Canyon Fuel
Company, LLC
A Subsidiary of Bowie Resource Holdings, LLC

Skyline Mine
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January 25, 2017

Coal Regulatory Program
Attn: Ms. Dana Dean, Associate Director of Mining
Division of Oil, Gas, and Mining
1594 West North Temple, Suite 1210
Box 145801
Salt Lake City, Utah 84114-5801

Re: Review of Recently Submitted Loughlin Water Associates, LLC report, Canyon Fuel Company, LLC, Skyline Mine, C/007/0005

Dear Ms. Dean:

Canyon Fuel Company, LLC, Skyline Mines (Skyline) recently commissioned Petersen Hydrologic Inc. to review a report submitted to the Utah Division of Oil, Gas, and Mining (Division) by Loughlin Water Associates, LLC (Loughlin) on December 19, 2016. Loughlin was commissioned by the Division to help it determine whether adequate hydrologic information had been provided by Skyline to protect and monitor the hydrologic system while mining in the Flat Canyon lease area. Skyline personnel believed a response to the Loughlin report was necessary because the report contained numerous inaccurate geologic and hydrologic assumptions which lead to some erroneous conclusions. Mine personnel acknowledge a well development table provided by the Mine had some information that was unclear or incomplete, however those discrepancies have been clarified in the M&RP and addressed in Petersen's response.

The attached Petersen Hydrologic, Inc. response refutes inaccuracies stated in the Loughlin report by referencing supporting data and studies collected over 35+ years. The Petersen response also addresses recommendations cited in the Loughlin report that already exist in the current Mine and Reclamation Plan, are included in the current amendment to the plan, or are not necessary.

Feel free to contact me, Craig Brown, Gregg Galecki, or Jeremiah Armstrong if you have any questions,

Sincerely,

Corey Heaps

Corey Heaps
General Manager
Canyon Fuel Company, LLC – Skyline Mine

25 January 2017

Mr. Corey Heaps
Canyon Fuel Company, LLC
Skyline Mine
HC 35 Box 380
Helper, Utah 84526

Corey,

At your request, we have reviewed the report entitled *Groundwater and Surface Water Hydrologic Review, Skyline Mine – Flat Canyon Lease Addition, Federal Coal Lease Tract UTU-71144, Carbon and Emery Counties, Utah*, dated 19 December 2016. The document was prepared by Loughlin Water Associates, LLC (Loughlin) of Park City, Utah. (It should be noted that the tract identification number is stated incorrectly in the report title and within the text of the Loughlin report as UTU-71144. The correct identification number for the Flat Canyon Coal Lease Tract is UTU-77114.)

The report was prepared by Loughlin for the Utah Division of Oil, Gas and Mining (Division) in response to a Request for Proposal and Proposed Work Assignment from the Division. It was the purpose of the Division to obtain a third party review of the proposed mining activity in the Flat Canyon Lease to assist them in determining whether the proposed mining has been designed to prevent impacts to State Appropriated Water Rights and Electric Lake and whether the proposed water monitoring plan is adequate to identify impacts.

The purpose of this document is to present the findings of our review of the Loughlin report. Our conclusions are summarized in the subsequent sections of this report.

1.0 OVERVIEW OF HYDROLOGIC INVESTIGATIONS

The Canyon Fuel Company, LLC Skyline Mine (Permit number C0070005) is located in the Wasatch Plateau coal field approximately three miles southwest of the town of Scofield, Utah. The mine, which was opened in December 1981, produces low-sulfur bituminous coal.

During the 35-year period of its operation, the Skyline Mine has been the subject of numerous hydrologic studies. These studies, which have been performed in support of ongoing mine permitting activities and for various mine operational purposes, have included numerous groundwater and surface water investigations, 35 years of quarterly hydrologic monitoring of springs, streams, and wells, baseline monitoring activities, spring and seep surveys, in-mine hydrogeologic investigations, and numerical modeling of groundwater systems at the Skyline Mine area.

In conjunction with the performance of these activities, a large quantity of hydrologic data has been obtained. This includes groundwater and surface-water discharge rate data, potentiometric data from wells, solute geochemical data from groundwaters and surface waters, and isotopic data from springs, streams, wells, and in-mine locations. The isotopic sampling has included analysis of the stable isotopes $\delta^{2}H$, $\delta^{18}O$, $\delta^{13}C$, and $\delta^{34}S$ and the radioactive isotopes ^{3}H (tritium) and ^{14}C. The isotopic sampling program at the Skyline Mine area has been extensive, including more than 350 tritium analyses and approximately 100 radiocarbon analyses for age dating purposes.

In 2003, Mayo et al. (2003) authored a peer-reviewed professional paper that presented the findings of a comprehensive, multi-year investigation of groundwater flow patterns in the mountainous terrain of Utah's Wasatch Plateau and Book Cliffs coal mining districts. This investigation describes a conceptual model of active and inactive groundwater flow regimes in the Utah coal mining districts that is directly applicable to groundwater flow regimes in the Skyline Mine and adjacent area. The Mayo investigation was based on analysis of a large volume of geologic, hydrogeologic, and hydrologic data from the study area. This included analysis of discharge data from 123 springs for which long-term discharge data were available, 1,930 sets of major ion water sample analyses, Carbon-14 and tritium analyses from 132 sampling locations, and δ^2H and $\delta^{18}O$ analyses from 329 sampling locations. Much of the hydrologic data as well as information on historical mining practices discussed in the Mayo investigation was obtained specifically from the Skyline Mine and Flat Canyon Tract area.

Through the performance of these varied activities, the groundwater and surface-water regimes of the Skyline Mine and adjacent areas have been investigated and characterized to a high level. The response of the hydrologic regime to underground coal mining at the Skyline Mine area has been well documented through the 35 years of mining history at the mine.

2.0 LOUGHLIN REVIEW OVERVIEW

Loughlin was commissioned by the Division to perform a third-party professional engineering, hydrologic and hydrogeologic review of proposed mining activity within the Flat Canyon Lease. Specifically, Loughlin was directed to produce a report that would discuss their analysis of the information and make a determination as to whether the proposed mining plan and supporting data is adequate to determine whether the proposed mining has been designed to prevent impacts to State Appropriated Water Rights and Electric Lake and that the proposed water monitoring plan is adequate to identify impacts.

Loughlin submitted their proposal to perform the work tasks to the Division dated 18 October 2016. They produced their final written report dated 19 December 2016. Loughlin was allotted only a minimal period of time to perform their review and analysis of the large volume of data and information provided to them and to prepare their final written report (about two months in total). The findings of their review should be evaluated in light of this consideration.

It is our opinion that the independent review by Loughlin of the data and analysis presented in the Skyline Mine Mining and Reclamation Plan (MRP) and the Flat Canyon Tract amendment has been beneficial in verifying the completeness and accuracy of the information contained in the amendment. It is noted that we agree with many of the findings that Loughlin sets forth in their written review. However, there are also several statements and conclusions contained in the Loughlin report with which we do not agree.

A discussion of our findings regarding the Loughlin review is presented in the following sections of this document. In the next section we present a summary of our general comments regarding the conclusions of the Loughlin document. In the final section of this report, we provide responses to Loughlin's evaluation of the Skyline Mine MRP.

3.0 GENERAL COMMENTS

Electric Lake water loss

Upon their review of the information and reports regarding the possibility of hydraulic communication and rapid flow from Electric Lake to the underground Skyline Mine workings, Loughlin concluded that there was little evidence for such a condition. Loughlin suggests that "if Electric Lake was losing up to 5,000 [gpm] directly into the mine, then evidence from these studies should have been more conclusive or convincing." They further indicate that "in our opinion, the results from early investigations, including the dye studies, geophysical surveys, tritium studies, and water balance studies of Electric Lake do not conclusively show that inflows into the Skyline Mine and water pumped from Well JC-1 were directly from a high-permeability conduit between the mine and Electric Lake. Small concentrations of tritium (tritium bound into the water molecule) do indicate a small component of mixing with modern waters." We agree with Loughlin's findings in this regard.

Monitoring Well Network

It is apparent from the statements in the Loughlin report that there was some confusion regarding the well completion information for the monitoring well network at the Skyline Mine and Flat Canyon Tract areas. Much of this confusion may have arisen from a misunderstanding of the completion characteristics of the wells in the tabular information provided to Loughlin. It is also possible that the Loughlin review may have been based on some unclear or incomplete information in the data table that was provided to them for use in their analysis. While the reported well screened intervals for several wells correspond to the lower Blackhawk Formation, drilling logs and Skyline Mine personnel indicate that the boreholes for these wells were drilled through the Blackhawk Formation and into the underlying tongues of the Star Point Sandstone. Because the well bores are open to the Star Point Sandstone, the potentiometric responses noted in these wells are believed to be reflective of conditions in the Star Point Sandstone. Table 2.3.7-4 has been updated and clarified within the Skyline Mine MRP to reflect the correct monitored strata for the Skyline Mine monitoring wells. It is unfortunate that the Loughlin review was performed without resolution of this issue, as many of the conclusions presented throughout their report are apparently based on an incorrect interpretation of the monitored intervals of the Skyline Mine monitoring wells.

Groundwater flow directions and gradients

Apparently, as a consequence of the misunderstood monitoring well information utilized throughout the Loughlin analysis (as described above), incorrect conclusions were drawn regarding groundwater flow directions and hydraulic gradients in the monitored hydrostratigraphic units at the Skyline Mine. As an example, Loughlin notes that the well closest to the Flat Canyon Tract that monitors the Star Point Sandstone is W14-2A. W14-2A is located in Eccles Canyon, more than two miles from the Flat Canyon Tract. However, W14-2A is a shallow monitoring well (total depth of 122 feet) that is screened in the Blackhawk Formation more than 490 feet in elevation above the top of the coal zone on a steep hillside above the Skyline Mine portal area (Mayo and Associates, 1996). Clearly, the well does not provide potentiometric data on the Star Point Sandstone, but rather indicates water levels in the shallow Blackhawk Formation bedrock several hundred feet above the elevation of the coal seams. The statement of Loughlin that W14-2A is screened in the Star Point Sandstone is obviously in error, as in the event that the well was indeed screened in the Star Point Sandstone, a typical water level elevation measurement in the well (8,975 feet) would be about 530 feet above the level of the top of the coal seams (Mayo and Associates, 1996) which would equate with a hydrostatic pressure of 229 psi in the Star Point Sandstone referenced at the level of the mine workings. Such hydrostatic pressures, were they to actually exist, would likely present a serious flooding and safety hazard within the mine workings near the Skyline Mine portals.

It is considered likely that the marked variability in water levels measured in W14-2A that were first observed in late 2010 are a result of damage to the well casing, which has brought the well into hydraulic communication with shallow, seasonal recharge waters associated with active-zone groundwater systems near the well. These fluctuations are clearly not indicative of hydraulic communication between shallow active-zone recharge and the underlying deep, Star Point Sandstone groundwater systems. As indicated in Table 2.3.7-4, there are numerous wells in and around the Flat Canyon Tract that monitor potentiometric levels in the Star Point Sandstone groundwater system. Loughlin's calculated groundwater flow direction and gradient for the Star Point Sandstone, that was based largely on potentiometric data from the shallow Blackhawk Formation well W14-2A, while not accounting for numerous wells in the vicinity of the Flat Canyon Tract that reflect potentiometric levels in the Star Point Sandstone, is clearly in error. The water level contours depicted in Figures 6, 7, and 8 of the Loughlin report appear to be based incorrectly on an assumption that Blackhawk Formation wells W10-1 & W14-2 are monitoring the Star Point Sandstone. When these two wells Blackhawk Formation wells are correctly considered, the potentiometric gradient is completely different than that plotted on Figures 6, 7, and 8. Additionally, data from Star Point Sandstone wells W2-1 (W98-2-1), 91-35-1, and 91-26-1 apparently were not incorporated into the analysis. Figures 6, 7, and 8 also show the spring locations on the map but there is not any discussion that indicates how their presence may or may not have been utilized in the potentiometric analysis.

It is our opinion that the northerly groundwater flow direction and gradient in the Star Point Sandstone determined by SRK that was based on a complete analysis of potentiometric data from all appropriate monitoring wells is likely the most correct determination of groundwater gradients and flow directions in the Star Point Sandstone.

Over the life of the mine, mining operations in the Skyline Mine have encountered groundwater in some portions of the mine, while other nearby locations were dry. Wells drilled into both the mine roof and mine floor at the Skyline Mine encountered significant thicknesses of unsaturated bedrock (Mayo and Associates, 1996). The presence of unsaturated zones in the deep system is not consistent with a condition of continuous hydraulic saturation/connectivity with overlying or underlying groundwater systems (Mayo and Associates, 1996). This condition is likely the result of limited groundwater recharge potential and the limited potential for groundwater migration in the lenticular rock bodies of the Blackhawk Formation and unfractured Star Point Sandstone. Because of these circumstances (discontinuous saturation), it is not possible to create meaningful potentiometric surface contour maps of disconnected inactive-zone groundwater systems adjacent to coal mining areas (most notably in the highly partitioned groundwater systems of the Blackhawk Formation). Similarly, there is little practical meaning to a finding of downward hydraulic gradients when evaluating potentiometric head in disconnected groundwater systems with little or no hydraulic communication and discontinuous zones of saturation. Such a finding is not necessarily indicative of downward groundwater flow.

Radiocarbon dating of groundwaters

Of particular significance to the overall findings of the Loughlin report are their statements regarding their disbelief in radiocarbon dating of groundwaters. In their report, Loughlin states that "we do not believe radiocarbon dating to establish the age of water from the formation is very reliable because (1) the carbon analyzed is that which is dissolved in the water, mainly in the form of carbonates and (2) the aquifer contains large amounts of coal and carbonate minerals that were deposited thousands to millions of years ago." Loughlin's statements in this regard are concerning and suggest that they did not have an understanding of the methods of radiocarbon dating of groundwater in carbonate terrains utilized at the Skyline Mine that are widely accepted in the scientific community. The radiocarbon dating methods utilized at the Skyline Mine fully account for the perceived difficulties noted by Loughlin. Notably, the ^{14}C analyses referenced in the Skyline Mine Flat Canyon amendment were all performed specifically on the dissolved inorganic carbon (DIC) present in the groundwater (coal, being organic, is not included in the DIC). Additionally, the models by which radiocarbon dates are determined from the analytical data have been developed specifically for use in carbonate-rich terrains (they model both open and closed systems with abundant carbonate mineral). Radiocarbon mean residence times for groundwaters from the Skyline Mine area have been calculated by isotopic mixing (Pearson et al., 1972) and by isotopic mixing exchange (Fontes and Garnier, 1979). Contributions of "live" carbon from near-surface CO_2 sources and "dead" carbon from old carbonate minerals are fully accounted for in these models. The carbon histories of groundwaters are evaluated in light of the $\delta^{13}C$ (DIC) and solute geochemical compositions to verify geochemical evolutionary pathways. It is noted that very similar radiocarbon dating techniques were utilized by Mayo et al. (2003) with similar modeled radiocarbon ages in their peer-reviewed research of radiocarbon ages of groundwaters in the Wasatch Plateau and Book Cliffs coal fields – including groundwater samples specifically from the Skyline Mine.

While there are reasonable margins of error in modeled radiocarbon ages, we have a high degree of confidence in the identification of very old groundwaters and the determination of their approximate radiocarbon ages (mean groundwater residence times) at the Skyline Mine.

Loughlin's disbelief of radiocarbon dating at the Skyline Mine has significant and troubling implications to the general conclusions they present in their review of the Flat Canyon Lease amendment. The demonstrated presence of groundwater intercepted in the Skyline Mine underground workings that is many thousands of years old is of central importance to the conceptual groundwater flow model of the region (Mayo et al., 2003). Loughlin's rejection of this fundamental measure of the characteristics of the hydrogeologic regime may have influenced other major conclusions of their review of the amendment and thus such conclusions may be in error.

Conceptual model of groundwater flow

Throughout their document, Loughlin indicates their belief in direct hydraulic communication (in varying degrees) between the deep Star Point Sandstone groundwaters encountered in the Skyline Mine and shallow overlying active-zone groundwater systems and surface-water systems. As evidence for this occurrence, Loughlin infers the existence of hydraulic communication between shallow recharge sources and the Star Point Sandstone as observed in monitoring wells (such as W14-2A). This concept is used, for example, to support their conclusion that, as a result of potential declines in the hydraulic head in the Star Point Sandstone associated with draining of water from the unit, increased hydraulic gradients will result. The increased hydraulic gradients will in turn result in increased flow rates from overlying strata into deeper units. However, drilling and in-mine potentiometric information demonstrate that there is generally not continuous saturation from the land surface to the deep underground mine environment (Mayo and Associates, 1996; Mayo et al., 2003). Accordingly, removal of groundwater from the deep groundwater systems encountered in the mine environment would not result in any increase in the potential for downward migration of perched overlying active-zone groundwaters into deeper strata because of the hydraulic discontinuity (unsaturated zones) between these two systems. Additionally, the old radiocarbon ages (thousands of years) and the lack of tritium usually measured in the deep groundwaters in the mine environment are not consistent with a conceptual model that includes rapid hydraulic communication between shallow recharge waters and deep groundwater systems encountered in the mine.

Loughlin also suggests that temporal fluctuations in water levels measured in some monitoring wells indicate communication with shallow recharge sources. For example, Loughlin discusses the water level responses measured in the nested monitoring well pair 79-35-1 in Burnout Canyon. It is apparent that the deep well (79-35-1A) rapidly declined by more than *300* feet in response to pumping of water from the Star Point Sandstone in the Skyline Mine (1998 to early 2003). Water levels measured during the same time period at the shallow well (79-35-1B) varied by less than *2* feet. A somewhat larger drop in water levels that was measured later during 2003 at well 79-35-1B, but this was most likely a result of subsidence effects resulting from the almost direct undermining of the well area that occurred at that time and not from pumping of Star Point Sandstone groundwater from the mine and JC-1. Subsequently, it is apparent the well casings at both 79-35-1A and 79-35-1B have since failed, likely as a result of ground movement associated with subsidence effects, and both wells became inoperable.

Loughlin indicates that when the scale on the vertical axis in the plot for W35-1B is increased, the well shows the Blackhawk response to pumping. In the Petersen Hydrologic analysis we plotted the data for both W79-35-1A and W79-35-1B using the same vertical scale to compare the magnitudes of the water level responses in both wells. While the magnitude of pumping related drawdown in the deep well W79-35-1A is more than 150 times greater than any variability noted at that time in the shallow well, as described above, we suspect that the small amount of variability observed in the water levels measured in W79-35-1B are more likely attributable to subsidence effects (to either the Blackhawk Formation groundwater system in which the well is screened, or to the physical well casing. Broken well casings and/or compromised well annular seals may result in changes to measured values of hydraulic head in a well and may also produce indications of seasonal variability in well water levels as a result of communication with shallow recharge sources in the well through the damaged casing).

Loughlin also indicates that several Blackhawk Formation wells "showed clear responses to pumping" from the mine and JC-1. However, as mentioned previously, the open intervals for most wells in the Flat Canyon Tract and adjacent areas have been mischaracterized in the Loughlin report. Responses to pumping from the mine and JC-1 would be as anticipated for wells open to the Star Point Sandstone groundwater system.

In summary, we do not concur with Loughlin's determination that there is appreciable vertical hydraulic communication and downward vertical flow from the surface through the relatively impermeable Blackhawk Formation to the underlying Star Point Sandstone groundwater systems. We suggest that groundwater recharge to the Star Point Sandstone likely occurred anciently under climatic conditions that do not exist today (i.e. wetter, cooler conditions with associated glaciation) as suggested by Mayo and Associates (1996), with groundwater flow and recharge occurring primarily via lateral flow through the formation.

Star point Sandstone Groundwater flow

Loughlin posits that groundwaters with mixed-modern isotopic compositions (having old radiocarbon "ages" and also containing appreciable tritium) are likely characteristic of groundwater generally present throughout the Star Point Sandstone groundwater system in the region. Apparently, Loughlin extrapolates this conclusion to suggest that diminished flows at spring S17-2 (see Note 1 below) are reflective of mining-related impacts related to draining of groundwater (of similar isotopic composition) from the Star Point Sandstone groundwater system in the surrounding regions. For several reasons, we do not concur with Loughlin's findings in these regards.

Note 1: It has been discovered that there is an incorrect value in the UDOGM on-line hydrology database for the discharge rate monitored at S17-2 on 8 December 2015. The incorrect value contained in the database (30.3 gpm) resulted from a data entry error. The correct value for the discharge rate measured on that day is 60.0 gpm (personal communication, Jeremiah Armstrong, 2017). The erroneous discharge rate value has been incorporated into the discharge hydrograph for S17-2 in Figure 14 of the Loughlin report.

It is observed that most Star Point Sandstone groundwaters sampled in underground Skyline Mine locations have radiocarbon ages of several thousands of years and have low (<0.5 TU) tritium concentrations (Petersen Hydrologic, 2016). While some tritium is occasionally measured in samples of old in-mine groundwater, this is likely a result of mixing of old, tritium-free groundwaters with waters that have been contaminated with tritium derived from non-aquifer sources. Generally, tritium levels are usually low.

The old radiocarbon ages and the general lack of tritium in the in-mine samples is supportive of our finding that the deep, inactive-zone Star Point Sandstone groundwater systems are not in good hydraulic communication with shallow recharge sources. We consider it very likely that both the seasonal and climatic variability observed in discharge rates at spring S17-2 and the mixed-modern isotopic compositions of groundwaters sampled at S17-2 are a result of the characteristics of the mixed groundwater flow regime that supports discharge at the spring. The presence of an old component of groundwater at the spring is clearly indicated by the old radiocarbon mean residence time (3,000 years) for the groundwater at the spring. The seasonal variability in the discharge rate measured at the spring is consistent with a component of modern, shallow recharge water that is tied to the annual recharge event. In contrast, note that discharge rates from in-mine Star Point Sandstone groundwater system do not respond to seasonal or climatic variability (Mayo and Associates, 1999; Mayo et al., 2003). The presence of tritium in the groundwater at S17-2 also clearly indicates a component of modern recharge. It is noteworthy that fractured Star Point Sandstone bedrock is exposed at the surface over large areas in and around the S17-2 discharge location. The fractured bedrock exposures near the spring may possibly be related to the modern recharge component at the spring.

The discharge hydrograph for spring S17-2 also shows the influence of climatic variability on discharge rates measured at the spring (see note 1 above). Notably, increased discharge rates were measured at the spring around 1983-84, and again around

1997-1998. Both of these periods were characterized by extreme wetness as reflected in the Palmer Hydrologic Drought Index (Petersen Hydrologic, 2016).

In considering the discharge rates measured at S17-2, it should be noted that discharge from the spring is collected in a buried groundwater collection system and piped through a steel culvert beneath the paved highway to the discharge system near Eccles Creek. It is considered likely that some portion of the observed variability in the discharge rates measured at S17-2 could be due to the long-term operational conditions of the collection and piping system. It is not uncommon for buried groundwater collection systems to become clogged and loose efficiency over time due to the infiltration of fine-grained sediments into the systems and/or precipitation of mineral deposits in the collection system due to the geochemical character of the spring water. It is noted that groundwater discharging from S17-2 actively precipitates iron hydroxide precipitates at the spring discharge location.

In summary, we consider it likely that the discharge from spring S17-2 is comprised of a component of old Star Point Sandstone groundwater and a component of shallow, modern, recharge water. The seasonal and climatic variability in discharge rates are likely related to variability in the shallow, modern recharge component of the spring water. In evaluating long-term trends in discharge rates measured at S17-2, it is noted that for all monitoring events during the previous 20 years, the measured discharges were greater than that measured in June of 1995, when a discharge of 46.88 gpm was measured. Additionally, although Loughlin does not present the discharge rate information collected from S17-2 during 1981, the discharge rates at S17-2 were less than 23 gpm during the March, April, May, and September monitoring events of that year (Mayo and Associates, 1996), which are much lower than those measured in the past several years at S17-2.

It is noted that there is no marked decline in the discharge rates measured at S17-2 beginning around 1999, which would correspond with the first interception of appreciable Star Point Sandstone groundwaters inflows in the Skyline Mine in 1999.

In consideration of these factors and also considering the inherent errors in the performance of the discharge rate measurements at the spring, we do not find convincing evidence that discharge rates at S17-2 have been adversely impacted by mining activities in the Skyline Mine. Rather, we considered it more likely that recent discharge rates measured at S17-2 reflect the prevailing climatic conditions in the region.

It seems likely that the presence of significant low-permeability faults in the region between the location of S17-2 and the Skyline Mine workings to the west (including the Connelville Fault) isolate Star Point Sandstone groundwater systems on opposite sides of the faulting.

Loughlin suggests that the removal of water from mine workings in the Huntington Drainage will impact flows to the Star Point Sandstone, potentially impacting springs down-canyon. As discussed above, it is our opinion that the deep, inactive-zone groundwater systems intercepted in the Skyline Mine are generally not in strong hydraulic communication with shallow active-zone groundwater systems. Consequently, while flow paths of surface-water systems and shallow, active-zone groundwater systems are usually constrained in large measure by surface topography (i.e. drainage basins), the deep, inactive-zone groundwater systems of the Star Point Sandstone (away from shallow, near-surface outcrop areas) operate independently of the surface topography. Consequently, the removal of deep, inactive-zone groundwaters intercepted in the underground mine environment likely does not result in diminution of waters from the overlying surface water drainage basin. Rather, the pumping of the ancient, inactive-zone groundwaters intercepted in the mine workings to surface drainages likely makes water resources available to downstream water users that otherwise would not be available for use.

Potential mining-related impacts to groundwater resources

Many of the conclusions of Loughlin regarding potential mining-related impacts to the hydrologic balance at Skyline Mine Flat Canyon amendment area are qualified with language such as being “uncertain” or “difficult to predict” etc. We agree that in many instances making determinations with certainty regarding how groundwater flow through the heterogeneous, isotropic hydrogeologic regime will occur, and how it may be impacted by mining activity, is indeed difficult and in some instances not possible with the available data. We conclude that the most reliable method for predicting the future behavior of the hydrologic regime in response to the proposed mining activities in the Flat Canyon Tract is to evaluate the collected hydrologic and geologic data together with a review and analysis of the history of mining at the Skyline Mine and at other similar mining operations in the Wasatch Plateau coal field.

It is noted that over the 35-year history of mining at the Skyline Mine, impacts to groundwater and surface water discharge rates and water quality have been minimal. Perceptible or quantifiable impacts to discharge rates or water quality parameters at springs or streams that could be attributable to the dewatering of deep, inactive-zone groundwaters intercepted by mining operations have not been identified in the 18 years that have elapsed since substantial quantities of Star Point Sandstone groundwater began to be intercepted at the Skyline Mine in 1999.

In the general sense, coal mining has the potential to impact discharge rates from shallow, active-zone groundwater systems that support springs and provide baseflow to streams locally. The mechanisms whereby these systems may hypothetically be impacted by mining activity include:

1) A mechanism whereby shallow groundwater flow pathways and groundwater discharge locations may be altered as a result of subsidence-induced tension cracking and fracturing of near-surface rock strata (usually overlying longwall mined areas), and

2) An alternate mechanism whereby shallow groundwaters may hypothetically be impacted involves the diversion of shallow groundwaters to deeper strata in response to withdrawals of groundwater from deeper underlying groundwater systems (a mechanism that generally does not occur in coal mines in the Wasatch Plateau coal district under typical mining depths of cover).

While impacts associated with the first of these mechanisms have occurred rarely as a consequence of mining in Utah's Wasatch Plateau coal mining district, impacts occurring from the second potential mechanism are generally not observed in the Wasatch Plateau coal mining district. This is because, as discussed previously, the Blackhawk Formation overburden overlying coal mining areas does not support appreciable downward migration of groundwater due to the lenticular, discontinuous character of permeable units and the abundant presence of interbedded low-permeability shales, claystones, mudstones, and hydrophilic swelling clays in the formation.

This observation has important implications to the proposed mining in the Flat Canyon Tract. This is because, while there is believed to be a reasonable potential that substantial quantities of deep, inactive-zone Star Point Sandstone groundwater may be intercepted during mining operations in the Flat Canyon Tract, it is believed that inactive-zone Star Point Sandstone groundwater systems are likely not in rapid hydraulic communication with overlying shallow groundwater or surface-water systems that support springs and provide baseflow to streams in the Flat Canyon area. Consequently, based on these considerations, it is considered unlikely that the interception of the inactive-zone Star Point Sandstone groundwaters during mining in the Flat Canyon Tract would result in significant diminution of discharge rates from the shallow, active-zone groundwater systems that support springs or baseflow discharge in streams.

This conclusion is supported by an examination of the behavior of shallow, active-zone groundwater systems near the locations of major interceptions of deep, inactive-zone groundwaters in the Star Point Sandstone in the existing Skyline Mine area. It is noted that there is a general similarity of the hydrogeologic conditions present at the southwest portion of the Skyline Mine permit area and the proposed mining areas in the Flat Canyon Tract. The lack of communication between the deep Star Point Sandstone groundwater system and overlying shallow, active-zone groundwaters and surface waters is illustrated by noting that even though a discharge of greater than 5,000 gpm from fractures in the Star Point Sandstone (combined CS-14 mine water discharge and discharge from JC-1) has persisted for fifteen years, there have been no perceptible decreases in flow from nearby springs or surface waters during this time.

It is of particular significance that discharge rates from the stream that flows down James Canyon almost directly over the 10-Left inflow area and JC-1 well area (monitored at site F-10) has not been appreciably impacted during this period of pumping. Similarly, discharge rates at nearby springs 2-413, S34-12, and S35-8 have not been decreased perceptibly as a consequence of the prolonged extraction of deep groundwater from the area. The lack of perceptible or quantifiable impacts to shallow groundwater or surface-water systems in the vicinity of the pumping in the existing Skyline Mine permit area demonstrates the hydraulic disconnect between the shallow and deep groundwater systems in the area. It follows that similar occurrences would be anticipated in the event that the interception of similar amounts of deep, Star Point Groundwater were to occur during mining in the nearby Flat Canyon Lease.

Whether the proposed mining has been designed to prevent impacts to State Appropriated Water Rights and Electric Lake

The proposed mining plan for mining in the Flat Canyon Tract has been designed to mitigate potential impacts to State Appropriated water rights. State appropriated water rights in Electric Lake have been protected by not proposing any mining that could result in subsidence of the lake. Other than a small length of full-support development entries that are proposed near the western high-water shoreline area, no underground coal mining is proposed in any portion of the region defined by the high-water lake shoreline. The implementation of a mining plan that has been designed to prevent subsidence to the lake (which will result in the loss of a substantial amount of otherwise mineable coal reserve) will prevent impacts to State appropriated water rights and Electric Lake.

It was noted during mining operations at the nearby Valley Camp (Belina) Mine, located east of the Flat Canyon Tract, that subsidence-related disturbances (including shallow tension cracks and sink holes) were observed above mining areas under shallow cover. Most of the surface disturbance occurred where the overburden thickness was less than 500 feet (OSM, 1991). In consideration of these factors, to mitigate the potential for impacts to State appropriated water rights, mining under such shallow depths of overburden within the Flat Canyon Tract area has not been proposed. Minimum overburden thicknesses will significantly exceed 500 feet in all proposed mining areas in the Flat Canyon Tract.

Narrative provided in Section 2.5.1 of the Skyline Mine MRP describes CFC's commitments to replacing water that is determined to be impacted due to mining. As specified in R645-301-731.530, the permittee (Canyon Fuel Company, LLC) is required to promptly replace any State-appropriated water supply that is contaminated, diminished or interrupted by underground coal mining and reclamation activities. Thus, in the unanticipated event that State appropriated water rights were to be impacted as a result of proposed mining activities in the Flat Canyon Tract, the replacement of affected water rights would be ensured under Utah Administrative Code, section R645-301-731.530.

Management of potential intercepted groundwater

Section 2.3 of the Skyline Mine MRP describes how mine inflows are both managed and controlled. Monitoring of large inflows will be documented on Plate 2.3.6-3, and the analysis is outlined Table 2.3.7-1.

It is anticipated that the Skyline Mine will manage groundwater intercepted during mining operations in Mine 4 as it has customarily done at the existing Skyline Mine over the past 35 years. Intercepted groundwaters discharged from the mine are quantified and water quality parameters are monitored regularly. The discharge and water quality data are reported regularly to both the Utah Division of Water Quality and the Utah Division of Oil, Gas and Mining. Water quality of mine discharge waters are regulated through enforceable stipulations of the Skyline Mine Utah Pollutant Discharge Elimination System (UPDES) permit administered through the Utah Department of Environmental Quality.

Springs, seeps, streams, and wells were selected for baseline monitoring to characterize seasonal variability in water quantity and water quality in groundwaters and surface waters in the Flat Canyon Tract and adjacent area. The baseline monitoring locations provide spatial coverage over the entire lease and adjacent area. Monitoring locations were included to provide information from each of the major water-bearing geologic formations present at the surface in the area. Baseline monitoring was performed during high flow and low flow conditions in the area over a period of several years. Baseline monitoring was performed during both periods of unusual wetness and also during periods of drought.

The proposed monitoring plan for the Flat Canyon Tract mining area includes springs, streams, and wells. As described in the amendment, there are numerous springs and seeps in the Flat Canyon Tract and adjacent area. Selected springs from within and adjacent to the Flat Canyon Tract have been included in the hydrologic monitoring plan as specified in the amendment. Additionally, because there are numerous springs and seeps in the tract area, monitoring of surface water systems above and below proposed mining areas has been included in the hydrologic monitoring plan. By monitoring surface-water yield from mining areas, which during most of the year is derived primarily from discharge from shallow active-zone groundwater systems, mining-related impacts to water quantity and water quality in these systems may be detected.

There is an abundance of hydrologic monitoring data that is routinely collected from the Electric Lake surface-water system. The two primary inlets to Electric Lake, upper Huntington Creek and Boulger Creek, which comprise the majority of the surface water that flows into the lake, are routinely monitored for water quantity and water quality by Skyline Mine. Discharge and water quality parameters are also routinely monitored on James Creek at monitoring site F-10. James Creek, which flows from the east into Electric Lake below the Huntington Creek and Boulger Creek inflow locations, contributes water to storage in Electric Lake, albeit in lesser quantities than either Huntington Creek or Boulger Creek. Discharge of groundwater from well JC-1, which contributes substantially to the water storage in Electric Lake, is also routinely monitored by Skyline Mine. Monitoring at JC-1 includes daily discharge rate, and quarterly measurements of field water quality parameters, total dissolved solids, total suspended solids, total phosphorous, radiocarbon, tritium, deuterium, and oxygen-18. Field water quality parameters and tritium concentrations are also routinely monitored within the lake itself at EL-1 (upper Electric Lake) and EL-2 (Electric Lake outlet at Electric Lake dam). Additionally, discharge measurements are performed at frequent intervals at automated flow measuring stations operated on both upper Huntington Creek and Boulger Creek. Discharge rates from Electric Lake to lower Huntington Creek are also routinely measured a short distance below the Electric Lake dam. The data collected from the automated flow stations on upper Huntington Creek and Boulger Creek as well as the lake discharge measurements to lower Huntington Creek are available upon request from PacifiCorp and the Huntington Cleveland Irrigation Company.

Collection and analysis of hydrologic monitoring data

In their review, Loughlin opines that the use of Piper (1944) plots would have been preferable to the use of Stiff (1951) diagrams for use in our hydrogeologic analysis. We do not agree with this conclusion. Stiff diagrams were selected for use in the analysis because they are useful to graphically depict (on a map) the spatial distribution of solute geochemical types, reflect the spatial distribution of dissolved solids concentrations, and graphically depict the spatial distribution of seasonal variability in water quality of groundwaters and surface waters from many monitoring stations over the study area. Piper plots, while useful for certain applications, would have been unsuitable for the intended use in our hydrologic analysis.

Loughlin further opines that the results of the field water quality measurements should be calculated in the field, and that water quality monitoring data should be plotted on Piper plots by the mine operator in order to show mixing of waters over time. While the performance of these activities as recommended may or may not be useful, such activities are not required per the Utah coal mining rule as specified in the Utah Administrative Code.

Loughlin also suggests a specific discharge measuring methodology for use in performing the seasonal discharge measurements at streams and springs at the Skyline Mine. Specifically, Loughlin recommends the use of a portable cutthroat flume for performing discharge measurements in conjunction with the hydrologic monitoring plan. While in certain situations, a portable flume may perform well, it should be understood that the magnitudes of seasonal variability in both stream and spring discharge rates are large in the Skyline Mine area. Consequently, varying measurement techniques are often appropriate depending on the prevailing conditions at the individual monitoring sites. Discharge measurements have historically been performed using a variety of appropriate measurement techniques, including the use of flumes, weirs, calibrated containers, and current-velocity meters at the Skyline Mine. Skyline Mine monitoring personnel are competent in the performance of discharge measurements using a variety of industry-standard methods as appropriate for the prevailing conditions. Accurate and reliable discharge measurements will continue to be performed as part of the hydrologic monitoring at the Flat Canyon Tract.

In conjunction with the hydrologic monitoring at the Flat Canyon Tract, Loughlin recommends that CFC add one or more shallow wells that are screened in sandstone or potentially permeable units below the water table in the Blackhawk Formation near springs. The purposes of the well(s) would be to evaluate changes to water levels in the Blackhawk Formation near the springs, to assess the effects of dewatering No. 4 Mine, and to assess the effects of subsidence in the Blackhawk. As noted previously, the Blackhawk Formation does not act as a continuous aquifer in the area. Rather, groundwater in the formation typically exists as discontinuous partitions of permeable strata that are not in good hydraulic communication with surrounding partitions. Accordingly, it is our opinion that the construction and monitoring of such wells in the discontinuous Blackhawk Formation would not provide appreciable additional data beyond that which could be obtained by simply monitoring the discharge rates and water quality parameters of springs discharging directly from the Blackhawk Formation.

However, a total of six (6) shallow wells or piezometers will be installed in Boulger Canyon to monitor near-surface groundwater.

Numerical Groundwater Model

An update to the numerical groundwater model of the Skyline Mine area was performed during 2016 by SRK Consulting in conjunction with permitting activities for the Flat Canyon Tract. As part of the update, the most recent hydrologic data from the region was incorporated into the model.

As reflected in Loughlin's analysis of the SRK updated model, the hydrogeology of the proposed Flat Canyon Mine area is structurally and stratigraphically complex. Groundwater flow in the Star Point Sandstone is controlled largely by the presence of fractures and faults in the formation, with groundwater migration through the intergranular spaces in the sandstone occurring at a much lower rate. The fault and fracture densities, orientations, and water transmitting properties are not uniform within the formation. In the experience of mining at the Skyline Mine, it has been observed that while some faults and fractures intercepted by the mine workings convey appreciable amounts of groundwater, other similar faults and fractures intercepted underground do not. Additionally, individual geologic strata (in the Star Point Sandstone and overlying Blackhawk Formation) are often laterally and vertically discontinuous and lenticular permeable strata are commonly encased in surrounding lower permeability zones which creates complex groundwater flow patterns. The presence of the generally low-permeability Blackhawk Formation bedrock overlying the Star Point Sandstone generally isolates the deep groundwater system from the overlying shallow groundwater and surface-water systems. It should be noted that, historically, in locations where sustained Star Point Sandstone groundwater inflows have been encountered in the Skyline Mine, these inflow locations have almost always been associated with upwelling from the mine floor rather than leakage from the mine roof. Based on these considerations, it is apparent that the construction of a numerical model of the groundwater flow regime in such an environment is complicated. Additionally, as is the case with any numerical flow model, the model output is dependent on the many assumptions employed in the model construction. The data necessary to fully validate these assumptions in the Skyline Mine area are limited. It is important to consider these limitations when evaluating the results of any numerical model from the Skyline Mine area.

When the Skyline Mine numerical model was initially constructed in 2003, the model demonstrated that it was possible to account for the quantity of groundwater extracted from the Skyline Mine in full (including JC-1 discharge) and also to account for the observed potentiometric response of the Star Point Sandstone and shallow Blackhawk Formation groundwater systems exclusively by the extraction of old groundwater from storage in the deep Star Point Sandstone members below the mine. When the model was updated in 2016 to include recently collected data (including water level “recovery” data subsequent to the mine flooding events and decreased mine water discharge rates), it was found that acceptable calibration (during both drawdown and recovery) was achieved when an additional shallow recharge source was added to the model simulation. The postulated shallow nature of the additional recharge source was consistent with the presence of a modern water component identified in JC-1 (and possibly to a lesser extent in the 10-Left inflow area – which was found to contain some tritium in 2002 when the area was accessible). To evaluate possible source(s) of the additional shallow recharge component, two different model simulation runs were performed using the existing model framework. It should be noted that the two scenarios modeled here represent only two possible sources, and are not the only potential sources for the shallow recharge component. To model the shallow recharge component the modeling simulations evaluated two conceptual scenarios. These included 1) modeling the shallow recharge component as recharging through the South Gooseberry Fault zone from a shallow groundwater system, and 2 – modeling the shallow recharge component as recharging from Electric Lake through a splay of the Diagonal Fault. Note that both of the above scenarios also incorporate recharge from storage in the deep Star Point Sandstone groundwater system.

The results of the modeling simulations indicated that the model can be calibrated to Scenario 1 or Scenario 2 *equally well* (SRK, 2016). SRK noted that the source of the shallow recharge component and its mechanism are not clear. It should be emphasized that the modeled solutions for these two scenarios are not unique. Rather, these modeled scenarios reflect two possible sources of the modern recharge component that generally satisfy the mathematical constraints of the calibrated numerical groundwater model.

Loughlin indicates that SRK did not model or address impacts associated with mining in the Flat Canyon Lease. It is correct that the updated model did not address that issue. This was because it was understood that as a result of the complexity of the hydrogeologic system in the Flat Canyon Lease and the limited amount of detailed information from the Flat Canyon Lease area, it was not possible to produce reliable and verifiable projections of impacts. Most significantly, it was acknowledged that there was a lack of specific hydrologic information relating to the heterogeneity and water transmitting properties of individual fault segments in proposed mining areas. It was also understood that such information was fundamental to the performance of the impact simulations for the Flat Canyon Tract. In the absence of such data, it was acknowledged that accurate and verifiable predictions could not be performed and thus those modeling simulations were not performed (in other words, the output from the modeling runs would be essentially only as accurate as was the information entered into the numerical model regarding to the hydrologic properties of the individual fault segments.)

Loughlin also suggests that SRK may have incorrectly characterized the monitored formations for the monitoring wells from which data were incorporated into their model. However, based on the information discussed previously in this report, we suspect that Loughlin may have been in error regarding their assumptions of monitored intervals in the monitoring wells. We suspect that SRK has correctly interpreted the information from the monitoring wells.

Loughlin further suggests that the SRK model is not robust because different combinations of assumptions and parameters could be devised to obtain a calibrated model. We suspect that this would be the case, to one degree or another, with any attempt to create a numerical model of the Flat Canyon Lease area because of the limited data available and the very complex hydrogeology of the modeled domain.

Loughlin notes that the source of the shallow recharge incorporated into the updated numerical model is not identified in the model simulation. As indicated, the numerical model calibrated equally well using either Scenario1 or Scenario 2 described above. The model demonstrated, using the available hydrologic data, that the numerical constraints of the calibrated model could be satisfied by incorporating either of the two shallow simulated recharge scenarios, but the specific source of the shallow recharge was not intended to be determined by the model.

4.0 MRP Review Comments

Hydrology and Assessment of Potential Impacts

Loughlin states their belief that groundwater removed from the mine will be replaced in time by water recharging from the surface, and that there will be very small impact to the surface directly above the mine, apparently as a result of downward migration through the bedrock formation overlying the mine workings, while granting that impacts to the surface may not always be obvious. It is our opinion that downward vertical migration of groundwater through the low-permeability Blackhawk Formation bedrock overlying mining areas probably does not occur at any appreciable rates. We suggest that groundwater recharge to the Star Point Sandstone most likely occurs as groundwater flows from bedrock outcrop recharge areas horizontally through permeable members of the formation along groundwater flow paths. As indicated by Mayo and Associates, (1996), stable isotopic deuterium and oxygen-18 compositions and unstable tritium and radiocarbon data suggest that recharge to the deep inactive-zone groundwater systems likely occurred thousands of years ago under wetter, cooler climatic conditions. Under the current dryer climatic conditions, it is unknown how long it will take for the deep, inactive-zone groundwater to recharge after the completion of mining in the region.

As indicated previously in this document, it is our suspicion that Loughlin has incorrectly evaluated the monitored intervals in the monitoring wells in the Skyline Mine area. Accordingly, it is our belief that their statements suggesting that groundwater systems in the highly partitioned Blackhawk Formation groundwater systems rapidly respond to the interception and pumping of groundwater from the Star Point Sandstone are incorrect. For similar reasons, as stated above, it is our opinion that Loughlin's determination of a southerly groundwater gradient and groundwater flow direction is incorrect. It is our opinion that the northerly hydraulic gradient and northerly groundwater flow directions determined by SRK during the performance of their numerical modeling activities is most likely correct.

Water Rights

Information on water rights in the existing Skyline Mine and the Flat Canyon Tract are presented in the current Skyline Mine MRP and are specifically addressed in Section 2.5.1 of MRP. Plates 2.3.5.2-1 and 2.3.5.2-2 provide the surface water and groundwater rights in the area, respectively. The status of the water rights may have changed since the plates were created in 2002. Copies of the water rights are provided in Water Rights Appendix Volumes 1 and 2.

To date, there have been no observed impacts to water rights in the Star Point Sandstone in the Skyline Mine area. Additionally, no quantifiable impacts to water quantity or water quality at water monitoring sites in the vicinity of the Flat Canyon Tract have been observed.

It should be noted that there are no water rights associated with the Star Point Sandstone in the Flat Canyon area.

Potential impacts to water rights are addressed in the Skyline Mine MRP in Sections 2.3.5.1, 2.5.1, and 2.5.2. Additional narrative specific to the Mine #4 – Flat Canyon lease area is included in all said sections. A specific commitment to address options for designs is located in Section 2.5.1.

No finding of trans-basin diversion of groundwater has been confirmed. The current potentiometric information for the Star Point Sandstone suggests the hydrologic gradient is to the north in the region.

A thorough explanation of why the water bodies will not be impacted by the proposed mining operations is provided in Sections 2.3, 2.4, and 2.5 of the MRP and Appendix N (Petersen Hydrologic 2017 report).

A discussion of possible contingency plans to mitigate potential impacts to water rights is not a requirement of the State mining rules. However a commitment to water replacement and possible alternatives measures are mentioned in Section 2.5.2 of the Skyline Mine MRP.

Monitoring Plan

Surface- and ground-water monitoring plans specific to the Mine #4 Flat Canyon lease area are addressed in Sections 2.3 and 2.4 of the MRP.

Section 2.3 of the Skyline Mine MRP describes how mine inflows are both managed and controlled. Monitoring of large inflows will be documented on Plate 2.3.6-3, and the analysis is outlined Table 2.3.7-1.

The amendment proposes to add operational laboratory chemical analysis to the monitoring parameters at JC-1. Mine inflows in Mine #4 will be analyzed with Operational laboratory chemical analysis and tritium testing when the sampling threshold is met.

Section 2.3.7, subsection "Use of the Groundwater and Surface-Water Monitoring Plans" provides a narrative on how the water monitoring data should be used.

The rationale for spring monitoring at the Flat Canyon tract is outlined in Section 2.3.7 subsection Mine #4 Flat Canyon Area Monitoring. The springs adequately monitor the area per discussions and review with the regulating agency. Information collected from wells that are no longer functioning provides valuable historic information. The regulating agency believes the five (5) functioning wells in the vicinity of the Flat Canyon Tract adequately monitor the area.

Conclusions and Recommendations

The Skyline Mine MRP and the Flat Canyon Tract amendment currently address water management, control, and discharge of water. As indicated in the previous section, the plan for monitoring mine flows has been provided.

Loughlin indicates that CFC predicts subsidence of the ground surface (up to 0.5 feet), but that potential impacts to surface or near-surface groundwater would be short-lived as streams would fill the ground surface with sediment. The Petersen Hydrologic (2017) report has been updated to clarify that potential subsidence fracturing generally occurs along ridges and side hills, not in stream bottoms. Subsidence fractures with open apertures in the bottom of stream channels only rarely occur.

Information on measures designed to prevent impacts to water rights and to prevent impacts to Electric Lake and Boulger Reservoir has been provided.

Consistent site names and designations currently exist in Section 2.3.7 of the Skyline Mine MRP. Other site designations used for the same monitoring locations from previous documents currently exists in Section 2.3.7 of the MRP. In accordance with UAC R645-301-722.300, sites are clearly identified on Plate 2.3.6-1. Location common names (such as lower Boulger Creek) are clearly identified on Plate 2.3.6-1. Monitoring parameter information (such as stream flow rate) currently exists in Section 2.3.7 of the MRP. Monitoring frequency and schedule currently exists in Table 2.3.7-1 of the MRP. Monitoring site locations are documented with GPS, site photo, and location maps that are located at the Skyline Mine site. A summary of monitoring-well construction information in accordance with UAC R645-301-722.400 currently exists in the MRP as Table 2.3.7-4. Monitoring Tables 2.3.7-1 have been updated. Monitoring of groundwater inflows is adequately addressed in Section 2.3 of the MRP.

It was recommended that a water level transducer be installed in well JC-1. However, it was determined that a transducer in JC-1 well would not provide reliable data due to turbulence caused by the pump in the well. Water level data from the adjacent JC-2 well will be provided.

CFC will consider implementing the recommended monitoring practices as recommended by Loughlin where appropriate and where such practices may be required under the Utah coal mining regulations.

5.0 REFERENCES CITED

Fontes, J. Ch., and Garnier, J.M., 1979, Determination of the initial ^{14}C activity of the total dissolved carbon: a review of existing models and a new approach: Water Resources Research, v. 15, p. 399-413.

Mayo and Associates, 1996, Investigation of surface and groundwater systems in the vicinity of the Skyline Mines, Carbon, Emery, and Sanpete Counties, Utah: probable hydrologic consequences of coal mining at the Skyline Mines and recommendations for surface and groundwater monitoring, unpublished consulting report, Canyon Fuel Company, LLC.

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

OSM, 1991, Potential Subsidence Impacts – Belina Mine, Valley Camp of Utah, Act/007/001, Carbon County, Utah, Memorandum from Alan Wilhelm to Donna Griffin, Natural Resources Specialists, Albuquerque Field Office, on file with the Utah Division of Oil, Gas and Mining.

Pearson, F.J., Jr., Bedinger, M.S., and Jones, B.F., 1972, Carbon-14 dates of water from Arkansas Hot springs, *in* proceeding of eighth international conference on radiocarbon dating; Wellington, Royal Society of New Zealand, v. 1 p. 330-247.

Petersen Hydrologic, 2016, Addendum to: Investigation of fault-related groundwater inflows at the Skyline Mine, 27 October 2002, Unpublished consulting report prepared for Dorsey & Whitney LLP, Salt Lake City, Utah.

Petersen Hydrologic, 2017, Investigation of groundwater and surface-water systems in the Flat Canyon Tract and adjacent area; Probable hydrologic consequences of coal mining in the Flat Canyon Tract, Sanpete County, Utah, Unpublished consulting report for Canyon Fuel Company, LLC, Helper, Utah.

Piper, A.M., 1944, A graphic procedure in the geochemical interpretation of water analyses: Trans. Am. Geophys. Union, v. 25, p. 914-928.

Stiff, A.H., Jr., 1951, The interpretation of chemical water analyses by means of patterns: Journal of Petroleum Techniques, Technical Note 84, p. 15-17.

Utah Division of Oil, Gas and Mining, 2017, Utah Coal Mining Water Quality Database, available on-line at: http://linux3.ogm.utah.gov/WebStuff/wwwroot/wqdb.html

Please feel free to contact me should you have any questions in this regard.

Sincerely,

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