Received by Oil, Gas & Mining
Crandall Canyon Mine PHC; replaces the entire text of Appendix 7-15 Chapter 7 Table 7-4(A); replaces the old Table 7-4(A) Chapter 7 Surface water monitoring summary page; replaces the old page	RECEIVED JAN 07 2013 DIV. OF OIL, GAS & MINING

APPLICATION FOR COAL PERMIT PROCESSING

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

Permittee: Genwal Resources, Inc.
Mine: Crandall Canyon Mine **Permit Number:** 015/032
Title: Response to Division Task ID #4194

Description, Include reason for application and timing required to implement:

Instructions: If you answer yes to any of the first eight 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# 10-A, Task ID #4194
☐ 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?
☐ Yes ☒ No 24. Does the application include confidential information and is it clearly marked and separated in the plan?

Please attach three (3) review copies of the application. If the mine is on or adjacent to Forest Service land please submit four (4) 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.

Print Name	Position	Date	Signature (Right-click above choose certify then have notary sign below)

Subscribed and sworn to before me this ______ day of ____________, ________

Notary Public: ______________________________, state of Utah.

My commission Expires: ______________ }
Commission Number: ______________ } ss:
Address: ______________ }
City: ______________ State: ______ Zip: ______________ }

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Form DOGM- C1 (Revised December 10, 2007)

TABLE 7-4(A)

Mine-Water Discharge Analysis List

Field Measurements:

Ferrous iron
pH
Dissolved oxygen
Conductivity
Temperature
Flow

Laboratory Measurements:

Calcium (dissolved)
Potassium (dissolved)
Sodium (dissolved)
Magnesium (dissolved)
Silica
Chloride
Hot acidity by Standard Method 2310B4(a)
Aluminum (total and dissolved)
Iron (total and dissolved)
Manganese (total and dissolved)
Sulfate
Alkalinity (total, carbonate, and bicarbonate)
TDS
Suspended solids

Isotopic Laboratory Measurements:

Tritium
Carbon-14
Deuterium
Oxygen-18

Note: All Mine-Water Discharge monitoring data will be submitted to the Division monthly. Water chemistry and field measurements data will be submitted electronically using the Division's water monitoring database EDI system. Isotopic laboratory measurement data will be submitted when the results become available from the laboratories. Mine-water discharge rate data will be provided in a spreadsheet format.

Surface Water

Streams

1	Upper Flume Crandall Creek	Flow, field parameters, and Table 7-8 parameters quarterly
2	Lower Flume Crandall Creek	Flow, field parameters, and Table 7-8 parameters quarterly
3	Horse Canyon Creek	Flow, field parameters, and Table 7-8 parameters quarterly
4	Blind Canyon Creek	Flow, field parameters, and Table 7-8 parameters quarterly
5	Indian Creek	Flow, field parameters, and Table 7-8 parameters quarterly
6	IBC-1	Flow, field parameters, and Table 7-8 parameters quarterly
7	Section 4 Creek	Flow, field parameters, and Table 7-8 parameters quarterly
8	Section 5 Creek (lower)	Flow, field parameters, and Table 7-8 parameters quarterly
9	Section 5 Creek (Upper Right Fork)	Flow and field parameters quarterly
10	Section 5 Creek (Upper Left Fork)	Flow and field parameters quarterly
11	Little Bear Creek	Flow, field parameters, and Table 7-8 parameters quarterly
12	Shingle Creek	Flow, Field parameters quarterly.

UPDES

1	001	Sediment Pond Discharge	Flow, field parameters, and UPDES parameters per occurrence
2	002	Mine Water Discharge	Flow, field parameters, and UPDES parameters monthly

Mine Discharge

1	Pre-002 Pre-treated Mine Water	Flow, field parameters and Table 7-4(A) laboratory parameters (chemical) monthly; Table 7-4(A) isotopic laboratory measurements semi-annually in 2nd and 4th quarters until time of 2018 permit renewal.

Ledge seep water flow:

The treatment area is separated from the portal bench above by a massive sandstone ledge of bare sandstone rock. There are several seeps emanating from this ledge and this seep water drains down the ledge toward the area of the settling basin. Based on previous measurements, the flow is minimal (approximately 2-5 gpm), but constant. A concrete trough has been poured behind the existing retaining wall (between the ledge rock and the back of the wall) to collect this seepage water and route it through a 4" PVC pipe to the settling basin overflow culvert inlet. In this manner the seepage water is contained, can be monitored, and is also subject to treatment thru dilution. The flow data collected from monitoring this seep will be provided to the Division and will assist in determining the most appropriate geotechnical method for future reclamation of this area, i.e., final reclamation. Monitoring will be conducted monthly, although freeze/thaw conditions in winter months will have to be factored into interpreting the data. The monitoring information will be provided to the Division (via the electronic water monitoring data base) on a monthly basis and will continue until the Division determines that it is no longer necessary, and at a minimum, until such time as the revised final reclamation plan has been approved, since this information will be needed in order to properly design the approximate-original-contour requirements for the "old loadout area".

APPENDIX 7-15

PROBABLE HYDROLOGIC

CONSEQUENCES DETERMINATION

1/23/95 revised 11/2012
12275601.1

R645-301-728 Probable Hydrologic Consequences Determination

This document has been prepared in accordance with requirements of the State of Utah R645 Coal Mining Rules. The format follows the regulations R645-301-718.100 through R645-301-728.400. This Probable Hydrologic Consequences evaluation of the coal mining and reclamation operations has been prepared by Genwal Resources, Inc. to provide a description of the potential impacts of the mining operation on the hydrologic systems and the means to prevent or mitigate those identified impacts.

R645-301-728.100 Determination

This determination section presents a brief summary of the surface water, groundwater, and geologic resource descriptions of the permit area and the South Crandall Lease area and the U-68082 lease mod area and a description of the possible impacts of the coal mine on the hydrologic resources.

The geologic and hydrologic data and their associated appendices are contained in Chapter 6 and Chapter 7, respectively. The potential sources of contamination to the hydrologic resources in the area of the mine were identified through site visits, knowledge of the working operations of the mine and discussions with Genwal Resources personnel. These potential contamination sources and impacts include:

Water Quantity

- Interception of groundwater and surface water
- Water consumption within the mine
- Seepage from mine sumps
- Pumping from Crandall Creek

Water Quality

- Additional sediment contribution
- Fugitive dust
- Oil and grease
- Mine water discharge
- Acid-toxic materials
- Flooding or Streamflow Alteration

Each of these potential sources of contamination or impact and their associated mitigating measures or circumstances are discussed in the following sections.

Water Quantity Impacts

Possible impacts to the surface and groundwater systems from the mining operation could affect the quantity of water in the mine area. Interception, consumption, and seepage of surface or groundwater are possible mechanisms which could affect the water systems.

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Groundwater Interception.

Groundwater was commonly intercepted in the Crandall Canyon Mine workings when the mine openings intercepted sequences of water-bearing sandstone paleochannel deposits in the mine roof. In some locations, groundwater also upwelled from the Star Point Sandstone through the mine floor (this occurrence was visible in the westernmost portion of the mine near where the underlying Star Point Sandstone is truncated by the Joes Valley Fault). As described by Mayo and others (2003) a limited potential exists for interception of shallow, active-zone groundwater systems or surface waters due to subsidence which may affect the perched aquifers (springs and seeps), and stream flows in Crandall Canyon, Blind Canyon, Horse Creek, the upper headwaters of the Indian Creek drainage (Upper Joes Valley), and the streams and springs of the South Crandall Lease area and the U-68082 lease mod area. This is because of the heterogeneous nature of the interbedded bedrock lithologies comprising the overburden above mined areas. Within the Blackhawk Formation, permeable sandstone paleochannels are usually encased both vertically and horizontally in a matrix of low-permeability shales, claystones, and mudstones. Because the permeable rocks of the sandstone paleochannels are not continuous vertically or horizontally over substantial distances, the potential for both vertical and horizontal flow through the bedrock is greatly limited. The Blackhawk Formation is also known to contain hydrophyllic clays, which swell when wetted to seal mining-related cracking which may form during mining operations. Because of the hydraulic disconnect between the deep, inactive-zone groundwaters that are commonly intercepted by the mine workings, and the overlying shallow, active-zone groundwater systems that support most springs in the area and provide baseflow to streams (Mayo and others, 2003), the likelihood that mining operations could cause impacts to groundwater flow in the overlying perched aquifers, the interruption or lessening of flow to springs, or the interception of surface water flow from ephemeral streams is small. This conclusion is strongly supported by the very large existing database of hydrologic monitoring data collected at springs and streams in and around the Crandall Canyon Mine permit area, which to date have not shown any quantifiable diminution of flow rates from monitored springs and streams that could be attributed to mining and reclamation activities at the Crandall Canyon Mine. Continued monitoring of streams and springs will occur to verify that no impacts occur.

A notable exception to the hydrologic isolation that typically exists between the deep, active-zone groundwaters encountered in the mine workings and the overlying shallow, active-zone groundwater systems was found to be present in the northwest portion of the Crandall Canyon Mine workings (herein defined as longwall panels 7, 8, 9, 10, 11, and 12 and the associated development entries for these panels). The northwest portion of the mine was sealed on June 17, 1999. While some water was encountered in the main Joes Valley Fault, the most significant quantities of water encountered in this area were associated with damaged zone fracturing and synthetic faulting associated with the Joes Valley Fault. When this area was first mined in the late 1990s, groundwaters of mixed source were identified (i.e containing appreciable tritium but also having radiocarbon ages on the order of hundreds to thousands of years) (Mayo and Associates, 1997, provided in Appendix 7-53). As described by Mayo and others (2003) the presence of appreciable tritium indicates hydraulic communication with surface water in that location. Mayo concluded that the communication with the surface exists where the stress field associated with the outward expansion of cliff faces creates aperture in the damage zone associated with the fault. It is noteworthy that a sample of groundwater collected from the main Joes Valley Fault underground

(Main West Fault) contained no tritium and had a carbon-14 mean residence time exceeding 2,000 years. It should be noted that, as stated above, although hydraulic communication between the mine workings and overlying active-zone groundwater systems was present in that location, there is no indication that impacts to spring or stream discharge rates has occurred (based on water monitoring data collected to date). Continued monitoring of streams and streams overlying and surrounding the synthetic faulting and associated damage zone continues to be performed to verify that the interception of active-zone waters does not detrimentally impact spring and stream discharge rates.

To better understand this occurrence, it is useful to provide additional information regarding the geologic and hydrogeologic character of the Joes Valley Fault Zone. The Joes Valley Fault Zone (East Fault) is a normal fault bounding the east side of the Joes Valley graben. The fault zone shows evidence of Holocene movement with an estimated slip rate of 0.2 to 1 mm/year (Utah Geologic Survey, 1999). The trace of the fault trends approximately N2°E. The Joes Valley Fault Zone has previously been described by Doelling (1972). Doelling describes the Joes Valley Fault Zone as the most extensive of the fault zones of the Wasatch Plateau, with a total length of 75 miles. The fault zone's northern limit is somewhere not far north of Cleveland Reservoir, while the fault is visible to the south at Quitchupah Creek. Doelling indicates that the offset on the fault is from 1,500 to 2,500 feet and that the dropped graben block is everywhere "much shattered". Rather than an individual fault plane, the system is described as a "fault zone", reflecting the complexity of the internal faults of the zone. Where the fault was initially encountered along the western edge of the Crandall Canyon Mine there was found to be considerable clayey gouge associated with the structure. A seal constructed of concrete, timbers, and bentonite was emplaced at the fault location to minimize the potential for groundwater inflow from the fault into the mine workings. When the Joes Valley Fault location was visited in February 1997 for isotopic sampling, it was observed that only minor amounts of groundwater were weeping from the fault area at that time (0.1 gpm).

Stokes (1963) shows that an alignment of faults along the Joes Valley Fault Zone extends from McGrath Lake south of Boulder Mountain in Garfield County northward, west of Thousand Lake Mountain and past Cleveland Lake, northward toward Strawberry Reservoir. At the north end, it fuses with the Pleasant Valley Fault Zone. The total length of this zone may be as much as 160 miles.

As discussed previously, copious amounts of discharge were not observed emanating from the main Joes Valley Fault where it was intersected in the Main West entries at the Crandall Canyon Mine. When the exposed segment of the Joes Valley Fault was visited for isotopic sampling in 1997, the total discharge was estimated to be less than 5 gpm in total. The vast majority of the total water intercepted within the Crandall Canyon Mine originated from fracture systems or exposed saturated sandstone paleochannels intersected in the mine roof. Lesser quantities of groundwater welled-up from the underlying Spring Canyon member of the Star Point Formation in the mine entries in the western portion of the mine. It should be noted that an unknown quantity of groundwater may possibly have upwelled from the mine floor in inaccessible longwall-mined gob areas after mining in the area was completed. It is not possible to quantify the amount of groundwater that may have originated from the Star Point Sandstone in the mine floor in these areas.

Synthetic faults that likely have a genetic origin associated with the stress field of the adjacent Joes Valley Fault Zone are present in the western portions of Sections 26 and 35, Township 15 South, Range 6 East. It is noteworthy that in some locations, the synthetic faults intercepted underground contained clayey fault gouge and did not transmit any water, but rather were likely barriers to groundwater flow. In other locations, the faults discharged some groundwater, although generally at rates of a few gallons per minute or less. More appreciable quantities of water were encountered in damage zones associated with the fault system where fractured sandstone rocks in the mine roof drained into the mine openings. When the land surface in the synthetic fault area was visited, no indication of pronounced brecciation of the exposed bedrock was observed, nor were there indications of groundwater discharge associated with these features at the surface.

As part of the Division-requested Work Plan activities performed during 2011, the surface trace of the Joes Valley Fault along the western escarpment of East Mountain was visited. During the site visits several springs which discharge from near the fault trace were monitored for flow and field water quality parameters. Additionally, the projected surface locations of the synthetic fault system associated with the Joes Valley Fault Zone in the northwest portion of the Crandall Canyon Mine were visited and monitored during 2011. Springs on East Mountain were also monitored as part of the 2011 work plan investigation. Almost without exception, the discharge rates measured at all of these springs during 2011 were similar to or in most cases greater than the discharge rates measured during pre-mining baseline monitoring activities. Several springs not identified during initial spring and seep surveys were identified during the 2011 Work Plan investigations. Based on these findings, there is no indication that any quantifiable or perceptible impacts to springs discharging near the Joes Valley Fault Zone have been impacted by mining operations at the Crandall Canyon Mine. It should also be noted that Genwal Resources, Inc. is not aware of any claim made by water rights holders regarding impacts to groundwater or surface-water resources in the Joes Valley Fault area near the Crandall Canyon Mine.

A plot of discharge rates measured at the Indian Creek monitoring station is presented in Figure PHC-6. Also included on Figure PHC-6 is a plot of the Palmer Hydrologic Drought Index (PHDI) for Utah Region 4. 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, the index is a useful for evaluating the long-term relationship between climate and groundwater recharge and discharge. It is apparent in Figure PHC-6 that discharge rates measured at Indian Creek have been variable over the period of record. Generally, the baseflow discharge rates measured in the creek respond to long-term climatic variability. The measured peak discharge rates are less predictable, which is likely largely controlled by the date of the first monitoring event of the year (i.e., whether the monitoring event occurred prior to, during, or after the passage of the seasonal discharge peak. It is noteworthy that the 4th quarter baseflow discharge measurement recorded during October 2011 is the largest baseflow measured recorded in the past 14 years at the site. There is no indication of any diminution of flow in Indian Creek that could be attributable to any mining-related activities at the Crandall Canyon Mine. It should also be noted that Genwal Resources, Inc. is not aware of any claims made by water rights holders regarding impacts to surface-water resources in the Indian Creek drainage near the Crandall Canyon Mine.

Springs and streams in the upper Joes Valley drainage along the Joes Valley Fault Zone were visited and inspected on 9 August 2007, which was three days after the mine collapse event of 6

August 2007. The purpose of this supplementary site visit was to observe conditions in the region immediately west of the collapse event location to ascertain whether any notable impacts to groundwater or surface-water systems had occurred as a result of the event. Visual observation did not indicate any increases in groundwater or surface-water turbidity, nor any obvious increases or decreases in groundwater or surface-water discharger rates in the region investigated. Measured discharge rates and field and laboratory water quality parameters performed on water samples from these the three springs (SP1-47, SP2-1, and SP1-33) and one creek site (Indian Creek) were similar to those monitored at these sites previously. Additionally, similar observations were made at each of other the regular Crandall Canyon Mine water monitoring sites during monitoring activities in the third quarter of 2007. Anomalous conditions were not noted at the monitoring sites during the 3rd quarter.

Groundwater Interception.

Previously, researchers commonly referred to a regional aquifer existing in the Blackhawk Formation and the Star Point Sandstone. However, a new conceptual model of groundwater has been developed that describes two largely disconnected groundwater systems (Mayo and others, 2003). These two systems include 1) shallow, active-zone groundwater systems that generally support discharge at springs and seeps in the area and provide baseflow to surface waters, and 2) deep, inactive-zone groundwater systems that are commonly encountered in the coal mining environment away from cliff faces and in areas under shallow cover. Groundwater that occurs in the deep, inactive-zone groundwater systems in the Blackhawk Formation often occurs in discrete sandstone paleochannel deposits that may or may not be connected to adjacent channel sands. Inactive-zone groundwaters are also commonly intercepted in fault systems that have open apertures, both in the mine floor and in the mine roof. Rarely, the deep, inactive-zone groundwater systems come into hydraulic communication with overlying shallow, active-zone groundwater systems through interconnecting faults or associated damaged zones. It is believed that recharge to the deep, inactive-zone groundwater systems may occur where the sandstone members are exposed at the surface and horizontal movement of the recharge waters into the exposed rock may occur. There is also isotopic evidence that suggests that, regionally, recharge to the deep, inactive-zone groundwater systems occurred under paleoclimatic conditions, when climatic conditions in the region were considerably wetter and cooler than they are at present.

Petersen Hydrologic, LLC performed isotopic sampling of the Crandall Canyon Mine discharge water on 18 October 2011. The results of this investigation are presented in a letter report to Mr. David Hibbs. The Petersen Hydrologic, LLC letter report is included as Appendix 7-71.

Sandstone paleochannels that are saturated with groundwater are present in the strata overlying the mine roof in many locations throughout the mine. Groundwater monitored in the Spring Canyon Member of the Star Point Sandstone at monitoring well MW-7 exists under flowing artesian conditions. The shut-in pressure measured at the well during November 1997 was 22 psi, which equates with a hydraulic head that is 50.8 feet above the top of the well casing at that location. It is considered likely that the artesian pressure at this location exists in large part as a result of westward dip of the saturated sandstone beds of the Star Point Sandstone toward the Joes Valley

Fault, which truncates the sandstone beds on the west. The flowing artesian discharge from MW-7 was meager, typically in the range of 0.1 to 0.2 gpm, which suggests a low permeability for the Spring Canyon Member in the vicinity of the well. A shut-in recovery test was performed on the well MW-7 which indicated a low hydraulic conductivity of 7.4×10^{-8} feet per second.

The fact that large quantities of groundwater were released from storage through the mine roof during longwall mining operations in the northwest and southwest portions of the Crandall Canyon Mine indicate that saturated sediments were obviously present in the mine roof in these areas. It is interesting to note, however, that the occurrence of groundwater from the mine roof was variable from location to location. This occurrence is attributable to 1) the fact that bedrock lithologies are spatially variable in the heterogeneous Blackhawk Formation (i.e., in some areas the mine roof consisted of aquifer-quality sandstsones, while in other areas siltstone or mudstones are present immediately above the mined coal seam), and 2 the presence or absence of fault or fracture systems, which have the effect of enhancing the secondary permeability of the rocks surrounding the mine openings.

Monitoring of in-mine and surface wells indicate that water levels in the underlying Spring Canyon Member of the Star Point Sandstone are typically about 50 to 60 feet below the top of the formation over much of the mine. In the western portion of the mine near the Joes Valley Fault systems, the Spring Canyon Member was found to be fully saturated with groundwater systems existing under flowing artesian conditions. A shut-in pressure of 22 psi was measured in monitoring well MW-7, which is completed in the Spring Canyon Member below the mine. In these areas, minor amounts of groundwater weep from the floor of the mine (particularly where the permeability of the tight sandstones is enhanced by fracturing or faulting).

Historically, the springs within the permit area which are monitored on a quarterly basis, in the perched aquifer of the Blackhawk Formation above the mine, have not been affected by operating the Crandall Canyon Mine. Locally, modest amounts of groundwater were initially intercepted during mining operations at the Crandall Canyon Mine. Prior to 1996, discharge from the Crandall Canyon Mine was minimal or did not occur. As mining occurred in the northwest portion of the mine in Sections 26 and 35, T15S, R6E, appreciable groundwater inflows were encountered. Most of this groundwater entered the mine workings from fracture zones in the mine roof. This groundwater discharge appeared to be associated with release of groundwater from storage in fractured paleochannel systems overlying the Hiawatha coal seam. The fracture systems from which the groundwater emanated are likely associated with synthetic faulting related to the Joes Valley Fault system. The Joes Valley Fault system, which extends considerable distances to both the north and south, is present immediately west of mined areas.

It is important to note that, although during the life of the Crandall Canyon Mine substantial quantities of groundwater were intercepted by the mine workings, more than 20 years of water monitoring data indicates that the interception of this water has not had any measurable impact on the discharge rates from springs or streams in the area (i.e., it did not impact the hydrologic balance). This observation supports the conclusion that the water being intercepted by the mine workings is largely derived from deep, inactive-zone groundwater systems that are hydraulically disconnected from shallow, active-zone groundwater systems that support springs and streams in the region.

(With the exception noted here of the interconnection between the underground mine openings and overlying active-zone groundwater systems in the northwest portion of the mine).

The amount of groundwater flowing into the mine from Sections 26 and 35, T15S, R6E, together with groundwater originating from less significant sources located elsewhere in the mine, exceeded the amount of groundwater utilized in underground mining processes. Consequently, it became necessary to discharge the excess groundwater from the Crandall Canyon Mine. The mine water was pumped from underground sumps to the surface and then discharged into Crandall Canyon Creek at monitoring point UPDES 002. The northwest portion of the Crandall Canyon Mine was sealed on June 17, 1999 after mining in that area was complete. However, drainage of groundwater from the sealed northwest portion of the mine continued. Groundwater discharge from the Crandall Canyon Mine was essentially continuous throughout the remaining period of active mining (through August 2007).

In August 2007, a tragic mine collapse event occurred at the Crandall Canyon Mine. As a consequence of this event, the Crandall Canyon Mine was subsequently closed and sealed. Accordingly, as the mine pumps were removed, it was no longer possible to pump groundwater from the Crandall Canyon Mine workings and discharge from the mine ceased during September 2007.

Beginning in January 2008, groundwater began to discharge from the Crandall Canyon Mine portals via gravity drainage. It should be noted that, based on the geometry of the Crandall Canyon Mine workings (with the lowest elevation regions occurring in the southern part of the mine), large portions of the mine workings likely remain free of mine water.

A reconnaissance of field information and data available from the old Huntington #4 permit indicates that Little Bear Spring located in T16S-R7E-Sec9 (see Plates 7-12, 7-13, and 7-14) emanates from the Panther (lowest member) of the Star Point Formation. Previous drilling within the mine area has shown that the three members of the Starpoint Sandstone are vertically isolated from one another. The Spring Canyon member is located within the upper 100 feet of the Starpoint Sandstone. This member has been found to contain water in some areas of the mine. The Storrs member was isolated from the Spring Canyon member by interbedded shale and siltstone. It did not appear to contain any appreciable water. The Panther member was found to be about 36 feet thick at a depth of 315 to 351 feet. Flow from this bed varied from about 2.1-7.0 gallons per minute. Although Little Bear spring emanates out of the Panther member, age dating showed the water to be of recent age (<50 years old). Age dating of water from the Starpoint Sandstone shows it to be of an age greater than 10,000 years old. It appears that Little Bear Spring emanates from a fault zone which may be serving as a conduit for diversion of recent water intercepted in some of the larger drainages in the area. It is doubtful that mining activities would have any affect on flow from Little Bear Spring due to the large age difference between the water encountered underground and the water flowing out of Little Bear Spring.

Meetings with the Castle Valley Special Service District officials and their representatives, as well as the other water user districts of the area, were held on 10 June 1993. The concern of the Castle Valley Special Service District regarding diminution and mitigation of the Little Bear Spring flow that could result from future mining were discussed. Given the elevations of the Starpoint potentiometric surface, in relation to that of the Hiawatha Coal Seam, it was shown that the present and future mine workings would not interfere with the Starpoint aquifer.

Little Bear Spring is a developed spring that provides municipal water to nearby municipalities. It emanates from a fracture system in the Panther Member of the Star Point Sandstone that trends in an approximate northeast-southwest direction.

Because of its importance as a municipal water supply source and its proximity to proposed mining areas, Little Bear Spring has been extensively studied. Several hydrologic studies have been performed since 1977 to investigate the recharge source for Little Bear Spring (Forest Service Project File). These studies have agreed that the spring flow is supported by a fault/fracture system. Since Little Bear Spring lies more than 300 feet below the level of the mineable coal seams and past mining encountered the fault/fracture system without significant inflow of water, there is general consensus among the Castle Valley Special Service District (CVSSD), mine operators, scientific community, and the regulatory agencies that adverse effects to the spring are unlikely.

Several studies have been done that suggest a northerly component of flow feeding Little Bear Spring. These studies include:

- Vaughn Hansen Associated, *Water Quality and Hydrologic Study in Vicinity of Huntington Creek Mine No. 4 and Little Bear Spring*, Prepared for Swisher Coal Company, August1977.
- Hydro-Sciences, Inc., *Ground Water Hydrology in the Vicinity of the Huntington No. 4 Mine,* Prepared for ARCO Coal Company, December 19, 1980.
- Beaver Creek Coal Company, *Huntington Canyon No. 4 Mining and Reclamation Plan,* Prepared for UDOGM, 1983.
- Utah Geological and Mineral Survey, *Effects of Coal Mining at Huntington Canyon No. 4 Mine on Little Bear Spring, Emery County,* Prepared for Castle Valley Special Services District, Job No. 84-005, January 21, 1984.
- Vaughn Hansen Associated, *Hydrologic Conditions in Huntington Canyon No. 4 Mine,* 1984.

These referenced studies are available for review at the Division's Public Information Center.

Other studies indicate that the Little Bear Spring may possibly be fed by a fault/fracture system which intercepts surface water in Mill Fork Canyon southwest of the South Crandall Lease area. These scientific investigations include an investigation of the Little Bear Spring groundwater system and the groundwater systems encountered in the Crandall Canyon Mine (Appendix 7-52), a solute and isotopic investigation of groundwater from Little Bear Spring and the Star Point Sandstone and Blackhawk Formation groundwater systems the Crandall Canyon Mine (Appendix 7-53), an investigation of the hydraulic conductivity of the Star Point Sandstone in the vicinity of the Crandall Canyon Mine (Appendix 7-54), an investigation of the alluvial groundwater system in Mill Fork Canyon with implications for recharge to Little Bear Spring (Appendix 7-55), an investigation of the potential for Little Bear Spring recharge in Mill Fork Canyon (Appendix 7-56), and a fluorescent dye-tracing study that conclusively demonstrates the hydraulic connection between the stream/alluvial groundwater system in Mill Fork Canyon and Little Bear Spring (Appendix 7-57).

Sunrise Engineering also performed a series of investigations using a proprietary geophysical technique that demonstrated a hydraulic connection between Little Bear Spring and the surface drainage in Mill Fork Canyon. These investigations are included as Appendix 7-59, Appendix 7-60, Appendix 7-61, and Appendix 7-62.

These studies, taken as a whole, have indicated that Little Bear Spring is possibly recharged through surface water and alluvial groundwater losses in Mill Fork Canyon, located well beyond the boundary of the South Crandall Lease area, approximately 1.5 miles southwest of the spring. The basis for this assumption is discussed briefly below. The reader is referred to the above mentioned appendices for a more rigorous discussion of the recharge of Little Bear Spring.

The assumption that Little Bear Spring may possibly be recharged from surface-water and alluvial groundwater losses in Mill Fork Canyon is based on several findings. These include:

1) the finding that, from a water budged standpoint, there is sufficient water available in Mill Fork Canyon to account for the recharge to Little Bear Spring and any surface water drainage that leaves the Mill Fork drainage and flows into Huntington Creek,

2) the finding that there is a chemical and isotopic match (or a plausible chemical evolutionary pathway) between surface waters and alluvial groundwaters in Mill Fork Canyon and groundwater at Little Bear Spring, and

3) the finding that there is a demonstrated hydraulic connection between Mill Fork Canyon and Little Bear Spring and the hydraulic gradient and flow volume through the connection is sufficient to provide Mill Fork water to the spring.

These findings are discussed below.

An investigation was performed in 2001 to determine the quantity of water available in Mill Fork Canyon to recharge Little Bear Spring (Appendix 7-56). It is the finding of this investigation that there is an excess of approximately 300 gpm in the Mill Fork drainage that is available for recharge to the spring. Indeed, it is difficult to explain the loss of approximately 300 gpm from the drainage basin without taking the recharge to Little Bear Spring into account. This finding is based on a comparative analysis of baseflow in the Crandall Creek drainage, which is very similar in geology, topography, aspect, and elevation to the Mill Fork Creek drainage. The baseflow in Crandall Canyon Creek during most years is approximately 300 gpm greater than that in Mill Fork.

Another investigation examined the capacity of the alluvial groundwater system in Mill Fork Canyon to transmit sufficient groundwater to sustain the baseflow of Little Bear Creek during periods when there is not surface flow in the Mill Fork drainage (Appendix 7-55). This investigation was based on a quantitative determination of the flow of groundwater migrating through the alluvial groundwater system above the spring recharge location compared to that flowing through the alluvial deposits below the spring recharge location in Mill Fork Canyon. It is the conclusion of this investigation that there is appreciably more groundwater flowing through the alluvial deposits above the spring recharge location as compared to that flowing in the alluvial deposits below the spring recharge location (approximately 300 gpm more).

Investigations regarding the solute and isotopic compositions of groundwater at Little Bear Spring and other shallow groundwater systems in the vicinity have been performed. These investigations have also examined the solute and isotopic compositions of Star Point Sandstone groundwater systems encountered in the Crandall Canyon Mine. These studies are included as Appendix 7-52 and Appendix 7-53. It is the findings of these investigations that groundwater discharging from Little Bear Spring is modern in origin (<50 years old), while groundwater from deep Star Point Sandstone groundwater systems in the Crandall Canyon Mine have a mean groundwater age of many thousands of years. Shallow Groundwater systems (that provide baseflow to upper Mill Fork Creek) are modern in origin. The solute composition of groundwater in Little Bear Spring and that of surface water and shallow alluvial groundwater in Mill Fork Canyon are similar.

The fact that the discharge in Little Bear Spring shows rapid seasonal variations in discharge rate suggests that the recharge is related to a shallow recharge source that is closely tied to seasonal recharge. The ancient groundwater systems encountered in the Star Point Sandstone in area coal mines do not exhibit seasonal variability.

Finally, in order to explore the assumption that Little Bear Spring may possibly be recharged from Mill Fork Canyon, a fluorescent dye tracing study was performed in 2001 (Appendix 7-57). In this investigation, fluorescent dye was placed in the upper Mill Fork drainage immediately above the spring recharge location. A positive dye recovery occurred at Little Bear Spring within 40 days of the dye placement. Thus, a hydraulic connection between the alluvial system in upper Mill Fork Canyon was positively confirmed.

The elevation of the spring recharge location in upper Mill Fork Canyon is approximately 7710 to 7790 feet, while the elevation of Little Bear Spring is approximately 7475 feet. Thus, there is a substantial hydraulic gradient between the possible Mill Fork recharge location and Little Bear Spring. It is important to note that the possible recharge location for Little Bear Spring in Mill Fork Canyon is outside the boundaries of the South Crandall Lease area. Likewise, the groundwater flowpath connecting Mill Fork Canyon and Little Bear Spring is outside of the area of potential coal mining by Genwal Resources.

While the flow mechanisms conveying water to Little Bear Spring are not completely understood, additional hydrologic studies performed since the Mill Fork EA was written have indicated that adverse impacts to the spring are not expected due to the vertical separation between the coal seams and flow. (Forest Service, BLM Joint Decision Notice/Finding of No Significant Impact, Coal Lease Application UTU-78953)

In conclusion, because mining occurs above the Panther Member of the Star Point Formation, the source of water of the Little Bear Spring; because the mine is relatively dry; and because age dating has shown that the water sampled underground from the Starpoint Sandstone and from Little Bear Springs are not the same age (: there is little, if any chance, that current or proposed future mine workings of the Crandall Canyon Mine could affect the Little Bear Spring. Operation of the mine should not adversely impact the Star Point aquifer or Little Bear Spring.

Mitigation for potential disruption to the Little Bear Spring was accomplished though the construction of a water treatment plant which can provide replacement water for the spring should the need arise. Construction of this water treatment plant will be done under the provisions of a water replacement agreement between Genwal Resources, Inc. and the Castle Valley Special Service District who maintain culinary water rights to Little Bear springs. A copy of this water replacement agreement is included in Appendix 7-51. With construction of this water treatment plant an uninterrupted supply of culinary water is assured irrespectively of whether mining can be conclusively shown to have affected Little Bear Spring. This is in compliance with special stipulation #17 of federal lease UTU-78953 (see Appendix 1-13).

Spring and Seep Interception.

There is a potential for impact to overlying seeps and springs through interception of the perched aquifers as a result of subsidence. Seeps and springs throughout the mine area and the South Crandall Lease area and the U-68082 lease mod area have been identified through intensive field and aerial surveys. These survey results are presented in Chapter 7, Section 7.24.1, associated appendices, and are shown on Plate 7-12. Water rights have also been researched and are provided in Chapter 7, Table 7-6.

Genwal is currently monitoring the water flow rates and quality of representative springs and seeps as indicated in section 7.31 within and adjacent to the current mine permit area (including LBA No. 9 and the South Crandall Lease area). The springs which are monitored cover both the proposed aerial extent of the mine and also are located within each of the major lithologic units from the Blackhawk (above the regional aquifer) to the North Horn Formation (which caps the highest portions of the top of East Mountain).

As stated in Section 7.24.1, the water emitting from seeps and springs which overlie the coal seam originates from perched aquifers. These perched aquifers appear to have no direct communication with the Star Point Sandstone, or with the mine. Isotopic sampling has shown the chemistry of these springs to be substantially different than water from underground sources or the Starpoint Sandstone. These springs do not appear to have any vertical communication with the Blackhawk or Star Point Sandstone formations even when subsidence has occurred. This is due to the extensive interbedded shale in the intervening strata. Also, during the drilling conducted for the LBA No. 9 only one hole, DH-7, intercepted any groundwater. These data indicate that a significant zone of non-saturated, low-permeability strata (aquitard or aquiclude) are present between the Star Point Sandstone and the overlying perched aquifers.

Prior to the 1996, inflows into the Crandall Canyon Mine were usually modest in magnitude and of short duration. Beginning around 1996, most of the natural inflows originated from mined-out, subsided portions of the mine. Less frequently, natural inflows occurred from bolt holes in the roof and from very limited sections at the active mining face. As mining occurred in the northwest portion of the mine in Sections 26 and 35, T15S, R6E, appreciable groundwater inflows were encountered. By late 1998, the total discharge from the northwest portion of the mine was approximately 600 gpm. Most of this groundwater entered the mine workings from fracture zones in the mine roof. This groundwater discharge appeared to be associated with release of groundwater from storage in fractured paleochannel systems overlying the Hiawatha coal seam. The fracture systems from which the groundwater emanated are likely associated with synthetic faulting related to the Joes Valley Fault system. While discharge from the northwest portion of the mine continued, it is noteworthy that discharge rates from individual groundwater inflow sources where encountered in mine entryways almost without exception gradually declined over time. This suggests that the intercepted water sources existed as isolated partitions which were not in strong hydraulic communication with a continuous, actively flowing groundwater system. Discharge from the northwest portion of the mine continued after the mine was sealed in 1999, although at a much diminished rate, on the order of 50 to 100 gpm (personal communication, Gary Gray, 2012).

Longwall mining in the southwest portion of the mine (longwall panels 13-18) occurred between mid-1999 and early 2003. Appreciable groundwater was encounted during mining of the southwest portion of the mine (personal communication, Gary Gray, 2012). Discharge from the 9th west entries on November 29, 1999 was estimated at 300 gpm. By December 7, 1999, the flow had decreased to an estimated 150 gpm. When mining operations advanced in longwall panel 14 in mid-2000 large surge of groundwater from the mine roof was encountere. However, within a matter of just a few days, the discharge rate from the system had declined dramatically. Occurrences of this nature (intermittent periods of high flow followed by a period of declining discharge rates) were common during mining of the southwest portion of the mine (personal communication, Gary Gray, 2012).

Genwal has an operational monitoring plan which includes monitoring surface flows from Crandall, Blind Canyon and Indian Creeks using flumes and continuous recorders. In addition, Genwal has committed to monitor Horse Canyon at station H-1 on a quarterly basis. Genwal is currently monitoring 24 springs on a quarterly basis across their potential area of influence (see Chapter 7 for additional details).

Prior to about 1996, due to the dryness of the mine, water from Crandall Creek had been pumped into the mine to provide dust control water and water for the mining equipment. A water supply well provided shower water for the bathhouse. This well (MW-1) is no longer operative in the now closed Crandall Canyon Mine. Based on the 1992 mine water records, approximately 6.9 million gallons of water were used in the mining operation. Of this volume, it is estimated that approximately 6.2 million gallons of water were pumped into the mine from either the water supply well MW-1 or from Crandall Creek. These volumes indicate that the water collected from natural inflow underground was approximately 700,000 gallons, which is about 10 percent of the 1992 water usage. This amounts to a 1.3 gpm inflow rate. Much of the natural inflow water is used in the mining operation. Discharge from the mine had occurred only 3 times prior to 1990. Beginning in January 1996, relatively continuous discharge of mine water began to occur. A plot of Crandall Canyon Mine discharge as monitored at UPDES 002 is presented in Figure PHC-1. It is apparent in Figure PHC-1 that mine-water discharge rates increased gradually from 1996 to 2001. The northwest portion of the mine, where considerable groundwater inflows were first encountered, was sealed on June 17, 1999. By the early 2000s, discharge from the sealed northwest portion of the mine had declined to approximately 50 to 100 gpm (personal communication, Gary Gray, 2012). Beginning in mid-1999, mining of longwall panels in the southwest portion of the mine commenced. Intermittent zones of groundwater were intercepted primarily in the mine roof during the mining of these longwall panels. Discharge from the mine peaked during the period from 2001 through 2004, with discharges commonly exceeding 1,000 gpm. After 2004, discharge data from the mine show a gradual decreasing trend. During the first three quarters of 2010, the reported discharge has averaged about 500 gpm.

In the event that a subsidence fracture did reach the surface or intercept one of the overlying perched aquifers, it is likely that the affect would be temporary in nature. As indicated in Appendix 7-41, the clays within the Blackhawk Formation have a tendency to swell when exposed to water. Therefore, if the fracturing from subsidence did intersect a saturated, perched aquifer and conveyed water, the clays within the formation would swell and seal the fracture. This self-healing condition has been identified within the headwaters of the Huntington Creek drainage (DeGraff, 1978) and at other mines in the area.

An alternative water source plan has been developed in the event any water rights or springs/seeps impacted in a long-term manner by the mining operation or reclamation activities. This plan is detailed in Chapter 7, Section 7.27.

The Division of Oil, Gas and Mining has requested that this PHC be revised with respect to:

1. The magnitude and potential source of the groundwater inflows currently occurring at the Crandall Canyon Mine

2. The nature of the groundwater system currently being intercepted in the mine

3. The potential impacts of intercepting groundwater in the mine including the potential for impact to State appropriated water rights, and

4. The potential impacts to the Crandall Creek stream channel resulting from sustained discharge, including potential impacts to stream channel morphology and aquatic habitat.

In conjunction with this request, a written work plan was prepared that outlined the specific work tasks that would be performed in conjunction with the Division's request. The work plan was discussed in detail with Division personnel and representatives of Genwal Resources in a meeting held at the Division's offices on 4 April 2011. Petersen Hydrologic, LLC was commissioned to perform the requested hydrologic investigations and other work tasks in accordance with the plans outlined in the 4 April 2011 meeting.

<u>2011 Investigative Tasks</u>

- <u>Monitoring of supplemental Spring and Seep locations</u>

During the 2011 field season, Petersen Hydrologic performed a field investigation of selected springs and seeps in the permit and surrounding areas. The purpose of this investigation was to collect supplemental discharge and water quality data from springs in the study area to which baseline hydrologic data could be compared. The purpose of this analysis was to determine whether there has been any measureable interception or diversion of groundwater resources into the subsurface as a result of mining operations at the Crandall Canyon Mine. For this investigation, hydrologic monitoring was performed by Petersen Hydrologic at 36 spring locations distributed over the study area during the 4th quarter of 2011 (an additional spring site was monitoring during July 2011 and a general observation of conditions in the Joes Valley alluvium was performed during October 2011). Additionally, as part of the routine quarterly water monitoring activities at the Crandall Canyon Mine, an additional 12 monitoring sites in and adjacent to the study area were monitored during the 4th quarter of 2011. Additionally, laboratory water quality analysis for four additional springs was performed as part of this investigation. These springs include SP1-3, SP1-19, SP1-24, SP1-22, which are part of the approved monitoring plan, but for which laboratory water chemistry analysis is not generally performed. The results of the laboratory water quality measurements will be submitted electronically to the Division's on-line hydrology database together with the other 4th quarter 2011 monitoring information when the results from the analytical laboratory become available.

Additionally, as part of their water monitoring activities at the adjacent Deer Creek Mine, PacifiCorp previously performed monitoring at 10 spring sites situated near the Crandall Canyon Mine permit area (See Appendix 7-67, Figure 1 and Table 1). Monitoring information collected by PacifiCorp (including discharge and field water quality data) was obtained for these sites from the Division's publically available on-line hydrology database. Information from the Deer Creek Mine monitoring activities for the 4th quarter 2010 was utilized for this investigation (which was the most recent 4th quarter monitoring data available).

A summary of the comparison between the 2011 monitoring data and the historic monitoring data previously provided to the Division (Work Plan Table 1) for the comparison is presented in Appendix 7-67, Table 1. From the data presented in Appendix 7-67, Table 1 it is apparent that groundwater discharge rates measured during 4th quarter of 2011(and during 2010 for the PacifiCorp monitoring) generally equal or exceed those measured during the period of baseline monitoring (in some instances by a considerable amount). There is no indication that groundwater discharge rates from springs in any portion of the study area have been adversely impacted by mining operations at the Crandall Canyon Mine. Similarly, there is no indication that appreciable changes to water quality have occurred relative to conditions observed during the baseline monitoring activities (with the possible exception of some marginally elevated specific conductance values at a few monitoring sites). What this suggests is that the groundwater systems that support springs and seeps and provides baseflow to streams in the mine permit and surrounding area are apparently not in good hydraulic communication with the groundwater systems which have previously been intercepted in the Crandall Canyon Mine workings.

- Monitoring of Surface Water

As part of this investigation, surface water flow rates and stream water quality from the mine permit area have been measured in the Indian Creek drainage, Horse Canyon drainage, Blind Canyon drainage, Shingle Canyon drainage, Crandall Canyon drainage, Little Bear Canyon drainage, the Section 4 Creek drainage, and the Section 5 Creek drainage. These surface water drainages together drain essentially the entirety of the land surface in the Crandall Canyon Mine permit area.

The results of regular quarterly monitoring activities on streams are reported to the Division quarterly through the Division's on-line coal water quality database. The results of previous year's surface water monitoring activities have been summarized in annual reports of water monitoring at the Crandall Canyon Mine. These reports include graphs of discharge rates and important water quality parameters for each stream monitoring site. An analysis of the current year's surface-water monitoring data together with data from previous years is provided in the annual report to the Division.

To date, other than the effects of the permitted discharge of mine water to Crandall Creek, no detrimental impacts to water quantity or water quality in streams that could be attributed to mining and reclamation activities at the Crandall Canyon Mine have been identified.

The UPDES permit for the Crandall Canyon Mine specifies the maximum allowable total iron concentration

- Hydrogeologic field investigation

During the 2011 field season, the land surface overlying mining areas were traversed and geologic and hydrogeologic conditions were observed. The locations of identified features of potential hydrogeologic significance are shown in Appendix 7-67, Figure 1.

The land surface area overlying the synthetic faulting encountered in the underground mine workings (in Section 35 and in the southern portion of Section 26, T15S, R6E) was traversed and inspected. Lineaments were observed in this area on high-resolution aerial imagery. However, the presence of a relatively thick soil mantle in the area and the unusually dense vegetative cover present during the 2011 field season made field identification of these structures difficult. As a result of these factors, together with the fact that these faults apparently have only relatively small offsets, positive identification of the surface traces of these faults in the field was not made during the 2011 field investigation (i.e. the previously mapped fault locations have not been changed). It was notable that when the fault area was surveyed, groundwater discharge was observed at several springs and seeps in the area. The presence of the springs and seeps in the area suggests that the land surface overlying the synthetic fault system is a groundwater discharge area and not an area where recharge to fractures would potentially be occurring. The fact that these springs (numbers 20, 21, 22, 23, and 25) discharge along the approximate trend of the westernmost of the mapped synthetic faults suggests the possibility that the discharge mechanisms for these springs could be associated with a damaged zone associated with the fault.

The surface trace of the Joes Valley Fault system was observed in several locations. It is readily apparent that groundwater discharge along the surface expression of the fault trace is not significant. While there are a few springs that discharge along the length of the Joes Valley Fault zone within the study area, the discharges from these few springs are generally meager (See Work Plan Table 1). These observations suggest that groundwater discharge as upwelling from the Joes Valley Fault along the steep, fault-related escarpment is either not appreciable or does not occur. It should be noted that appreciable groundwater discharge does occur in Joes Valley west of the East Mountain escarpment. Earthfax Engineering previously performed an isotopic investigation of groundwaters discharging from selected springs in Joes Valley. The results of their investigation demonstrated that each of these springs (SP1-1A, SP1-47, SP1-42A, and SP1-37A) had elevated tritium concentrations ranging from 19.2 to 38.2 TU (See Mayo and Associates, 1997). These elevated tritium contents clearly indicate that recharge to these springs occurred within the past approximately 50 years. In contrast, tritium and radiocarbon analysis on the Joes Valley Fault water intercepted underground contained no tritium and had old radiocarbon ages.

The land surface overlying the Blackhawk Formation sandstone channel scour that was encountered in the underground Crandall Canyon Mine working was inspected as part of this investigation (primarily in Sections 25 and 26, T15S, R6E, and also the southern portions of Sections 23 and 24, T15S, R6E). Where encountered underground, the southern extent of the channel scour area is situated along the northern margins of the mined area. No unusual or hydrogeologically significant features were observed at the land surface in these regions, although a few springs with appreciable groundwater discharge were identified (Refer to springs 26, and 29-33 in Appendix 7-67, Table 1). The significance of the presence of these springs is that it indicates that these areas are groundwater discharge locations. Accordingly, there is no indication that large quantities of groundwater are being diverted from these areas into the subsurface. Because of the thickness of the overburden in these areas, the lower Blackhawk Formation scour is not exposed at the surface in the study area. Where the lower Blackhawk Formation is exposed in Horse Canyon east of the study area, no unusual hydrogeologic characteristics were observed.

Other than the considerable and spatially extensive erosion of near-surface soils and colluvium along the steeper slopes below the ridge line of East Mountain, no particularly anomalous geologic or hydrologic conditions were observed during the 2011 field geologic inventory.

- Analysis of historic discharge data from Crandall Creek

Prior to the temporary cessation of mining in 2007, flow measurements were generally performed using an in-line totalizing flow meter and are believed to be accurate. Gary Gray, the Genwal Resources engineer primarily responsible for the collection of mine discharge rate data indicates that the totalizing flow meter utilized through September 2007 was believed to be reasonably accurate. Mr. Gray indicates that he periodically checked the accuracy of the discharge meter by comparing the discharge measured at the upper flume on Crandall Creek (UPF-1) with that measured below in Crandall Creek below the mine discharge point (LOF-1). He generally found the readings to be in good agreement. The measured discharges were also generally in good agreement with information regarding the levels of activity at pumping stations at various locations in the mine. Mr. Gray indicates that in his opinion, the reported discharge measurements are likely within a 10% margin of error. Accordingly, it is the Genwal's belief that the mine water discharge rate data provided to the Division measured using the in-line totalizing flow meter is reasonably accurate.

From the time that gravity discharge from the mine portal commenced in early 2008 until October 2011, various methods were utilized to measure the mine-water discharge rates. Several factors complicated the performance of the mine water discharge flow measurements subsequent to the commencement of gravity discharge (including the necessity of correcting flow meter readings for the rate of pumped water recirculation associated with the water treatment facility). Accordingly, the flow measurements performed during this time period may be less accurate than those measured prior to September 2007. A new flow meter was installed at the Crandall Canyon Mine discharge location on 3/19/2010. However, personnel responsible for operating the meter indicated that corrosion associated with the ferric chloride coagulant utilized in the treatment system eventually damaged the flow meter. The time at which the meter became significantly damaged is not known. Commencing in October 2011, an improved flow metering system was installed and flow measurements being performed currently are believed to be accurate. On 18 October 2011 a manual measurement of the discharge from the mine was performed using a current-velocity meter and a wading rod. The result of this manual flow measurement (427 gpm) was in good agreement with that reported by the automated flow meter at that time.

The mine water discharge rates measured at the Crandall Canyon Mine are graphed in Appendix 7-67, Figure 2. Also included in Appendix 7-67 is a plot of the 6-month running average for the mine discharge (Figure 3). The 6-month running average plot is useful for analyzing long-term trends. The running average data analysis technique typically results in a smoothed data plot which simplifies the identification of long-term trends while minimizing the noise and clutter of short-term data anomalies (such as potential measurement errors). The period during which there was no discharge from the mine during late 2007 was omitted from the running average flow rate calculation. A bar graph summarizing the average yearly mine water discharge rates are presented in Appendix 7-67, Figure 4.

It is apparent from Appendix 7-67, Figures 2, 3, and 4, that after peaking in the early 2000s, the mine discharge rate plot indicates a downward trend beginning around 2004. This trend is more readily discernable in the 6-month running average plot for mine discharge shown in Figure 3. Additionally, the yearly-average mine discharge rates plotted in Figure 4 show an obvious generally declining trend, and do not correlate with recent climatic trends (i.e. extremely wet years in 2005 and 2011). It is notable from Figure 4 that the average yearly discharge rate for 2011 (first 6 months) is less than half the average rate for 2001, demonstrating the declining trend in mine water discharge rates. The observed declines are likely the result of two main factors. These include 1) with a decrease in the mining rate or a cessation of mining activities, the potential for the underground interception and exposure of water-bearing features in the subsurface is minimized or ceases, and 2) over time it is common for discharge rates from intercepted underground water-bearing features in the Wasatch Plateau coal district to decline as the contained water is gradually drained from storage.

It has been suggested that it is inappropriate to compare trends in mine water discharge rates that occurred prior to the start of gravity discharge with the current trends for the rates of gravity discharge. An analysis of the overall trend in discharge rate data prior to the cessation of pumping is reflected in a very similar trend observed during the period of gravity discharge (See Appendix 7-67). It is important to note that because of the geometry of the mine workings, during the period of active pumping of mine discharge from the mine (pre September 2007) mine water naturally flowed by gravity along the western and southern margins of the mine workings where it was collected in sumps before being pumped to the surface. Under the current non-pumping conditions, similar patterns of mine water flow along the western and southern portions of the mine (with some likely increased pool sizes) are likely present (Personal communication, Dave Shaver, 2011).

While some additional areas of the mine are now flooded (particularly in the southeast portion of the mine), the additional surface area that is now flooded is not believed to be extraordinarily large. While it is possible that the impounding of additional mine water in the mine workings could conceivably have some influence on the rate of groundwater flow into the mine (i.e. related to head/discharge relationships), the fact that most of the groundwater encountered in the mine originated from the northwest and southwest longwall mining areas essentially contradicts that possibility. Based on the topography of the mine, it is considered likely that groundwaters that may be currently flowing into the mine in these areas readily drain down gradient toward the southern portion of the mine, leaving the mine voids in these areas non-flooded. Accordingly, groundwater inflows to these areas, whether free-falling from the mine roof to the floor, or upwelling unobstructed from the mine floor into a non-flooded mine area would likely continue uninterrupted under the non-flooded condition. Assuming that these conditions are present (i.e. a hydraulic break existing between the inflow locations and the elevations of any down-gradient pooled mine waters), groundwater inflow rates would not be expected to change appreciably relative to those occurring prior to the onset of gravity discharge.

It is has also been suggested that to evaluate yearly total mine discharge rates from the mine is an inappropriate method to determine whether the mine discharge rate responds to long-term climatic trends. As indicated previously, it is Genwal's belief that the mine discharge rates reported prior to the decommissioning of the mine pumps are reasonably accurate (within about 10%). A definite declining trend is evident in the mine discharge plots presented in Appendix 7-67. A similar trend is apparent in the post gravity discharge data (See Figures 5 and 6 in Appendix 7-67). It seems incorrect to suggest that the recent range of discharge occurring from the mine (389-431 gpm during the 7-month period from January to July 2012) which is substantially lower than the typical range of mine discharge that occurred in the early 2000s (which exceeded 1,000 gpm) is not indicative of a significant downward trend in mine water discharge rates (i.e. a >50% decrease in the discharge rate in about 10 years). Genwal Resources, Inc. will continue to monitor discharge rates from the Crandall Canyon Mine using the recently installed flow meter (which is believed to be accurate). As additional flow rate data are collected from the mine discharge, these data will be evaluated on an on-going basis in an attempt to identify trends in the recent discharge rate data and to determine whether seasonal and climatic variability is evident in recent mine discharge rates.

Prior to the onset of gravity discharge, seasonal and/or climatic variability was not observed in the groundwater systems encountered in the Crandall Canyon Mine (personal communication, Gary Gray, 2003). This conclusion is supported by an inspection of mine water discharge data as shown in Figure PHC-1. Similarly, indications of seasonal and/or climatic variability are not readily apparent in the discharge hydrograph for the period subsequent to the onset of gravity discharge (Figure PHC-1). Utilizing a technique whereby a graphical analysis of the yearly discharge totals from the mine is performed, the task of evaluating long-term climatic trends is greatly simplified because the "noise" of short term (monthly discharge) anomalies in the data (see Figure PHC-1) are removed from the analysis.

It has been observed by Genwal Resources personnel that recent increases in the mine discharge rate seem to correlate with the passage of weather fronts or the onset of cold weather. It is important to note that these flow rate changes occur even in the absence of any associated precipitation. The observation that the discharge rate surges occur even in the absence of precipitation events indicates that this phenomenon is apparently not in any way related to groundwater recharge. Rather, this suggests the possibility that the temporary increases in mine water discharge rate may possibly be related to other influences (such as a relationship between local barometric pressure-effects and mine discharge rates). Because some of these events are not associated with any precipitation, those surges in discharge rates cannot be attributed to infiltration of precipitation.

An x-y scatter plot of the daily Crandall Canyon Mine discharge rate versus barometric pressure for the period 1/1/2012 to 7/31/2012 is presented in Figure PHC-7. Barometric pressure data for plotting in Figure PHC-7 were obtained for the Price Airport station from the Western Regional Climatic Center and also from mine instrumentation at the Crandall Canyon Mine. It is evident in Figure PHC-7 that there is correlation between the prevailing atmospheric pressure and mine discharge rate. Likely due to difficulties obtaining highly accurate mine discharge-rate data and possibly to the influence of antecedent atmospheric pressure trends, there is considerable scatter in the data plot. However, in the general sense, the highest reported discharge measurements generally occur during times of low barometric pressure, while the lower discharge rates often occur during periods of moderate to high atmospheric pressure.

In the general sense, groundwater flows from areas of high pressure towards areas of low pressure. Groundwater discharge is proportional to the groundwater hydraulic gradient. Increasing the hydraulic gradient will result in an increase in the discharge rate. When the barometric pressure decreases (typically due to the passage of a low-pressure storm front) at the down-gradient portion of the flow path (near the mine portal area) the hydraulic gradient necessarily increases immediately relative to the up-gradient area if the deeper, up-gradient portions of the groundwater system are isolated and thus not immediately influenced by the changing barometric pressure. If the up-gradient and down-gradient portions of the groundwater system are equally influenced by the prevailing barometric pressure, no change in hydraulic gradient would be anticipated. Consequently, when a low pressure weather system moves into the mine area, it would be anticipated that discharge rates from the mine would increase due to the increased hydraulic gradient. In contrast, when a high pressure atmospheric system is situated over the mine area, a decrease in discharge from the mine would be anticipated. The fact that such discharge variability is observed at the Crandall Canyon Mine suggests that the deeper portions of the mine workings are not in good communication with the atmosphere.

- <u>Crandall Creek stream channel morphology field investigation</u>

During November 2011, a field investigation of the stream channel morphology in Crandall Creek was performed. The purpose of this investigation is to characterize the physical properties of the stream channel to assist in determining whether the addition of mine discharge water to creek could have detrimental impacts to the stream channel. Measurements were performed at 13 stations on the creek between the mine water discharge location and the confluence with Huntington Creek. The stream channel morphology evaluation points are shown in Appendix 7-67, Figure 1.

At each creek station, measurements of the channel geomorphology were made. These measurements were made using a field laser transit, a tape measure, and a stream wading rod. The widths of the surveyed cross sections at each location were made of sufficient length such that the inner channel, bank full level, and flood plains were included in the measured sections.

It should be noted that where the water was deep in ponded areas associated with beaver dams, and the substrate consisted of relatively uniform fine-grained sediments (which could not reasonably be waded), the water depths in the ponds was approximated. Also, in some locations where the hillside rises precipitously above the lateral extents of the highest flood plain level, the slope of the adjacent hillside was estimated.

At each station, the measured section included the inner channel geometry (width and depth), the bank full channel geometry, and the geometry of any associated flood plains. These measurements are presented herein graphically as a series of cross-section profiles that are presented in Appendix 7-67, Attachment 1. These cross-sections were generated electronically using SigmaPlot™ version 9.01 scientific graphing software.

In most locations, the stable inner channel, which was accommodating the entirety of the stream flow at the time of the stream survey in November 2011, is well vegetated and does not appear to be easily erodible. The abundant presence of cobbles and boulders in the stream bed and stream banks minimizes the potential for appreciable erosion during increased flow events. In many locations, the stream bed is stabilized by the presence of deposited carbonates.

It was noteworthy that there were many beaver ponds in the surveyed portion of Crandall Creek. The presence of these beaver ponds has resulted in a stepped stream channel geometry, with areas of impounded, quiescent water behind the beaver dams in which fine-grained sediments are deposited. The intervening reaches between the ponds have steeper stream gradients and swifter water currents. As expected, little fine-grained material is present in the steeper gradient reaches of the stream.

It is evident in the discharge record for Crandall Creek that peak seasonal flows exceeding 6,000 gpm are common. The potential for erosion in the stream channel during these high-flow periods likely exceeds the erosion potential associated with baseflow conditions, which, although persistent for longer periods of time, are an order of magnitude lower in flow rate.

It is of significance to this investigation to note that the existing Crandall Canyon stream channel has accommodated the addition of mine discharge flows near to or exceeding the current mine water discharge rate for at least 10 years (see Appendix 7-67, Figures 2 and 3). In its current state, the stream channel appears to be in a fairly stable condition. Given the general downward trajectory of the mine water discharge rate in recent years, it follows that the potential impact associated with the inclusion of mine water should generally decrease rather than increase over time.

It should be noted here that in some locations, slumpage of the soils and colluvium situated on the steep hillsides adjacent to the active stream channel has occurred. However, inspection of the Crandall Creek stream channel in locations above the mine discharge location shows similar mass movement occurrences throughout the upper reaches of the Crandall Creek drainage. This phenomenon is likely largely attributable to entrenchment and downcutting of stream channels into their associated unconsolidated sediments – a phenomenon that is currently being observed regionally throughout the Wasatch Plateau and adjacent regions of Utah.

- <u>State appropriated water rights inventory</u>

As part of this investigation, an inventory of State appropriated water rights in the study area was performed. Specific water rights have been filed with the Utah Division of Water Rights on some specific springs and stream reaches in the Crandall Canyon Mine permit and surrounding areas (see Table 7-22 and Plate 7-14).

State appropriated water rights for springs in and near the study area include 93-1176 (SP1-3), 93-1404 (SP2-9), 93-1403 (SP2-14), 93-624 (SP2-23), 93-1406 (SP2-24), 93-1410 (SP1-26), and 93-1409 (probably SP-58). Each of these springs was inspected and monitored as part of the 2011 field investigation (with the exception of SP2-14). Based on comparisons with baseline water quantity and water quality data, there is no indication that there have been impacts to water quantity or water quality in these springs.

As part of this investigation, an inventory of State appropriated water rights on streams in and around the study area was also performed. Each of the major stream drainages was visited and inspected as part of the 2011 field investigation. Based on an analysis of water monitoring data for the surface water drainages in the study and surrounding areas, there is no indication that water quantity or water quality has been impacted at these drainages.

- Whole effluent toxicity (WET) testing

Whole effluent toxicity testing was performed during the 2011 field season as required. Reports summarizing the findings of the Phase 1 and Phase 2 TIE investigations are provided in Appendix 7-68.

- Macroinvertebrate studies

Macroinvertebrate field studies were performed in 2011 during the early- and late-season time periods as required. The results of the macroinvertebrate studies are provided in Appendix 7-69. Genwal Resources, Inc. will continue to perform macroinvertebrate studies in Crandall Creek on a yearly basis to evaluate the potential impacts to fish and wildlife resources and potential impacts to aquatic communities and aquatic habitat. These investigations will be performed by individuals and organizations qualified to perform the required investigations.

Conclusions

The magnitude and potential source of the groundwater inflows currently occurring at the Crandall Canyon Mine;

The nature of the groundwater system currently being intercepted in the mine

While the storage volume of the source(s) of water contributing to the Crandall Canyon Mine discharge is unknown, it is readily apparent that the rate of discharge is gradually declining (See Appendix 7-67, Figures 2, 3, and 4). Additionally, there is no correlation evident between mine water discharge rates and climatic variability (i.e. wet and dry spells). During mining operations, seasonal variability in discharge rates from water sources intercepted underground were not observed. These observations support the conclusion that at least some of the source(s) of the mine inflow waters are not in good hydraulic communication with appreciable recharge sources (i.e., the groundwater is primarily being removed from storage). These considerations also suggest that the observed declining trend in the mine water discharge rate may continue into the future.

Mayo and Associates, LC (1997), and Mayo et al. (2003) have previously conducted a series of investigations regarding groundwater systems in the Crandall Canyon Mine and surrounding mines in the Wasatch Plateau coal district.

Mayo and Associates (1997) concluded that 1) the groundwater in the Joes Valley Fault system within the Crandall Canyon Mine is thousands of years old, with no component of modern water, 2) the fault system groundwater has a stable isotopic affinity for other groundwaters encountered within the mine, suggesting that the recharge source for the fault waters is different from the recharge source for modern, shallow groundwaters and surface waters, 3) no expression of groundwater discharge from the fault system into springs and creeks at the surface in the vicinity of the Genwal lease area was identified, suggesting that groundwater discharge to the surface is either minimal or non-existent, and 4) groundwaters are upwelling from beneath the mine along the fault system, and do not appear to be under great confining pressure.

Mayo et al. (2003) concluded that damage-zone groundwater at the Crandall Canyon Mine is compartmentalized and does not readily recharge adjacent aquifer-quality rock. They indicate that water issuing from a fractured sandstone channel in the mine roof, located 100 meters from the Joes Valley Fault, contained 0.95 TU, indicating hydraulic communication with surface water. This water (5th West fault) had a ^{14}C age of approximately 3,000 to 4,000 years (Mayo and Associates, 1997), indicating a mixed source. Mayo and others (2003) further concluded that elsewhere, water in the roof channel sandstone, located near the fault, had 0 TU and older ^{14}C ages. Water issuing from the mining face, located ~ 60 meters from the fault, had 0 TU and had a ^{14}C age of 2,500 years. Additionally, modern water in the damage zone did not impact the deeper Star Point Sandstone where a sample from a well located ~ 60 meters from the fault contained 0 TU and had a ^{14}C age of 5,000 years.

Water sampled in a sandstone channel in the mine roof in the southwest portion of the mine (8th East roof drips), where longwall mining occurred from about 1999 to 2004, contained 0 TU and had a mean radiocarbon age of approximately 14,000 years (Mayo and Associates, 1997).

While much is known about the groundwater systems encountered in the Crandall Canyon Mine, a determination of precisely where the water in the various systems is ultimately recharged is probably not possible. However, potential source(s) include:

- Drainage of old, perched groundwater from fractured Blackhawk Formation paleochannels in the mine roof into the mine openings

- Upwelling of old Star Point Sandstone groundwater through fractures in the mine floor in the western portion of the mine
- Discharge of old groundwater leaking from the Joes Valley Fault along the western edge of the mine
- Drainage of groundwater with a mixed origin (with components of both old and modern water) from other sources.

All of these sources have in varying degrees contributed groundwater to the Crandall Canyon Mine workings in the past.

However, it is important to stress that the results of our 2011 investigation of groundwater and surface-water resources overlying and adjacent to the Crandall Canyon Mine workings *do not* indicate that quantifiable decreases in rates of discharge from groundwater systems that support springs and seeps and provide baseflow to streams in the area have occurred.

The potential impacts of intercepting groundwater in the mine including the potential for impact to State appropriated water rights

During the 2011 field season, Petersen Hydrologic, LLC conducted an inventory of selected springs and seeps in the region overlying areas where groundwater inflows into the Crandall Canyon Mine were observed. The details of this investigation are provided in Appendix 7-67. The purpose of this investigation was to determine whether shallow groundwater systems that support springs and seeps at the surface are a potential source of the water intercepted in the underground mine workings. The findings of this investigation indicate that after more than 14 years of inflow of groundwater into the Crandall Canyon Mine, no quantifiable impacts have occurred to spring or stream flow rates. This conclusion is based on 1) the results of the performance of the rigorous Division approved hydrologic monitoring plan for springs and streams (which show no impacts), and 2) the results of the 2011 supplemental monitoring of more than 36 different spring and seep locations, which showed no discernable impacts to water quantity or quality when compared to baseline, pre-mining hydrologic conditions. Accordingly, as the magnitude of the groundwater inflows is declining over time (Appendix 7-67, Figures 2, 3, and 4), there seems to be little basis to conclude that future impacts would be likely.

An analysis of the groundwater and surface-water resources associated with the specifically delineated State appropriated water rights indicates that no detrimental impacts to flow rates have occurred at these sources. Similarly, there is no indication that any regional or systematic impacts to water resources has occurred.

Potential impacts to the Crandall Creek stream channel resulting from sustained discharge, including potential impacts to stream channel morphology and aquatic habitat

A stream morphology survey was conducted on Crandall Creek below the mine discharge location

November 2011. This information includes channel widths and depths, the character of the materials in the bed and bank deposits, and measured stream gradients. This information was gathered to assist in the determination of whether erosion would be anticipated at varying creek discharge rates. However, based on the geometry and non-erosion prone materials present in the relatively stable inner stream channel, and the fact that the flow from the mine has been gradually decreasing over time, it seems probable that ongoing discharge of water in the stream under baseflow conditions similar to those existing currently, will not result in significant erosional changes to the stream channel morphology.

Information regarding the aquatic habitat in Crandall Creek has been collected and analyzed. This information is provided to as Appendix 7-69.

Surface Water Interception.

The possible surface water interception impacts may affect stream flows in Crandall Canyon, Blind Canyon, Horse Creek, the headwaters of Indian Creek, and drainages in the South Crandall Lease area and in the U-68082 lease mod area. These impacts would likely be the result of subsidence fractures intersecting the ground surface. If these fractures occur within or across a surface drainage channel, then a potential is created for the surface flow within the drainage to be temporarily intercepted. For the drainages within and adjacent to the Crandall Canyon Mine, all sections of the streams that are perennial will be protected from subsidence by limiting retreat mining activities within the area of the stream buffer zones as discussed in Section 5.25 of this permit.

The potential for significant water loss for these drainages is minimal. This conclusion is based on the existing hydrologic and geologic information presented in Section 7.24 and Appendices 7-2 and 7-23 and past mining experience within the Huntington Creek drainage. In addition, the streams in the majority of the surface area which overlies the current or proposed mine workings are ephemeral. However, due to the concerns raised by the U.S. Forest Service, regarding their uncertainty in supporting this conclusion, Genwal Resources Inc. has initiated extensive studies of within Blind and portion of Crandall Canyon to determine if mining through these drainages have an adverse affect on the surface or groundwater resources within the drainage. Until the results of these studies are determined, Genwal will continue to protect those portions of the streams that have been proven to be perennial.

It is important to note that the geologic units located in the formations stratigraphically above the Blackhawk Formation and the Hiawatha coal seam at the Crandall Canyon mine are hydrologically isolated from the contiguous area. East Mountain is bounded on the north by the South (Left) Fork of Huntington Creek; on the west by Upper Joes Valley; on the south by Cottonwood Canyon; and on the east by Huntington Canyon. Data show that the regional aquifer is located below the Hiawatha Coal. Field data indicate that Blind Canyon is ephemeral and that Horse Canyon is perennial only in that area where it intersects or is below the regional aquifer. Based on the baseline data (Appendix 7-58), it is apparent that all of the surface-water drainages in the South Crandall Lease area are likely ephemeral or intermittent in nature. The drainages in the U-68082 lease mod area are all ephemeral or intermittent.

The perennial portion of Crandall Canyon extends above the regional aquifer. This occurs because the perched Price River and North Horn Formation cover a broader area of this watershed and because Crandall Canyon has a larger drainage area (and thus, more potential for recharge and increased runoff) than the other two canyons.

Consumption.

The consumption of water by the mining operation is a combination of moisture added to the mined coal through the mining process and that which is extracted with the coal as well as evaporation due to ventilation of the mine workings. It is estimated that mining extraction and the mining process utilize approximately 200 gpm during the two 8-hour mining shifts per day. The volume of water extracted by ventilation is estimated to be approximately 50 gpm.

Seepage from Mine Sumps.

Underground sumps are utilized to store water pumped underground or collected from groundwater inflows until the water is used as mine process water. During the period that water is stored in these sumps it is probable for some seepage to occur to the underlying formation (Spring Canyon member). For the Crandall Canyon Mine, the potential volume of such seepage is expected to be quite low because of the presence of a fine-grained mudstone strata underlying the Hiawatha seam within the Blackhawk Formation. This layer limits the downward movement of seepage to a very slow rate.

Pumping from Crandall Creek.

Due to the past need for supplemental water underground, there is also potential for decreased surface flows in Crandall Canyon due to pumping from Crandall Creek. Surface water availability could only be impacted by excessive pumping of water from Crandall Creek for the operation. This is not expected to occur since Genwal has committed to not pump from Crandall Creek at a rate that will dewater the stream. (Chapter 7, Section 7.24.2). (Genwal will have determined the baseline water flow which needs to remain within Crandall Creek to sustain the existing flora and fauna by August 31, 1995) Essentially continuous groundwater inflows into the mine occurred beginning in 1996 and continuing through the cessation of active mining operations in 2007. Consequently, it was no longer necessary to pump surface water from the creek to the mine workings and accordingly, pumping of groundwater from Crandall Creek ceased. Accordingly, the potential for decrease in flow volume in Crandall Creek as a result of pumping of water from the stream is low. Under the current operational condition at the mine, pumping from Crandall Creek does not occur. Therefore, the in-stream water present at UPF-1 represents the minimum flow that would be present in the creek below the mine (since water is no longer pumped from the creek above the mining location).

Water Quality Impacts.

There is the potential for an increase in TSS due to fugitive coal fines and dust entering the adjacent surface water system at the mine surface facilities area. To minimize the potential for this impact, sweeping of the access roads and pads is performed as necessary. Water is misted onto the coal to minimize the potential for mobilization of fugitive dust.

The quality of the surface and groundwater in the mine area may potentially be affected by increased sediment loading, dust from the operations, mine water discharges, hydrocarbons used in the mining operations, and seepage losses from within the mine. The following sections discuss these potential impacts and mitigating measures.

With the installation of the main diversion culvert during the expansion of the mine yard facility area it is possible that additional sedimentation could occur. Genwal will install a pair of silt fences downstream in Crandall Canyon to collect any suspended material that may occur as a result of the installation of the 18" drain pipe bedded in drain rock or the 72" culvert. The silt fences will be checked periodically and cleaned out as needed to maintain maximum efficiency.

Once the culvert is in place and operable, the creek will be diverted through the culvert thus bypassing the disturbed area and minimizing the potential for runoff from the disturbed area accidentally flowing directly into the creek. The sediment pond may experience an increase in sediment loading during the construction process and until the construction has been completed. This would be a short term effect. The sediment pond will also be enlarged during the construction process to accommodate the increase in disturbed area. The net result will be that the pond will be better suited to handle runoff from the disturbed area once it has been reconstructed and enlarged. Drainage from the Forest Service parking area will now report directly to the sediment pond. All drainage from the disturbed area will report directly to the sediment pond and the potential for drainage to bypass the sediment pond and flow into the creek untreated will be virtually eliminated.

Flow in Crandall Creek will be temporarily (during the remainder of the life of the mine) diverted through the 72" culvert. However, when reclamation occurs, the channel will be replaced exactly in the same location as it existed prior to the culvert placement. Genwal will lay a geotextile over the existing channel to preserve the channel morphology prior to installation of the drain rock and 18" drain pipe. The drain rock and drain pipe will serve to allow any drainage from the channel bed or adjacent seepage from colluvial materials to flow downstream. Then, the 72" diversion pipe will be placed over this drain. The drain will preserve the integrity of the fill, thus minimizing the potential for problems from settling of the 72" pipe and ensuring the successful operation of the bypass culvert.

The Crandall Canyon Mine discharge water is routinely tested for toxicity through whole effluent toxicity (WET) testing. After failing several WET tests during 2011, a Phase 1 and a Phase 2 Toxic Identification Evaluation was performed by Water and Environmental Testing, Inc. Subsequently, because the mine discharge water passed the routine fourth quarter 2011 WET test (likely in response to an earlier change in the type of treatment chemicals utilized at the iron treatment facility), Water and Environmental Testing suggested that a Phase 3 TIE test was not recommended (see Appendix 7-68). It was their conclusion that "activities taken at the mine have got the situation under control". However, the fact that the mine discharge water has periodically failed the WET testing indicates that there is the potential for adverse impacts to water quality in Crandall Creek resulting from the use of chemical treatments in the mine discharge water. However, by carefully managing the use of chemicals at the mine treatment facility and by carrying out routine monitoring of residual treatment chemicals at the UPDES 002 discharge monitoring station, the possibility that adverse impacts to water quality in the creek may occur in the future can be minimized.

Increased Sediment Loading.

As discussed in Section 7.24.2, the permit area is drained by ephemeral, intermittent, and perennial watersheds. These watersheds are steep (with average slopes 50 percent) and well vegetated (with vegetative cover also often exceeding 50 percent). The primary potential for impact to surface water is in the form of increased sedimentation from the operations.

Sediment yield will naturally increase (on a temporary basis during construction and revegetation) from areas disturbed for the operation. A runoff control plan, required by the Division of Oil, Gas, and Mining, provides for the containment or treatment of all runoff and sediment produced from the disturbed areas. Based on this plan, described in Chapter 7, Section 7.42.22, the majority of the disturbed area runoff is directed to the sediment pond. The designed sediment storage for the pond is 0.348 acre feet. Storm runoff was determined to be 2.360 acre feet. The pond is designed with a total storage volume of 3.513 acre feet, which allows for complete containment of sediment.

There are 7 small areas (ASCA 2, 5, 6, 7, 8, 9, & 10) which do not drain to the sediment pond, as shown on Plate 7-5, and described in Chapter 7, Section 7.42.21. Sediment yield from these areas is minimized through the use of sediment traps, straw bale dikes, silt fences, and vegetation as described in Section 7.42.21. Sediment yield from the facility and the disturbed areas is minimized through the installation and maintenance of the above described controls.

A secondary potential source may exist due to subsidence creating surface irregularities which would be more susceptible to erosion. Calculations presented in Appendices 7-27 to 7-40 indicate a very small potential for increased sedimentation reaching a perennial stream. A study has been conducted by Genwal and the U.S. Forest Service in Blind Canyon to measure the amount of subsidence, erosion, and the associated sediment yield which may be produced as a result of current mining operations. (Refer to Appendices 7-38 and 7-39).

Fugitive dust.

The potential impacts of fugitive dust from the Crandall Canyon Mine include reduced air quality in the facilities area and a small decrease in the surface water quality of Crandall Creek. The air quality degradation result from particulate emissions from the paved road and pad, reclamation activities, and from coal loading operations. The water quality degradation and sediment loading increase would result from the settlement of dust within the waters of Crandall Creek. Placement of the stream within the culvert under the expanded mine yard will serve to minimize the possibility of coal dust settling in Crandall Creek.

These impacts are mitigated by sweeping the paved access roads and portions of the pad, water sprays in the coal handling process, and contemporaneous reclamation. These actions minimize the dust production from the facilities area.

Oil and grease.

The use of oil, grease, and flammable hydrocarbon-based products in the mine facilities area creates the possibility of contamination within and adjacent to the facilities area. Contamination could result from spillage of these products during maintenance of the mine equipment, accidental spillage during filling of fuel tanks, or leakage from equipment during operations. Such contamination could impact the soils, groundwater, and possibly surface waters downstream of the facility.

The impacts from spillage during maintenance activities and during filling of tanks will be mitigated by the implementation of the SPCC plan. Additionally, the runoff from all areas of the site where equipment will be operating is drained to the sedimentation pond. The pond is equipped with an oil and grease skimmer to prevent the release of hydrocarbons.

Mine water discharge.

A potential impact to water quality would be from mine water discharges. Prior to early 1996 there was no appreciable discharge from the Crandall Canyon Mine. Prior to 1990, there were only three discharges from the mine and these discharges were of a limited nature in both duration and quantity. The mine has an UPDES discharge permit.

Petersen Hydrologic, LLC performed an investigation of Crandall Canyon Mine discharge water chemistry entitled "*Investigation of iron concentrations in the Genwal Resources, Inc. Crandall Canyon Mine discharge water*" dated 7 November 2011. This report is included as Appendix 7-67. The information provided in the Petersen Hydrologic, LLC report provides much of the basis for the following discussion.

From early 1996 until the mine was sealed in September 2007, mine water was routinely discharged from the Crandall Canyon Mine to Crandall Canyon Creek. The quality of the mine discharge water was good, and almost always met the requirements of the UPDES discharge permit. Information on water quality and water discharge rates from the Crandall Canyon Mine (and also from all other monitoring sites) has been submitted quarterly to the Utah Division of Oil, Gas and Mining and is available for inspection at (UDOGM, 2011). The total dissolved solids (TDS) concentrations of mine discharge waters are plotted in Figure PHC-2. It is apparent in Figure PHC-2 that the TDS concentrations of mine discharge waters prior to the cessation of pumping in 2007 were (with a single anomalous exception in 2004) less than about 625 mg/L (see monitoring site UPDES 002, UDOGM, 2011). Total iron concentrations in the mine discharge water during this period were almost always substantially less than the UPDES discharge permit limit of 1 mg/L.

Beginning in January 2008, after a period of several months with no discharge subsequent to the cessation of pumping of mine discharge water, groundwater began to discharge from the Crandall Canyon Mine portals via gravity drainage. It should be noted that, based on the geometry of the Crandall Canyon Mine workings (with the lowest elevation regions occurring in the southern part of the mine), large portions of the mine workings likely remain free of mine water.

The TDS concentrations of the mine discharge waters that initially flowed from the Crandall Canyon Mine portals in early 2008 were somewhat elevated relative to that pumped prior to the mine's closure (see Figure PHC-2 and monitoring data for site UPDES 002 in the UDOGM online coal hydrology database, 2011). The elevated TDS concentrations were likely attributable to the initial flushing and dissolution of soluble minerals or other materials present in portions of the mine that had not previously been inundated with water. TDS concentrations of the mine water subsequent to its first discharge from the mine portals lowered precipitously during the first several months of discharge (Figure PHC-2). After a period of approximately 30 months, TDS concentrations in mine discharge waters had completely returned to the levels observed prior to the mine collapse event and the subsequent cessation of pumping of mine water in 2007. Total dissolved solids concentrations in the Crandall Canyon Mine pre-treatment water during the 21-month period from April 2010 to December 2011 (since the beginning of the period of record for monitoring site UPDES 002 pre-treatment) averaged 615 mg/L. This average concentration is entirely consistent with the TDS levels that were observed in the mine discharge water prior to the 2007 mine collapse event. It is noteworthy that this TDS concentration represents an increase of only about 11 percent relative to the average TDS concentration of the receiving Crandall Creek water during 2010 and 2011 (average TDS at UPF-1 of 552 mg/L).

Since gravity discharge from the Crandall Canyon Mine commenced in early 2008, total iron concentrations in the mine discharge waters have been elevated relative to the total iron concentrations of mine waters discharging prior to mine closure (See Figures PHC-2 and PHC-3; UDOGM, 2011). The likely source of increased total iron concentrations in the mine discharge water is the oxidation of sulfide minerals (such as pyrite) that have come into contact with oxygenated water in the newly flooded portions of the Crandall Canyon Mine.

It is apparent from the data plotted in Figure PHC-4 that total iron concentrations in the Crandall Canyon Mine discharge water peaked at a concentration of 8.03 mg/L in October 2009. It is apparent in Figure PHC-4 that since that time, total iron concentrations in the pre-treatment mine discharge water have been declining gradually. During the fourth quarter of 2010, total iron concentrations in the mine pre-treatment water were 2.81, 3.19, and 3.29 mg/L in October, November, and December, respectively, averaging 3.1 mg/L. Thus, the fourth quarter 2010 average total iron concentration in mine discharge water (untreated) represents a decrease of more than 60% relative to the October 2009 peak concentration over this approximately 12 to 14 month period.

In response to the increased total iron concentrations in the Crandall Canyon Mine discharge water, Genwal Resources, Inc. has constructed and operates a treatment facility that removes iron from the water prior to its discharge into Crandall Canyon Creek. Details of the treatment facility are provided in Appendix 7-65. Subsequent to the installation and successful operation of the treatment facility, total iron concentrations in the mine discharge water (UPDES 002) are now routinely in compliance with the 1 mg/L discharge limit established in the UPDES discharge permit (See Figure PHC-4; UDOGM, 2011).

A well oxygenated surface stream with near-neutral pH will rarely contain more than a few micrograms per liter of dissolved iron (Hem, 1985). Dissolved iron species in such streams are readily precipitated as solid precipitates (commonly iron hydroxides) which will settle to the bottom of the stream bed or may be incorporated as co-precipitates with other mineral precipitation processes. Accordingly, because elevated dissolved iron concentrations are not likely to persist in the well-oxygenated creek, the potential for significantly impacting iron concentrations in Huntington Creek into which Crandall Canyon Creek flows (more than a mile below the mine water discharge point) is considered minimal. Concentrations of total iron in Crandall Creek water above the mine water discharge point (at UPF-1), and immediately below the mine water discharge point (at LOF-1) are shown on Figure PHC-5.

Prior to the installation and operation of the iron treatment facility, some discoloration of the Crandall Canyon Creek stream substrate near and below the mine-water discharge point was observed. The discoloration of the creek likely resulted from the presence of iron hydroxide precipitates.

Whole effluent toxicity (WET) testing of Crandall Canyon Mine discharge water has occurred routinely subsequent to the onset of gravity discharge from the mine portals. WET testing of the chemically treated mine discharge water has been performed subsequent to the operation of the mine's iron treatment facility (second and third quarters of 2010). The results of Phase 1 and Phase 2 Toxicity Identification Evaluations performed by Water and Environmental Testing are included as Appendix 7-68.

The aquatic habitat of Crandall Canyon Creek has also been evaluated previously by JBR Environmental Consultants, Inc. In a report entitled *Crandall Canyon Mine Macroinvertebrate Study September 2009*, JBR evaluated the aquatic habitat by sampling the creek's benthic macroinvertibrates and assessed the resultant data to determine whether or not the mine discharge is affecting Crandall Creek's aquatic community. JBR found that overall, while both the upper and lower monitoring sites continue to support a variety of macroinvertebrates, the Crandall Creek macroinvertebrate community downstream of the mine's discharge was negatively impacted relative to the sampling site upstream of the mine discharge. However, they considered attributing the degradation directly to iron in Genwal's mine water discharge to be problematic. It should also be noted that this represents a potential impact that occurred prior to the onset of chemical mine-water treatment. Impacts to aquatic communities and aquatic habitat resulting from the increased flow in the creek resulting from the addition of mine discharge waters during 2011 are described in a Crandall Canyon macroinvertebrate study dated December 5, 2011 performed by JBR Environmental Consultants, Inc. which is included as Appendix 7-69. Genwal Resources, Inc. has committed to performing ongoing routine monitoring of the macroinvertebrate community in Crandall Canyon Creek in the future. The future sampling will provide additional data, which will be used to assess continued impact or recovery as the mine discharge water is now treated.

Based on the results of the 2011macroinvertebrate study (see Appendix 7-69), it is apparent "that the Crandall Creek macroinvertebrate community immediately downstream of the mine discharge continues to show negative impacts of the mine water discharge." Also, "although the furthest downstream reach of Crandall Creek (CRANDLWR-03) also has a degraded macroinvertebrate community, its poor substrate condition (embedded and cemented) is likely a contributing (if not dominating) factor affecting macroinvertebrate community health at that site". Based on these findings, it is evident that future impacts to the invertebrate community in Crandall Creek below the mine discharge location may continue to occur in the future. Genwal Resources, Inc. is committed to performing the macroinvertebrate study in Crandall Creek on an ongoing annual basis to further characterize and monitor for potential impacts to the creek.

Subsequent to the construction and operation of the iron-treatment facility for the Crandall Canyon Mine discharge, the treated mine discharge water is currently being discharged in compliance with all relevant regulations and guidelines. Impacts to the hydrologic balance resulting from the discharge of mine water are being minimized. To summarize current mine water discharge conditions:

1) The iron treatment facility (which uses both chemical and physical treatment processes) is successfully reducing total iron concentrations in the mine discharge water to levels in compliance with the UPDES permit (continuously for the last 10 months).
2) Aluminum concentrations in the treated mine discharge water are in compliance with the UPDES permit stipulations.
3) The use of polyacrylamide chemicals in the iron treatment facility at the Crandall Canyon Mine is in compliance with relevant NSF 60 standards for drinking water treatment chemicals.
4) Whole effluent toxicity testing of the treated mine discharge water indicates a lack of toxicity.
5) All applicable regulations and guidelines for the mine water discharge are currently and consistently being met, demonstrating the capability of Genwal Resources, Inc. to remain in compliance with the stipulations of the mine water discharge permit.

While the precise length of time during which elevated iron concentrations will persist in the untreated Crandall Canyon Mine discharge is difficult to determine with certainty, it is considered very likely that iron concentrations will gradually decline over time. This is because the system is reactant-limited. Crandall Canyon Mine waters that were pumped to the surface prior to the closure and sealing of the mine were consistently low in iron content (Figure PHC-3; UDOGM, 2011). These waters flowed over the mine floor and were held in underground sumps prior to being discharged to the surface via pumping. Subsequent to the mine closure and the cessation of mine water pumping, groundwaters within the mine likely came into contact with portions of the mine that had not previously been inundated with water prior to reaching the surface. This may include areas where coal debris resulting from the mine collapse event was emplaced in mine entries. Over time, the sulfide minerals exposed in the newly flooded portions of the mine will either 1) become depleted due to removal of the iron by oxidation processes (i.e. become consumed and flushed from the system as iron and sulfate in the mine discharge water), or 2) become non-reactive as the necessary chemical reactants facilitating the sulfide mineral oxidation processes become unavailable (i.e. depletion of dissolved oxygen levels in the mine water for example). Because there is not an unlimited supply of exposed and available sulfide mineral in the newly flooded portions of the mine, it can be stated with confidence that the discharge of iron from sulfide mineral oxidation <u>cannot</u> continue in perpetuity.

It should also be noted that, while damage occurred to pillars in some portions of the mine in conjunction with the August 2007 mine collapse event, such damage likely did not occur over widespread portions of the mine. In their July 2008 report of the August 2007 mine collapse incident, the Mine Safety and Health Administration (MSHA) provide a delineation of the likely spatial extent of collapse damage in the mine. This report includes a delineation of the approximate extent of "extensively damaged pillars" as well as a delineation of the approximate extent of "damaged pillars" (see Figure 33 on page 61 of the MSHA report). It is significant to note that the total acreage of "damaged" and "extensively damaged" pillars is on the general order of the size of one of the typical longwall panels in the Crandall Canyon Mine adjacent to the collapsed area.

Inasmuch as more than three years have transpired since the August 2007 mine collapse event (and the performance of any underground mining activities in the area), it seems unlikely that seismic activity in the mine area of significant magnitude to rubbleize currently in-tact coal and expose appreciable amounts of sulfide minerals to oxygenated mine water will occur in the future.

Petersen Hydrologic, LLC (Appendix 7-67) projects that total iron concentrations in untreated Crandall Canyon Mine discharge water will likely decline to below the UPDES discharge limit of 1.2 mg/L within a time frame on the order of approximately 3 years. This projection was based on a graphical analysis of the recent total iron concentration trends in the mine water. The approximately three year time frame was derived by extrapolating the graphed historical concentration trend line to the intersection with the 1.2 mg/L concentration level.

It should be noted that, while continuous discharge of untreated Crandall Canyon Mine discharge water to the creek at levels above the UPDES permit limit of 1.24 mg/L would constitute a negative impact to the biota in the creek, this impact is currently mitigated through the operation of the Crandall Canyon Mine iron treatment facility. The iron treatment facility effectively removes total iron from the discharge water such that the treated mine water discharged to the creek at UPDES 002 is consistently in compliance with the maximum allowable total iron concentrations as specified in the mine's UPDES permit. Accordingly, the potential for impacts to biota in the creek as a result of the discharge of mine water with elevated total iron concentrations is minimized.

It should be noted that Genwal's previous statement that elevated iron concentrations in the Crandall Canyon Mine discharge water likely would not persist for more than about 10 years was a very conservative, general estimate of the likely window of time during which the iron concentrations would likely abate (i.e. at some point within the 10 year window of time the concentrations would abate). It was provided to the Division as a conservative order-of-magnitude projection (i.e. it would be a few years, not decades or centuries). It was not meant to indicate that the concentration would decline to 1.2 mg/L after a period of10 years had elapsed.

The quantity of water in Crandall Creek increases substantially when Crandall Canyon Mine discharge waters are discharged into the creek. Typically, during mid-summer and low-flow conditions, the amount of water in the creek more than doubles as a consequence of the inclusion of the mine discharge water (UDOGM, 2011).

Impacts to aquatic communities and aquatic habitat resulting from the increased flow in the creek resulting from the addition of mine discharge waters are described in a Crandall Canyon macroinvertebrate study performed by JBR (Appendix 7-69) and in Phase 1 and Phase 2 Toxicity Identification Evaluations performed by Water and Environmental Testing (Appendix 7-68). The names of professional persons or organizations that collected and analyzed the data, dates of collection and analysis of the data, and descriptions of the methodology used to collect and analyze the data are provided in Appendix 7-69 and Appendix 7-68.

The JBR Environmental Consultants report provided in Appendix 7-69 provides an analysis that incorporates the results of macroinvertebrate studies from 2009 and 2010.

The proposed monitoring plan for the Crandall Canyon Mine discharge water (prior to any treatments) is presented below:

Water monitoring protocols for Crandall Canyon Mine discharge water (untreated mine discharge)		
Parameter	**Reported as**	**Frequency**
Field Parameters		
Mine discharge	gpm	Daily
Temperature	°C	Monthly
pH	S.U.	Monthly
Specific conductance	µS/cm	Monthly
Dissolved oxygen	mg/L	Monthly
Ferrous Iron (field)	mg/L	Monthly
Laboratory analyses		
Calcium (dissolved)	mg/L	Monthly
Magnesium (dissolved)	mg/L	Monthly
Sodium (dissolved)	mg/L	Monthly
Potassium (dissolved)	mg/L	Monthly
Bicarbonate	mg/L as $CaCO_3$	Monthly
Carbonate	mg/L as $CaCO_3$	Monthly
Sulfate	mg/L	Monthly
Chloride	mg/L	Monthly
Aluminum (total)	mg/L	Monthly
Aluminum (dissolved)	mg/L	Monthly
Iron (total)	mg/L	Monthly
Iron (dissolved)	mg/L	Monthly
Manganese (total)	mg/L	Monthly
Manganese (dissolved)	mg/L	Monthly
Silica	mg/L	Monthly
TDS	mg/L	Monthly
TSS	mg/L	Monthly
Alkalinity (total)	mg/L as $CaCO_3$	Monthly
Hot acidity (by SM 2310B 4(a))	mg/L	Monthly
Isotopic analyses		
^{14}C (carbon-14)	pmC	2nd and 4th quarters only*
^{3}H (tritium)	TU	2nd and 4th quarters only*
$\delta^{2}H$ (deuterium)	‰	2nd and 4th quarters only*
$\delta^{18}O$ (oxygen-18)	‰	2nd and 4th quarters only*

* Samples for these parameters will be collected during the 2nd and 4th quarters annually until the time of the 2018 permit renewal. The results of these analyses will be reported after results become

available from the isotopic laboratories. At the time of the 2018 permit renewal, Genwal Resources, Inc. will consult with the Division as to the need for further isotopic monitoring.

The specific chemicals currently being used at the iron treatment facility include NALCO ULTRION 8187 and NALCO NALCLEAR 7763. Further information on the chemical properties and the manufacturer's safety data sheets for these chemicals are provided in Appendix 7-70.

Laboratory analytical methods for the determination of polymer concentrations in a sampled solution are provided in Appendix 7-70.

Monitoring of residual polymer treatment chemical and aluminum (total and dissolved) will be carried out according to the protocols specified in the table below. Samples will be collected from the mine water treatment facility effluent at monitoring site UPDES 002 using appropriate, careful sample collection and handling procedures. Samples will be placed in sample containers as directed by the analytical laboratory performing the laboratory analyses.

Whenever chemicals are used in the vicinity of surface waters, there is always a possibility that the utilized chemicals could potentially impact water quality in surface waters as a result of chemical spills or leakage from storage containers. In order to minimize the potential for impacts to water quality resulting from the use of treatment chemicals at the iron treatment facility, the following protocol will be implemented when using treatment chemicals. The chemicals will be stored in well-maintained storage containers and handled carefully to minimize the potential for spillage and uncontrolled release of the chemicals into the environment. Emergency equipment for fires, spills, leaks, etc. will be kept available for use at the site. When spillage of any appreciable or hazardous quantity of a utilized chemical occurs, the spill will be promptly cleaned up and the recovered chemical will either be used in the treatment process or disposed of properly. The quantities and concentrations of chemicals used in the treatment process will be regulated and monitored such that conditions that would result in unacceptable impacts to water quality or health and safety do not occur.

Supplemental water monitoring protocols for Crandall Canyon Mine discharge water UPDES 002 (supplemental to existing UPDES monitoring requirements)		
Parameter	**Reported as**	**Frequency**
Laboratory analyses		
Residual polymer treatment chemical	Mg/L	Monthly while a polymer treatment chemical is being used.
Aluminum (total)	Mg/L	Monthly while a potentially aluminum releasing treatment chemical is being used.
Aluminum (dissolved)	Mg/L	Monthly while a potentially aluminum releasing treatment chemical is being used.

The water monitoring data for the untreated mine discharge water outlined above will be submitted to the Division monthly (with the exception of the isotopic data, which will be submitted to the Division after the data become available from the isotopic laboratories). The water chemistry and measurement data will be submitted electronically using the Division's water monitoring database EDI system. Mine-water discharge rate data will be provided in a spreadsheet format or other format acceptable to the Division. The monitoring of the untreated mine discharge water will be conducted for the life of the permit or until the Division deems it no longer necessary.

The monitoring data will be used to detect and characterize any potential changes in the quantity or quality of Crandall Canyon Mine discharge water. Although unanticipated, if changes to the chemical quality of the discharge water were to occur, the monitoring data would allow the detection of any such changes and appropriate responses to any such changes could be designed and implemented. This may be accomplished by evaluating changes or significant trends in individual monitored parameters over time (i.e. comparing previous chemical compositions or discharge rates with current chemical compositions or discharge rates). This information may then be used to determine whether adverse impacts to the quality or quantity of the receiving water (Crandall Canyon Creek) are occurring or are likely to occur. The monitoring data may also be used in future geochemical evaluations of groundwater regimes associated with the Crandall Canyon Mine.

It should be noted that during the period of active mining, some groundwater was removed with the coal during the mining operations or evaporated as a result of exposing the coal to circulating air, which represented a decrease in the quantity of groundwater present. The relatively small overall magnitude of these impacts during the period of active mining was moderate, largely because groundwater in the coal is generally part of the inactive-zone groundwater system that does not contribute groundwater to springs or streams in the area under non-mining conditions. Under the current condition with the mine in suspension and the ventilation fans turned off, this impact is currently negligible.

Acid-toxic materials.

As discussed in Section 5.28.30, waste rock is not normally produced during mining operations. When incidental quantities of rock are encountered, the rock is left in the mine and will not be removed in the future. All waters encountered have had a near neutral to slightly alkaline chemistry.

As is common with essentially all coal mines in Utah's Wasatch Plateau and Book Cliffs coal fields, sulfide minerals such as pyrite (FeS_2) are known to be present in varying quantities in mined coal seams When exposed to air and water, pyrite is oxidized according to:

$$FeS_{2\,(S)} + 7/2\ O_2 + H_2O = Fe^{2+} + 2SO_4^{2-} + 2H^+$$

The products of this reaction include aqueous dissolved iron, sulfate, and hydrogen ions (acid). In some coal mines in the eastern United States where appreciable quantities of pyrite are present, this reaction continues for prolonged periods of time and acid mine drainage occurs, which results in an iron-rich low-pH water. However, in coal mines in the western United States, where carbonate minerals are pervasive in the mine environment, the acidity produced through pyrite oxidation is rapidly consumed through carbonate mineral dissolution reactions and the pH of the solution rises correspondingly. For this reason, acid mine drainage generally does not occur in Utah's Wasatch Plateau and Book Cliffs coal fields.

As described by Petersen Hydrologic (Appendix 7-67) total iron has been present in the Crandall Canyon Mine discharge water at concentrations of a few milligrams per liter since 2008. As described in Appendix 7-67, "it is considered very likely that iron concentrations will gradually decline over time", "because there is not an unlimited supply of exposed and available sulfide mineral in the newly flooded portion of the mine, it can be stated with confidence that the discharge of iron from sulfide mineral oxidation cannot continue in perpetuity. Accordingly, although pyrite oxidation is occurring in the flooded mine workings and somewhat elevated total iron concentrations are currently present in the mine discharge water, this impact is considered to likely be temporary in nature. Because the currently occurring total iron concentrations in the Crandall Canyon Mine discharge water remain somewhat elevated, Genwal Resources, Inc. has constructed and operates an iron treatment facility at the mine discharge location. After being treated at the facility, iron concentrations in the treated mine discharge water are consistently below the UPDES permit levels. Based on the fact that the concentrations are projected to naturally decline within a few years to levels below the UPDES permit limit, the potential for on-going elevated total iron concentrations in mine discharge waters is considered low.

Total dissolved solids concentrations of the mine discharge water over the past year have averaged approximately 616 mg/L (see UDOGM's on-line coal water quality database), which is only about 11 percent greater than that of the receiving water (Crandall Creek). While this impact to water quality in Crandall Creek is currently occurring (as permitted in the mine's UPDES permit), the magnitude of this impact is minor.

Further, handling plans have been implemented for earth, refuse, and acid-toxic forming materials (if encountered), which, if needed, will prevent or control discharge of pollutants to the hydrologic system (Section 7.31.3). This will be accomplished using the best technology currently available.

However, to further characterize the acid-forming potential of strata immediately above and below the Hiawatha seam, the applicant has collected roof-, floor-rock, and coal samples from locations within the current mine workings. Analytical results from these sets of samples, Appendix 6-2, indicate that high levels of acid and toxic forming materials are not present within the overburden or underburden.

Flooding or Streamflow Alteration.

The potential for flooding is minimized by the design and installation of adequately sized diversions, sediment pond and velocity control structures as described in Chapter 7, Section 7.40. All diversions are sized for a 25 year - 24 hour storm event. Ditches, culverts and sediment pond are designed for a 10 year - 24 hour storm event. Ditches, culverts and sediment pond are designed for a 10 year - 24 hour storm event.

Currently, the potential for streamflow alteration as a result of subsidence is minimal because active mining (which could generate subsidence) is not presently occurring at the Crandall Canyon Mine.

Crandall Creek will be culverted for a distance of about 1,100 feet through the expanded mine yard area. While a minimal short term impact will occur as the culvert is being installed, the long term affect will be to reduce the potential for sediment to flow from the disturbed area into the creek. It will also reduce the potential for flow within Crandall Creek to impinge upon the sediment pond embankment due to their close proximity. The slopes of the sediment pond will be 2:1 on the outslope. The toe of the sediment pond has been fortified with an additional 2 feet of 12.5 inch D-50 rip-rap for protection and stabilization. The culvert outlet downstream from the pond will minimize the potential for impact from running water to damage the sediment pond embankment. An analysis of the Crandall Creek flow and pond protection measures indicates that these measures are adequate for a return period in excess of 10,000 years (Section 7.42.22). A slope stability analysis has also been performed on the pond embankment, indicating it meets the required slope-stability safety factors (Chapter 7, Table 7-7).

R645-301-728.200 Basis for Determination

The PHC Determination for this operation is based on baseline hydrologic, geologic, and other information gathered specifically for this site and the surrounding area by the permittee. This includes information from the South Crandall Lease area and from the U-68082 lease mod area. Additionally, regional information has been provided through various published reports as noted in the plan.

Specific groundwater information is provided in Section 7.24.1 and Appendices 7-16, 7-17, 7-18, 7-19, 7-21, 7-24, 7-40, 7-41, 7-43, 7-46, 7-47, and 7-48 of Chapter 7. Surface water data is presented in Section 7.24.2 and Appendices 7-14, 7-23, 7-25, 7-26, 7-27 through 7-39, 7-43, 7-44, 7-45, and 7-48 of Chapter 7. Geologic information is provided in Chapter 6 and Section 7.24.3, while climatic information is provided in Section 7.24.4.

R645-301-728.300 Findings

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Chapter 7, Sections 7.24.1 and 7.24.2, indicate the potential for adverse impacts to the hydrologic balance to be minimal in both the existing permit area and in the South Crandall Lease area, and in the U-68082 lease mod area. The basis for this determination is through extensive studies, past and on-going groundwater and surface water monitoring, past history, and performance of the on-going operation, and various protection plans for operations and reclamation.

The likelihood of occurrence of specific impacts that could potentially result from currently permitted coal mining and reclamation activities at the Crandall Canyon Mine are discussed below.

Acid- and Toxic-Forming Materials

As described above, sulfide minerals including pyrite are known to be naturally present at the Crandall Canyon Mine. The oxidation of pyrite liberates dissolved iron, sulfate, and hydrogen ions (acid) into the water. While the oxidation of pyrite can result in acid rock drainage in some coal mining environments, acid drainage does not occur in the Utah coal mining districts because of the pervasiveness of carbonate minerals in the geologic environment which neutralize the produced acid. That this is the case at the Crandall Canyon Mine is evidenced by the near neutral to slightly alkaline pH characteristics of the untreated mine discharge water. Accordingly, because of the abundant presence of carbonate minerals in the mine environment, there is no net acid-forming character to the materials at the Crandall Canyon Mine.

By this same sulfide mineral oxidation mechanism, dissolved iron is released into Crandall Canyon Mine groundwaters in flooded, oxygenated regions in the underground mine environment. Subsequent to the onset of gravity drainage from the mine after mining operations ceased, total iron concentrations exceeding 1.0 mg/L began to be observed in the mine discharge water. After peaking in late 2009 and early 2010, total iron concentrations in the untreated mine discharge water have been declining. It is considered likely that total iron concentrations in the mine discharge water will continue to trend downward as the chemical reactants for the sulfide mineral oxidation reactions are consumed and the reaction products are flushed from the mine environment. It is considered likely that within no more than a few years, total iron concentrations in the mine discharge water will decline to less than the 1.24 mg/L total iron UPDES discharge permit limit for the Crandall Canyon Mine. The fact that mine water discharges containing elevated total iron concentrations are not found in nearby closed coal mines supports this conclusion.

It is also important to note that the dissolved iron fraction of the total iron concentration in recent mine discharge water is very low (generally at or near the lower laboratory detection limit). What this indicates is that the iron in the pre-treatment mine discharge water is almost entirely in the form of solid particulate matter, rather than the more reactive dissolved iron forms.

As a mitigation measure, Genwal Resources, Inc. currently operates an iron treatment facility at the mine portal area which effectively removes total iron from the mine discharge water prior to its discharge to Crandall Creek. Genwal Resources, Inc. will continue to operate this facility until total iron concentrations in the untreated mine discharge water fall below the UPDES discharge limit. Accordingly, because the presence of total iron in the untreated Crandall Canyon Mine discharge water in concentrations exceeding the UPDES discharge limit will not be a long-term occurrence, and because Genwal is both committed to and obligated by applicable State and Federal regulations to continue treating the mine water prior to its discharge for as long as the concentrations exceed the UPDES permit limit, there is essentially no potential for sustained discharge of water containing elevated iron concentrations that could potentially be toxic to aquatic habitat. To verify this conclusion, monitoring of iron concentrations in the mine discharge water is currently being performed and will continue to be performed as part of Crandall Canyon Mine's approved water monitoring plan.

<u>Groundwater Availability</u>

As discussed previously, as anticipated, inactive-zone groundwater systems were routinely intercepted by the Crandall Canyon Mine underground workings during the period of active mining operations. These intercepted groundwaters were either used by the mining operation or discharged to the surface as mine discharge water. Intercepted inactive-zone groundwaters discharged from the mine to the surface had the effect of making available water resources in the Huntington Creek drainage which would otherwise not have been available.

Because the groundwater systems that support springs and provide baseflow discharge to streams in the mine area are from the active-zone, and because these systems are not in active hydraulic communication with the deep, inactive-zone groundwater systems intercepted by the mine workings, there should be no impact to the shallow, inactive-zone groundwater systems as a result of the interception of inactive-zone groundwater systems by the mine workings. That this has been the case is supported by the fact that through decades of hydrologic monitoring of springs and streams overlying mined areas there have been no identified mining-related impacts to groundwater availability.

It has been noted that a small percentage of the groundwater intercepted by the Crandall Canyon Mine workings during the period of active mining operations contained tritium, indicating some communication with waters that are less than about 50 years old. However, these waters also had radiocarbon compositions and calculated groundwater mean residence times indicating a component of paleorecharge. Accordingly, it is apparent that these groundwaters have a mixed recharge source. As described elsewhere in this document, it was noted that groundwater inflows in the region containing the modern recharge component declined substantially after being first encountered. Monitoring data obtained from many years of hydrologic monitoring activities do not indicate any perceptible or quantifiable impacts to surface-water or groundwater resources in regions overlying the locations of these inflows.

Underground mining operations are no longer occurring at the Crandall Canyon Mine. Thus, there is currently no potential for the interception of additional in-mine groundwaters by advancing underground mine workings. Historic and current hydrologic monitoring of springs and streams in the mine and surrounding areas do not indicate that any impacts to discharge rates for these water resources have occurred. Accordingly, the potential for impacts to groundwater availability are considered low.

Surface Water Quality

Whenever chemicals are used in the vicinity of surface waters, there is a possibility that the utilized chemicals could potentially impact water quality in surface waters as a result of chemical spills or leakage from storage containers. Because chemical additives are being used in the Crandall Canyon Mine discharge water treatment facility, there is the possibility of adverse effects resulting from residual treatment chemicals. However, by carefully managing the use of chemicals at the mine treatment facility and through the implementation of the mines SPCC plan and mine discharge water treatment chemical protocol, the potential for detrimental impacts to surface water quality is minimized. The quantities and concentrations of chemicals used in the treatment process will be regulated and monitored such that conditions that would result in unacceptable impacts to water quality or health and safety do not occur. Additionally, by carrying out routine monitoring of residual treatment chemicals at the UPDES 002 discharge monitoring station, the possibility that adverse impacts to surface-water quality may occur in the future can be minimized. For these reasons, the potential for adverse impacts to surface water quality resulting from spilled or residual treatment chemicals is considered low.

As discussed previously, as of 2012, total iron concentrations in untreated Crandall Canyon Mine discharge water exceed the UPDES permit limit of 1.24 mg/L. In early 2010, Genwal Resources, Inc. constructed and commenced operation of an iron treatment facility for the mine discharge water to ensure that the discharged mine water remained within the limitations of the UPDES permit. Prior to the treatment of the mine discharge water, some deposition of solid iron-hydroxide precipitates occurred in Crandall Creek below the mine water discharge point. However, the effluent waters from the iron treatment facility have total iron concentrations that are consistently below the limitations set forth in the Mine's UPDES permit. Accordingly, because Genwal Resources, Inc. will continue to operate the iron treatment facility as long as the untreated mine discharge water exceeds the UPDES permit limitations, the potential for adverse impacts to surface water quality as a result of the discharge of mine water with elevated total iron concentrations is considered low.

Genwal Resources, Inc. routinely monitors the treated mine discharge waters as specified in the approved hydrologic monitoring plan to verify that elevated total iron concentrations are not present. Additional water quality parameters are also routinely monitored as specified in the approved hydrologic monitoring plan (See Table 7-4(A) in Chapter 7 of this MRP for a listing of the water quality parameters included in the Crandall Canyon Mine discharge waters).

Prior to the commencement of operations at the mine's treatment facility, discharge of some mine discharge waters with elevated total iron concentrations to Crandall Creek occurred. As described above, the potential for toxicity of the effluent from the Crandall Canyon Mine discharge resulting from the presence of elevated total iron concentrations is mitigated through the operation of the mine's iron treatment facility. Genwal Resources, Inc. is committed to continue treatment of the mine discharge water until the total iron concentrations of the untreated mine discharge water is within the effluent limitations of the UPDES permit. The total iron concentration of the effluent from the iron treatment facility is consistently below the UPDES limits for total iron. Consequently, the potential for toxicity of the treated mine discharge water resulting from the presence of elevated total iron concentration is considered low.

The potential for impacts to surface waters resulting from iron in the mine discharge water is mitigated through the proper operation of the mine's iron treatment facility. Genwal Resources, Inc. also conducts routine whole effluent toxicity testing of the Crandall Canyon Mine discharge water to monitor for potential effects to the receiving water system.

Macroinvertebrate studies have been performed in the Crandall Creek drainage by JBR Environmental Consultants, Inc. of Sandy Utah. These studies have been conducted to evaluate the potential impacts to fish and wildlife resources and potential impacts to aquatic communities and aquatic habitat. In their 2009 report, JBR found that overall, while both the upper and lower monitoring sites continue to support a variety of macroinvertebrates, the Crandall Creek macroinvertebrate community downstream of the mine's discharge was negatively impacted relative to the sampling site upstream of the mine discharge. However, they considered attributing the degradation directly to iron in Genwal's mine water discharge to be problematic. It should also be noted that this represents a potential impact that occurred prior to the onset of chemical mine-water treatment. Subsequently, based on the results of their 2011 macroinvertebrate studies (Appendix 7-69), JBR concluded that it was apparent that "the Crandall Creek macroinvertebrate community immediately downstream of the mine discharge continues to show negative impacts of the mine water discharge." Also, "although the furthest downstream reach of Crandall Creek also has a degraded macroinvertebrate community, its poor substrate condition (embedded and cemented) is likely a contributing (if not dominating) factor affecting macroinvertebrate community health at that site". Based on these findings, it is evident that future impacts to the invertebrate community in Crandall Creek below the mine discharge location may continue to occur in the future. However, as discussed previously, Genwal Resources, Inc. is committed to properly operate the mine's iron treatment facility until total iron concentrations in the untreated mine discharge water are in compliance with the limitations of the UPDES discharge permit. Genwal Resources, Inc. is also committed to performing the macroinvertebrate study in Crandall Creek on an ongoing annual basis to further characterize and monitor for potential impacts to the creek.

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Waste rock is produced in limited quantities on a very infrequent basis during mining operations. When incidental quantities of rock are encountered, the rock is left in the mine and will not be removed in the future.

Further, handling plans have been implemented for earth, refuse, and acid-toxic forming materials, which, if needed, will prevent or control discharge of pollutants to the hydrologic system (Section 7.31.1). This will be accomplished using the best technology currently available.

As is common with coal mines in Utah's Wasatch Plateau coal district, sulfide minerals including pyrite (FeS_2) are known to be present in the mined coal seam at the Crandall Canyon Mine. When exposed to air and water, pyrite oxidizes according to:

$$FeS_{2\,(S)} + 7/2\ O_2 + H_2O = Fe^{2+} + 2SO_4^{2-} + 2H^+ \quad \text{(pyrite oxidation)}$$

This reaction, which may be facilitated and enhanced by the presence of certain bacteria, yields free, reduced iron (Fe^{2+}), sulfate, and H^+ (acid), and removes oxygen from the water. The liberation of H^+ in this reaction results in a temporary lowering of the pH and facilitates the dissolution of carbonate minerals according to:

$$H^+ + CaCO_3 = Ca^{2+} + HCO_3^- \quad \text{(calcite dissolution)}$$
$$2H^+ + CaMg(CO_3)_2 = Ca^{2+} + Mg^{2+} + 2HCO_3 \quad \text{(dolomite dissolution)}$$

These two reactions result in an increase in the calcium, magnesium, and bicarbonate concentrations of the water and consume H^+, resulting in a rising of the pH. Because of the abundance of carbonate minerals in the coal fields of the western United States, the acid produced from pyrite oxidation is readily consumed in the reactions described above and acid-mine-drainage does not occur.

Water flowing in a surface stream that is fully aerated with near neutral pH generally will generally not contain more than a few micrograms per liter of dissolved iron (Hem, 1985). This is because oxygen is continuously present in an actively flowing stream and the Fe^{2+} is rapidly oxidized to Fe^{3+} according to:

$$Fe^{2+} + 1/4\ O_2 + H^+ = Fe^{3+} + 1/2\ H_2O \quad \text{(iron oxidation)}$$

The oxidized iron is subsequently precipitated as a solid (commonly as an amorphous iron hydroxide) which eventually settles to the bottom of the water body. This simplified reaction may be expressed as:

$$Fe^{3+} + 3H_2O = Fe(OH)_{3\,(s)} + 3H^+ \quad \text{(iron hydroxide precipitation)}$$

The H^+ produced in the reaction is consumed in the carbonate mineral dissolution reactions described above.

The iron hydroxide sometimes co-precipitates with carbonate minerals such where supersaturation with respect to the carbonate minerals exists in the receiving water.

As a result of these chemical reactions,

Petersen Hydrologic (2011) indicate that total iron concentrations will likely decline to below the UPDES discharge limit of 1.24 mg/L within a time frame of approximately 3 years (Appendix7-67).

728.330

The following are expected impacts from the coal mining and reclamation operation:

728.331

Sediment yield does naturally increase on a temporary basis from areas disturbed for the operation. However, the majority of the disturbed area runoff is directed to the sediment pond. The pond is designed with a total storage volume of 1.061 acre feet, which allows for complete containment of sediment. The 7 small areas which do not drain to the sediment pond, as shown on Plate 7-5, are treated through the use of sediment traps, straw bale dikes, silt fences, and vegetation.

Genwal, in cooperation with the U.S. Forest Service, is conducting detailed sedimentation and erosion studies in the Blind Canyon watershed to determine the exact impact of mining and subsidence. To date, negative impacts to intermittent and perennial streams by sediment loading and increased turbidity has not been observed in the permit area.

The potential for increases in sediment yield in the permit area is minimized through the use of the sediment pond, diversions, and other sediment controls. The effectiveness of these techniques is monitored through implementation of the mine's water monitoring plan and UPDES monitoring.

728.332

Water quality parameters, including acidity, total suspended solids and total dissolved solids, are not expected to be impacted by the mining or reclamation operations. This determination is based on information provided in Chapter 7, Sections 7.24.1 and 7.24.2, and by results of the on-going water monitoring program detailed in Section 7.31.2.

It is unlikely that groundwater quality or quantity will be affected by the underground mining operations (as discussed in Section 7.24.1 and associated appendices, and Section 7.28.100). This is primarily because groundwater systems that support spring discharges and provide baseflow to streams in the mine area are predominantly from shallow, active-zone groundwater systems (Mayo and others, 2003). Over almost all locations in the Crandall Canyon Mine (with the exception of the fractured zones in the northwest portion of the mine), the groundwaters encountered in the underground mine workings are from deep, inactive-zone groundwater systems. The active zone and inactive zone groundwater systems are isolated by a thick sequence of heterogeneous bedrock strata which are known to have poor vertical and horizontal water transmitting potential. The potential for physical interaction between in-mine groundwaters and overlying active-zone groundwaters to result in chemical contamination of shallow, active-zone groundwaters seems remote. Accordingly, the potential for impacting overlying shallow groundwater systems as a result of mining within the deep, inactive zone is considered low. As discussed elsewhere in this PHC, hydraulic communication between the mine openings and active-zone groundwater systems was indicated in a fractured zone in the northwest portion of the Crandall Canyon Mine. However, in the 15 years that have elapsed since the active-zone groundwater system was first encountered in the mine workings, there is no indication that quantifiable or perceptible impacts to the water quantity or water quality of surrounding surface waters or groundwaters have occurred. This seems to suggest that the active zone system encountered in the northwest portion of the mine is apparently not in good hydraulic communication with a groundwater system that supports appreciable discharge to the surface. It is also evident that the total discharge from the northwest portion of the mine declined appreciably after that area was sealed in June 1999. Genwal mine personnel indicate that the estimated quantity of discharge reporting from the northwest portion of the mine in the early 2000s was on the order of 50 to 100 gpm (personal communication, Gary Gray, 2012).

In general, the conclusion that it is unlikely that groundwater quality or quantity will be impacted by mining activities is strongly supported by the fact that 1) active mining operations in the Crandall Canyon Mine have ceased, and 2) in the more than 25 years since mining activities commenced at the Crandall Canyon Mine, there is no indication that the mining activities have resulted in any perceptible or quantifiable impacts to groundwater quantity or groundwater quality that could be attributed to mining-related activities.

There does exist a potential for impacts to the surface water. However, any potential impacts that may occur are expected to be minimal for the following reasons:

(1) Sediment controls are in place and maintained to minimize sediment loading to drainages;

(2) All discharges from the sediment pond (or mine) are conducted in accordance with requirements of a U.P.D.E.S. Permit; Where elevated total iron concentrations (above UPDES discharge permit limits) in mine discharge waters may occur, the water will be treated to remove excess iron prior to discharge to receiving waters;

(3) Historical data from this site (which is summarized in the Annual Report and Appendices 7-16, 7-17, 7-18, 7-19, 7-21, 7-24, 7-40, 7-41, 7-43, 7-46, 7-47, and 7-48) show no indication of mine related impacts on the hydrology of the area, other than the permitted discharges of mine water to Crandall Creek regulated under the mine's UPDES permit; (Note that the UPDES permit for the Crandall Canyon Mine UT0024368 allows for discharge of water with TDS concentrations not to exceed 1,200 mg/L or one ton of TDS per day, total iron concentrations not to exceed 1.24 mg/L. Currently, the average TDS of the mine discharge water – pre-treatment is approximately 615 mg/L (April 2010-December 2011) which is only approximately 11% greater than the average TDS of the average Crandall Creek receiving water (552 mg/L). The total iron concentrations in the pre-treatment mine discharge water currently exceed the 1.24 mg/L UPDES limit. However, the mine operates an iron treatment facility that is effective at removing total iron from the discharge water. Petersen Hydrologic has projected that the total iron concentration in the pre-treatment water will likely fall below the UPDES limit of 1.24 mg/L within a few years).

(4) The water monitoring program will continue to be followed as described in Chapter 7, Section 7.31.2. Results will continue to be analyzed and any problem areas noted will be corrected to prevent further impacts to the hydrology.

The potential for detrimental impacts to groundwater or surface-water quality as a result of the spillage of hydrocarbons is minimized through the implementation of the mine's SPCC plan.

<u>728.333</u>

The potential for flooding of the surface facilities is minimized by the design and installation of adequately sized diversions, sediment pond and velocity control structures as described in Chapter 7, Section 7.40.

<u>728.334</u>

The Crandall Canyon Mine is expected to have little impact on groundwater.

Monitoring of in-mine and surface monitoring wells drilled within and adjacent to the Crandall Canyon Mine and completed in the regional Blackhawk-Starpoint aquifer indicate the potentiometric surface of this aquifer generally lies 50 to 60 feet below the top of the Star Point Formation in all but the westernmost portion of the mine. Thus, mining of the Hiawatha Coal Seam at the base of the Blackhawk Formation, overlying the Star Point Formation, will not intersect and drain any water from the regional aquifer. Nor would water from underground mining enter the Star Point Sandstone due to the relatively impermeable shale zone that lies between the Hiawatha seam and the sandstone below.

There may be some potential for impact to seeps and springs through subsidence. Genwal is currently monitoring the water flow rates and quality of the water rights associated with seeps and springs within and adjacent to the current mine permit area. No evidence of impacts has been identified; however, an alternative water source plan has been developed in the event any water rights or springs/seeps are adversely affected by the mining operation or reclamation activities.

At the request of the Division, an analysis of water-monitoring data at the Crandall Canyon Mine through the third quarter of 2010 has been performed. All related water-monitoring information has been submitted electronically to the Division's on-line hydrology database located at http://ogm.utah.gov/coal/edi/wqdb.htm.

As part of the requested analysis of water-monitoring data, graphs of discharge, specific conductance, and pH are provided together with plots of the Palmer Hydrologic Drought Index (PHDI) for Crandall Canyon Mine monitoring sites in PHC-Attachment 1. The PHDI is a monthly parameter that is generated by the National Climatic Data Center (NCDC) that indicates the severity of wet or dry spells. The PHDI is useful in evaluating spring or stream discharge data to determine whether variability in spring or stream discharge rates is related to climatic variability or attributable other factors.

Based on the analysis of all monitoring information performed in this investigation, it is concluded that, other than the permitted discharge of mine discharge water to Crandall Creek (which may include increased TDS concentrations of the mine discharge water relative to receiving waters), which is regulated under a UPDES discharge permit, there are no indications of mining-related impacts to water quality or water quantity that could be attributed to mining-related activities. It is apparent that effects of both seasonal and climatic variability influence conditions at monitored springs and streams in the mine area. Other than the permitted discharge of mine water to Crandall Creek with likely temporarily increased total iron concentrations as discussed previously, there is no indication that the events associated with the August 2007 mine collapse event have had any perceptible or quantifiable impacts on water quality or water quantity in surrounding streams or springs. Similarly, no perceptible or quantifiable impacts to water quality or water quantity in streams or springs overlying mine areas that could be attributed to the current discharge of mine water from the Crandall Canyon Mine portals have been identified.

Similar comprehensive analyses of water-monitoring data from the Crandall Canyon Mine have previously been provided yearly in annual reports of water monitoring activities submitted to the Division. An analysis of all monitoring data collected during 2010 will be provided to the Division with the submittal of the 2010 annual report of water monitoring activities.

Three springs which are monitored as part of the regular Crandall Canyon Mine monitoring plan have previously been directly undermined with longwall panels and subsided. These include the following:

SP1-22	Undermined by longwall Panel 12 (May 1999)
SP1-24	Undermined by longwall Panel 13 (September 1999)
SP2-24	Undermined by longwall Panel 11 (December 1998)

Long-term water monitoring information from these springs (which has been submitted electronically to the Division's Hydrology Database) does not indicate any perceptible or quantifiable impacts to discharge rates from these springs (see 2011 annual report of water monitoring for further analysis). Groundwater discharge currently continues uninterrupted at each of these spring locations.

Monitored springs which have experienced longwall subsidence in nearby surrounding areas but not directly at the spring discharge location include the following:

SP-58	Nearby undermining with Panels 4 and 5 (1996-1997)
SP2-9	Nearby undermining with Panels 7, 8, and 9 (1997-1998)
SP-47A	Nearby undermining with Panels 2 and 22 (1996, 2005)
SP1-19	Nearby undermining with Panel 12 (1999)

Long-term water monitoring information from these springs (which has been submitted electronically to the Division's Hydrology Database) does not indicate any perceptible or quantifiable impacts to discharge rates from these springs (see 2011 annual report of water monitoring for further analysis). Groundwater discharge currently continues uninterrupted at these spring locations.

Two monitored springs are located within the region delineated by MSHA as encompassing the likely 2007 mine collapse area. These include:

SP1-22 (August 2007)
SP1-24 (August 2007)

There is no indication that spring discharge rates at these two springs were impacted in any perceptible or quantifiable way as a result of the August 2007 mine collapse event though the event was centered not far from these two springs. Groundwater discharge currently continues uninterrupted at both of these spring locations.

What this indicates is that, in spite of extensive coal mining and subsidence of the land surface in the mine permit area, there is no indication that the groundwater systems that support discharge to overlying springs have experienced any quantifiable loss of flow. Likewise, as discussed previously, there is no indication that any quantifiable loss of flow has occurred at the springs and streams investigated as part of the 2011 work plan investigations. As described elsewhere, most of the groundwater historically intercepted at the Crandall Canyon Mine has been from fracture zones in strata overlying the mine openings. As described by Mayo and others (2003) the deep, inactive-zone groundwater systems commonly encountered in coal mines in the Wasatch Plateau are in most locations hydrodynamically disconnected from shallow, active-zone groundwater systems which typically support discharges to springs and seeps in the region. The fact that through the years appreciable quantities of groundwater have been intercepted in the Crandall Canyon Mine, while diminution of shallow groundwater discharge rates at overlying springs has not been identified, suggests that the groundwater intercepted by the mine is primarily derived from storage in the rock strata surrounding the underground mine workings.

At the request of the Division, we have performed a conceptual analysis of the quantity of groundwater that could be drained from storage from the rock strata surrounding the mine openings at the Crandall Canyon Mine. In presenting this analysis, it is important to note that the analysis provided is meant to determine whether it is reasonable to conclude that sufficient water could be produced from storage in the surrounding groundwater systems to account for the volume of water that has historically discharged from the mine. Because the detailed hydrogeologic conditions present in the overburden and underburden strata are not known, it is not possible to determine with certainty where the groundwaters intercepted in the mine originated.

The Blackhawk Formation is approximately 600 to 700 feet thick in the Crandall Canyon Mine permit area. Employing a commonly utilized assumption that bedrock fracturing above areas subsided by coal extraction may extend upward from the mined horizon for a distance of approximately 80 times the mined height, assuming an extraction height of 8 feet it would be projected that the zone of cracking above subsided areas could extend upward for a distance of about 640 feet. Based on the known lithologic characteristics of the Blackhawk Formation regionally, it seem reasonable to conclude that in the aggregate, 100 feet of saturated sandstone bedrock would be present (which conservatively estimates that about 16% of the total encountered Blackhawk

Formation lithology would consist of sandstone). Assuming an effective porosity of 14 percent for fine-grained Blackhawk Formation sandstones (Slaughter and others, 1995) it is possible to calculate a volume of groundwater held in storage within a hypothetical square mile of saturated sandstone. This calculation is presented below:

Blackhawk Formation (gallons drained from storage per unit square mile)

- Saturated sandstone thickness within cracked zone = 100 feet
- Effective porosity = 14 percent
- Cubic feet of rock = 5280 feet x 5280 feet x 100 feet thickness = 2,787,840,000
- Cubic feet of porosity volume = 2,787,840,000 cubic feet x 0.14 = 390,297,600
- Gallons of water = 390,297,600 cubic feet x 7.48 gallons/cubic foot = 2,919,426,048

It is apparent from these calculations that approximately 2.9 billion gallons of water could be drained from storage per square mile of Blackhawk Formation overlying mined areas at the Crandall Canyon Mine hypothetically (and somewhat arbitrarily) assuming a 100 foot thickness of saturated sandstone. Considering the total land area contained within the Crandall Canyon Mine permit area beneath which all or most of the Blackhawk Formation is present (within Sections 1, 2, 25, 26, 31, 35 and 36) it is estimated that these lands encompass roughly 5.5 square miles. Accordingly, it is calculated that for 2,919,426,048 gallons per square mile x 5.5 square miles, a total storage capacity in excess of approximately 16,000,000,000 gallons of groundwater would exist. Assuming that approximately 5,950,000,000 gallons of water has drained from the mine since 1996, it is readily apparent from these calculations that it would hypothetically be possible to produce the approximately 5,950,000,000 gallons of water from storage release in such a Blackhawk Formation groundwater system. Under this hypothetical scenario, approximately 37 percent of the total storage would be drained currently, with approximately 63% remaining in storage.

Assuming an arbitrary discharge rate of 400 gpm, the remaining volume of water would be depleted in approximately 48 years.

A similar series of calculations is presented below for the storage potential of the underlying Star Point Sandstone. The Spring Canyon Member of the Star Point Sandstone is present stratigraphically immediately or a short distance below the mined Hiawatha coal seam at the Crandall Canyon Mine. The thickness of the Spring Canyon Member locally is approximately 100 feet. For this hypothetical calculation, it is somewhat arbitrarily assumed that on average the Spring Canyon is only 50% saturated. Assuming an average effective matrix porosity of 15.5 percent for the Star Point Sandstone (Bills, 2000) it is possible to calculate the groundwater storage volume of such a hypothetical groundwater system.

Star Point Sandstone Formation – Spring Canyon Member (gallons of storage per square mile)

- Saturated sandstone thickness = 50 feet
- Effective porosity = 15.5 percent
- Cubic feet of rock = 5280 feet x 5280 feet x 50 feet thickness = 1,393,920,000
- Cubic feet of porosity volume = 1,393,920,000 cubic feet x 0.155 = 216,057,600
- Gallons of water = 216,057,600 cubic feet x 7.48 gallons/cubic foot = 1,616,110,848

Conservatively assuming a 5.5 square mile land surface area beneath which the Star Point Sandstone is present within Sections 1, 2, 25, 26, 31, 35 and 36 in the permit area, it is calculated that such a hypothetical Star Point Sandstone groundwater system could contain approximately 8,889,000,000 gallons of groundwater physically in storage. This quantity of water alone could account for the total approximately 5,950,000,000 gallons of water discharged from the Crandall Canyon Mine since 1996. Using this hypothetical estimate, approximately 67 percent of the water held in storage would have now been drained. This calculation is considered highly conservative because the Star Point Sandstone is known regionally to be present well beyond the extents of the Crandall Canyon Mine permit area.

Assuming an arbitrary discharge rate of 400 gpm, the remaining volume of water would be depleted in approximately 14 years.

It is important to emphasis that these calculations have been provided at the request of the division and are intended for the purpose of determining whether there could be adequate groundwater residing in storage in a specified hypothetical groundwater system to account for the approximate volume of groundwater that has been discharged from the mine since 1996. Genwal Resources, Inc. makes no inferences from these calculations as to actual groundwater conditions that may exist in the permit and adjacent areas.

These calculations demonstrate that it is indeed possible for the observed volume of water that has discharged from the Crandall Canyon Mine since 1996 to be accounted for through removal of groundwater entirely from storage in either the Blackhawk Formation overlying the mine, or from the Star Point Sandstone underlying the mine workings, or through a combination of these sources. This finding is consistent with the fact that no quantifiable impacts to discharge rates in springs or to baseflow components of streams that could be attributable to mining-related activities have been observed (i.e., no appreciable impact to the hydrologic balance). As discussed above, a component of the groundwater intercepted in the northwestern portion of the mine workings is known to have likely been in communication with shallow active-zone groundwater systems or surface waters. The specific location of the active-zone groundwater system(s) that contributed water to the composite mine discharge water is not known. However, rigorous monitoring of springs and streams in the mine permit and adjacent areas has not shown any quantifiable or perceptible impact to discharge rates at the monitoring sites. The source of the modern, active-zone component of the mine discharge water remains problematic. Monitoring of springs and streams in the permit and adjacent areas will continue to be performed to verify that impacts to shallow groundwater systems or surface-water systems do not occur.

The groundwater system that supports discharge at Little Bear Spring will not be subsided. As discussed above, the groundwater discharging from the spring is NOT derived from a regional Star Point aquifer. Rather, it is recharged from surface-water and alluvial groundwater losses in Mill Fork Canyon outside of the permit area. The significant fracture in the Star Point Sandstone from which the spring discharges serves primarily as a conduit for the conveyance of the Mill Fork water to the spring. Groundwater in the Star Point Sandstone that is not within the fracture system does not contribute appreciable quantities of groundwater to the spring. For these reasons, the potential for impacts to Little Bear Spring resulting from mining operations in Genwal's permit area is considered extremely unlikely.

Impacts to the surface water quality and quantity are minimized through the installation and maintenance of surface runoff and sediment control structures, and a commitment (Section 7.24.2) to not pump from Crandall Creek at a rate that will cause the in-stream flow to decrease below the minimum required rate.

In addition, groundwater and surface water quantity and quality are monitored on a quarterly basis to determine seasonal flow conditions for the permit and adjacent areas. Further, handling plans have been implemented for earth, refuse, and acid-toxic forming materials, which will prevent or control discharge of pollutants to the hydrologic system. Implementation of these plans will be accomplished using the best technology currently available.

Based on the above, there is some potential for the operation to have an impact on the groundwater and surface water resources of the area; however, the impacts are expected to be minimal due to natural geologic and hydrologic conditions, and the implementation of control and protection systems. Therefore, the "Probable Hydrologic Consequences" of this operation are expected to be minimal, if not negligible.

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Additional information will be provided if deemed necessary by the Division.

R645-301-728.340 N/A

This is an underground operation.

R645-301-728-400 Updated PHC

This document is provided as an up-dated PHC for the permit renewal in accordance with the State of Utah R645-Coal Mining Rules.

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