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WATER SUPPLY EVALUATION
PIÑON RIDGE PROJECT
MONTROSE COUNTY, COLORADO

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EXECUTIVE SUMMARY

Energy Fuels Resources Corporation (EFRC) is in the process of designing for a new uranium mill, termed the Piñon Ridge Project (the Site), located in Montrose County, Colorado. Golder Associates Inc. (Golder) was contracted to provide groundwater characterization and groundwater supply work for the Site. This report presents a compilation of that effort.

The Site is located in the eastern portion of the Paradox Valley, in the Dolores River basin. The Site is positioned south of the valley axis, bordering on the northeast foothill of Davis Mesa. To the north, the Site extends to approximately the center line of the valley. The drainage from the site trends northwest toward the Dolores River, which is located 7 miles northwest of the Site. The San Miguel River, located 6 miles northeast of the Site, is in a separate basin and does not receive drainage from the Site. The location of the project area with respect to the drainages and other salient geographical features are shown on Figure 2.1. The Site is remote with no significant industrial development, agricultural activities, or urban development. Therefore, existing information about groundwater resources within the eastern Paradox Valley is very scarce.

Therefore, an extensive on-site investigation was undertaken to identify potential groundwater sources within the Site. The investigation was conducted in three phases in 2008. Initial efforts, termed as Phase 1 and Phase 2, entailed drilling a series of groundwater exploratory holes (EX-series). During these two initial phases, 18 exploratory borings were drilled.

The drilling program found that the Chinle and Moenkopi formations in the southern portion of the Site are the only groundwater bearing strata identified within the vicinity of the Site. Davis Mesa, owing to its elevation, relief, and deeply incised arroyos, likely recharges the aquifer locally.

Fourteen of the exploratory borings encountered water in the Chinle and Moenkopi formations and were tested to assess potential productivity and estimate aquifer properties. The testing confirmed the presence of an aquifer 40 to 80 feet thick of moderate hydraulic conductivity (on an order of magnitude of 10^{-3} centimeters per second [cm/sec]) and of moderate water productivity (of up to several tens of gallons per minute [gpm]).

The Navajo Sandstone and Kayenta formations, known to host productive aquifers in the region, were found to be absent at the Site and water was not encountered in the alluvium on the valley floor.

Groundwater is present at the toe of Davis Mesa, but is absent in areas closer to the center of Paradox Valley (i.e., beneath the proposed mill facilities) due to the presence of a salt and gypsum dome. The sedimentary formations bearing groundwater have been significantly influenced by the dome's uplift, collapse due to subsequent dissolution of the underlying evaporites, and erosion of the sedimentary rock, characteristic of the entire Paradox Basin. The uplift of the dome resulted in extensive northwest trending faults which parallel the axis of the valley and have been documented within the project Site. The faults influence aquifer behavior as indicated by measured differences in water levels across the fault traces and measured aquifer responses to hydraulic testing.

Based on the findings from exploratory drilling, three exploratory holes EX-6, EX-8, and EX-12 were selected as the most favorable for groundwater production. In August 2008, Golder conducted the Phase 3 program, which consisted of three 48-hour constant-rate pumping tests on water supply wells constructed in these areas (PW-1, PW-2, and PW-3).

Following pumping tests, Golder developed a conceptual hydrogeologic model of the Site using all of the Site-specific data that had been collected. AQUATESOLV software was used to analyze the pumping test data. The conceptual model and data analysis model allowed Golder to estimate the potential for groundwater supply for the Piñon Ridge Project from the groundwater bearing formations. A detailed description of the model is set forth in Section 4.1 of the Report.

The complexity of the aquifer and the lack of historic data addressing hydrogeology in the area of the Site warrant the necessity to consider a range of possible groundwater supply. The primary variable in assessing the estimated groundwater supply is the extent of the aquifer identified by the field investigations. Accordingly, the conceptual model provides for two scenarios regarding aquifer boundaries:

- *Scenario 1*. Aquifer is bounded on one side to the northeast by the salt dome and extends below Davis Mesa to the southwest; and
- *Scenario 2*. Aquifer is bounded on two sides: to the northeast by the salt dome uplift; and to the southwest immediately south of the faults represented as a no-flow boundary along the edge of the mesa. Under this scenario, the aquifer is assumed to be a strip 4,500 feet wide.

If the aquifer is bounded on one side only (Scenario 1), the sustainable water supply may reach 135 gpm from aquifer storage and up to 40 gpm may be obtained from aquifer recharge. Hence, the rate of groundwater supply for the project may reach a rate of up to 175 gpm.

While there is no evidence of limits to the southwest which would bound the extent of the aquifer under Davis Mesa, a conservative estimate of potential groundwater supply would assume such a limit. Therefore, if the aquifer is bounded on two sides (Scenario 2), the sustainable water production from aquifer storage only is estimated at 64 gpm. As with Scenario 1, up to 40 gpm may be obtained from aquifer recharge. Hence the rate of groundwater supply for the project under this more conservative estimate may reach a rate of up to 104 gpm.

As noted, these predictions are based on the best available hydrogeologic conceptual model developed from the available site data. The productivity of the aquifer will be highly sensitive to the presence/absence of features such as faults and other boundaries, lithology, recharge and placement of wells. Accordingly, the actual pumping rates and long-term sustainability will need to be confirmed by future observation and interpretation of aquifer response to pumping.

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1.0 INTRODUCTION

Energy Fuels Resources Corporation (EFRC) is in the process of designing for a new uranium mill, termed the Piñon Ridge Project (the Site), located in Montrose County, Colorado. Golder Associates Inc. (Golder) was contracted to provide groundwater characterization and groundwater supply work for the Site. This report presents a compilation of that effort.

In an effort to locate potential groundwater sources within the Site, a three-phase hydrogeologic program was initiated, which allowed the investigation to evolve dynamically, as the results of earlier testing were used to guide more in-depth testing and analysis. Initial programs, termed as Phase 1 and Phase 2, were commenced by EFRC in the spring of 2008 and entailed drilling a series of groundwater exploratory holes (EX-series). During these two initial phases, 18 exploratory borings were drilled. Fourteen of these borings encountered water and were tested to assess potential productivity and to estimate aquifer properties.

Of the borings tested during the Phase 1 and Phase 2 programs, conditions at three exploratory holes (EX-6, EX-8, and EX-12) were identified as having the most favorable groundwater production potential. In May and June of 2008, 6-inch diameter production wells were installed at these locations. In addition to production wells, two observation wells were installed near each of the production wells to observe aquifer response to pumping and aid in additional aquifer characterization at these locations. In August 2008, Golder conducted three 48-hour constant-rate pumping tests on the new water supply wells PW-1, PW-2, and PW-3, which comprised the Phase 3 program. Figure 1.1 presents the locations of the exploratory holes, production wells, and nearby observation and monitoring wells.

Following the three phases of hydrogeologic field tests, Golder assessed the potential for groundwater development for the Piñon Ridge Project using predictive analyses. The primary objective of the predictive modeling presented in this report is to estimate long-term rates of sustainable groundwater pumping, based on the best available hydrogeologic conceptual model, various assumptions about aquifer boundaries and recharge, and standard computational methods.

2.0 HYDROGEOLOGIC SETTING

The Pinon Ridge Project site (the Site) is located in the eastern portion of the Paradox Valley, in the Dolores River basin. The Site is positioned south of the valley axis, bordering on the northeast foothill of Davis Mesa. To the north, the Site extends to approximately the center line of the valley. The drainage from the site trends northwest toward the Dolores River, which is located 7 miles northwest of the Site. The San Miguel River, located 6 miles northeast of the Site, is in a separate basin and does not receive drainage from the Site. The location of the project area with respect to the drainages and other salient geographical features is shown on Figure 2.1.

2.1 Hydrostratigraphy

Alluvial soils are present over the vast majority of the valley. Alluvium also covers most of the entire project Site. Extensive deposits of alluvial soils were originally wind-deposited, and were locally reworked by water and intermixed with sheet wash. Alluvial deposits within the Site range in thickness from 0 feet at the Hermosa outcrops within the north end of the site, to greater than 100 feet at the south end of the site. No groundwater was encountered in the alluvium, although the surface soil likely transfers recharge of meteoric water into the underlying Mesozoic rocks.

The southern flank of the valley is underlain by Upper Triassic sediments of the Chinle formation, which is underlain by the Moenkopi formation of Lower Triassic age. These two Mesozoic formations are truncated toward the center of the valley by the uplifted Pennsylvanian-age evaporites of the Paradox member of the Hermosa Group. These Paleozoic evaporites crop out along the center of the valley, north of the site (Figure 2.2). The geologic cross-sections transecting Paradox Valley north and south of the project Site are shown on Figure 2.3.

The Chinle and Moenkopi formations are the only groundwater-bearing strata identified within the vicinity of the Site. The Navajo Sandstone and Kayenta formations, known to host productive aquifers in the region, are absent at the Site (Figure 2.2). These strata were uplifted by the northwest trending salt dome and eroded. Outcrops of the Navajo Sandstone and Kayenta formations are documented along the flanks of the mesas bordering the Paradox Valley, miles away from the Site. Since these formations are found at the surface, they are not expected to contain groundwater at the location of the outcrops. For this reason, the investigation of groundwater presence and availability addressed in this report has concentrated on the Chinle and Moenkopi formations.

The Chinle formation within the Paradox Valley is composed of reddish or orange siltstone with layers of sandstone and limestone pebbles. In places, the lower section of the Chinle formation contains quartz conglomerates, which are of interest hydrologically. The Moenkopi formation has characteristics similar to the overlying Chinle formation. The Moenkopi formation contains arkosic beds that may contain and conduct water.

The beds comprising both the Chinle and Moenkopi formations are lenticular and discontinuous. Neither of these formations contains contiguous sand or sandstone layers that could host and deliver significant quantities of groundwater.

2.2 Documentation of Groundwater

The presence of groundwater in Mesozoic strata within and in close proximity to the Site is documented by:

- Fourteen EX-series exploratory borings (i.e., EX-5 through 15 and EX-20 through 22);
- Five previously-installed monitoring wells (i.e., MW-5 through 9);
- Three pumping wells (PW series); and
- Six observation wells drilled in the vicinity of the pumping wells.

Details regarding these 28 borings and wells are summarized in Table 2.1. All groundwater occurrences were documented in the southern portion of the Site. No groundwater has been encountered in the northern portion of the Site in:

- Four dry monitoring wells (i.e., MW-1 through 4); and
- Four EX-series exploratory borings (i.e., EX-2 through 4 and EX-23).

The locations of all wells advanced for groundwater exploration/characterization are shown on Figure 1.1.

2.3 Groundwater Levels, Recharge and Discharge

The groundwater within the project Site and its surrounding areas is present only on the southern side of Paradox Valley, along the flanks of Davis Mesa. Recent investigations did not encounter groundwater close to the center of the Site and to the north. The approximate northern extent of the aquifer at the Site is shown on Figure 1.1.

The water levels in the Chinle/Moenkopi aquifer vary with their proximity to the mesa and their location with respect to documented faults. In the southernmost part of the site, close to the buttress of the mesa, the water levels are approximately 5,355 feet (i.e., EX-9, EX-10, and EX-11). Groundwater elevations further north of the edge of the mesa are approximately 5,280 feet (i.e., EX-5, EX-6, EX-7, and EX-8). Groundwater levels continue to decline further to the north, with an elevation of approximately 5,147 feet in wells MW-6 and MW-8. The summary of water levels is given in Table 2.1 and illustrated on Figures 2.4 and 2.5.

2.3.1 Groundwater Recharge

Recharge occurs as infiltration of direct precipitation and snowmelt as a localized infiltration from runoff. Davis Mesa is steeply sloped and incised by arroyos which may contribute to focused recharge to the aquifer at the Site. In the Dolores River basin, the greatest recharge reportedly occurs along ephemeral channels, where deep infiltration is most likely (Weir 1983). The northern face of the mesa is heavily faulted, as shown on Figures 2.2 and 2.3. This faulting and associated fracturing likely promotes recharge in this area.

Higher precipitation on the mesa contributes to higher potential recharge with elevation. The relationship between elevation and precipitation is illustrated on Figure 2.6 (Weir 1983). In the Dolores River basin, the relationship between elevation and annual precipitation indicates precipitation at an elevation of about 6,500 feet above mean sea level (amsl) (i.e., corresponding to the top of the mesa) may reach 14.7 inches (360 mm) per annum. This is about 17 percent higher than the 12.6 inches of precipitation estimated for the project area at an elevation of 5,480 feet amsl. Consequently, the rate of groundwater recharge from precipitation may be higher over the mesa than in the valley.

Recharge along the mesa is supported by the lower concentrations of total dissolved solids (TDS) in groundwater from wells closer to the mesa compared to those near the valley center. Figure 2.7 presents a graph of the measured TDS concentrations in the monitoring wells within the Site. Groundwater near to the mesa is relatively low in TDS concentrations, suggesting recent recharge. Groundwater more distant from the mesa becomes progressively higher in TDS concentration as it flows further from the point of recharge.

2.3.2 Groundwater Discharge

The regional topography of the eastern Paradox Valley slopes toward the Dolores River, and it is reasonable to assume that the groundwater flow pattern mimics the terrain. With this assumption, groundwater outflow from the project area is most likely toward the Dolores River to the northwest. Locally, groundwater flow is likely controlled by fault orientation and connectivity. It is also reasonable to assume that flow occurs along the fault structures which also trend to the northwest.

Groundwater flow toward the Dolores River can also be inferred from observation of groundwater levels in wells installed in the southeastern and northwestern extremities of the study area. The elevation of groundwater in exploratory boring EX-15 installed 3.6 miles southeast of the project Site is at an elevation of 5,500 feet amsl, whereas the elevation of groundwater in boring EX-14 installed 2.3 miles northwest of the Site (toward the Dolores River) is at approximately 5,143 feet amsl (see Figure 1.1 for boring locations). The difference in these groundwater elevations (i.e., about 350 feet over a distance of 5.9 miles) translates to approximately a one percent (1%) groundwater gradient toward the northwest.

3.0 SUMMARY OF HYDROGEOLOGICAL INVESTIGATIONS

Existing information about groundwater resources within the eastern Paradox Valley is limited. Regional hydrogeologic studies have addressed groundwater in a very broad manner (Cater 1954, 1955; Weir 1983). However, no industrial, agricultural, or urban development has occurred or been proposed for this location. In effect, no studies of groundwater supply have been undertaken. This study attempts to quantify the groundwater supply within and in proximity to the Piñon Ridge project area, based upon the recent hydrogeologic investigation conducted at the Site.

In 2008, a field hydrogeologic program was conducted in three phases. After each field program phase, data was analyzed and interpretation of the findings was made. Each phase is described in the following sections.

3.1 Phase 1 Program

The Phase 1 groundwater investigation included drilling of six exploratory holes (EX-2 to EX-7) during April 2008. Of these holes, only three encountered groundwater (EX-5, EX-6 and EX-7). Location of these holes is shown on Figure 1.1. Hydrogeologic testing was performed in the three exploratory boreholes where groundwater was encountered and in previously installed groundwater monitoring well MW-6. Aquifer properties and potential productivity were estimated by analysis of the short-term, variable-rate (step-down) pumping tests.

A brief summary of the results of the Phase 1 program is supplied in Table 3.1. For details of the Phase 1 Program, refer to the following report: *Preliminary Water Supply Evaluation, Piñon Ridge Project, Montrose County, Colorado* (Golder 2008a).

3.2 Phase 2 Program

Following the Phase 1 investigation, eight (8) additional exploratory holes were drilled (EX-8 through EX-15) in May of 2008. Locations of these holes are shown on Figure 1.1. Each of the holes encountered water at or near the contact between the Chinle and Moenkopi formations. During drilling, water production estimated by air-lifting in wells EX-9, EX-13, and EX-14 was below 5 gpm, and therefore considered too low for further testing. Short-term constant-rate pumping tests were performed in EX-8, EX-10, EX-11, EX-12, and EX-15.

In an effort to delineate the northern extent of the aquifer at the Site, boreholes EX-20, EX-21, EX-22, and EX-23 were drilled (Figure 1.1). Water was encountered in EX-20, EX-21, and EX-22. EX-23 was dry, suggesting that the aquifer at the site does not extend to this location.

A brief summary of the results of the Phase 2 program is provided in Table 3.2. For details of the Phase 2 Program, refer to the following report: *Preliminary Water Supply Evaluation, Phase 2 Results, Piñon Ridge Project, Montrose County, Colorado* (Golder 2008b).

3.3 Phase 3 Program

Of the eight exploratory holes tested during the Phase 1 and Phase 2 programs, locations proximal to exploratory holes EX-6, EX-8, and EX-12 were selected as having the most favorable groundwater production potential and were considered for long-term pumping tests. In May and June of 2008, two observation wells were installed near each of the three selected exploration boreholes to observe aquifer response to pumping and aid in additional aquifer characterization at these locations. In July 2008, production wells were drilled near each of the selected exploration boreholes by Gordon Smith Drilling Company (i.e., PW-1 near EX-6, PW-2 near EX-8, and PW-3 near EX-12). Locations of the PW-series wells are shown on Figure 1.1.

Long-term (48-hour) pumping tests, followed by recovery observations, were conducted in all PW-series wells in order to estimate aquifer parameters, estimate the long-term water production potential, and characterize the hydrogeologic regime within and near the Site.

AQTESOLV software (Duffield 2007) was used to analyze the test data. To estimate saturated hydraulic conductivities, results from the pumping tests were analyzed using both the Theis equation (Theis 1935) and the Cooper-Jacob method (Cooper & Jacob 1946). No attempt was made to fit double porosity models or bounded solutions to the responses.

A brief summary of the results of the Phase 3 program is provided in Table 3.3. For details of the Phase 3 Program, refer to the following report: *Phase 3 Long-Term Pumping Test Data Report, Piñon Ridge Project, Montrose County, Colorado* (Golder 2008c).

4.0 AQUIFER CHARACTERIZATION

The characterization of hydrogeology within the Site and its vicinity is based on a review of available literature as well as data collected at the Site. Although no site-specific information is available, the published sources support the aquifer characterization. These sources are cited in the list of references at the end of this report. Field investigations conducted at the Site as part of the groundwater characterization studies included:

- Drilling and short-term testing of 25 borings and wells. Short-term testing yielded data on the presence and extent of the aquifer and provided tentative information on aquifer productivity;
- Shallow seismic survey (Geological Associates 2007). The survey yielded information on possible positions of faults, and lithological and structural contacts;
- Long-term (48-hour) aquifer pumping tests in three designated wells. The pumping tests provided data on hydrodynamic properties of the aquifer, groundwater recharge, and subterranean features such as faults and other discontinuities, and their influence on aquifer productivity; and
- Qualitative observations of the hydro-morphology of the Site and its surroundings. The observations cast light on features that could enhance or impede aquifer recharge from precipitation/runoff.

4.1 Hydrogeologic Conceptual Model

While groundwater occurs and can be developed from the conglomerates, sandstone and pebble layers of the Chinle/Moenkopi aquifer, the dominant sources of groundwater are most likely the fractures associated with the faults and their interaction with the formation matrix. There is little evidence to suggest that the faults act as barriers to flow. Rather, the faults and the associated fracture systems likely act as conduits for flow with some finite storage capacity. This is supported by the following lines of reasoning:

1. There is extensive known faulting in the area which parallels the general direction of groundwater flow to the northwest.
2. There is no known post-faulting mineralization or evidence of extensive fault gouge;

3. The hydraulic testing demonstrates relatively high hydraulic conductivity averaging 2 x 10^{-3} cm/s, significantly higher than what might be expected for intact, fine-grained sedimentary rocks; and

4. The hydraulic testing indicates a relatively low storativity. Together with the relatively high hydraulic conductivity, this is indicative of an aquifer comprised of fracture systems. An intact, unfractured siltstone would be expected to exhibit a low hydraulic conductivity with high storativity (Davis and DeWiest 1966).

As will be described, the distribution of estimated hydraulic conductivity from the testing is narrow, with a standard deviation of 0.59 log units, discounting the test results from MW-9 where hydraulic conductivity below 10^{-7} cm/s was measured. This uniformity suggests extensive fracturing which is typically associated with faulting.

The fracture systems are likely fed largely by recharge to the faults along the front of the mesa. When stressed by pumping, the faults and fracture systems will depressurize quickly and draw water from the rock matrix. Thus, in the short term, the aquifer behaves as a fracture controlled system under stress. In the long term, the aquifer will likely behave as a true double porosity system with fractures interacting with the rock matrix. As such, the 48-hour testing likely would not represent the long-term response for this conceptual model.

The aerial extent of the aquifer and boundary conditions are important factors affecting long-term groundwater production. The aerial extent of the aquifer is not well understood. However, it is documented to be limited by the Hermosa formation to the northeast, toward the center of Paradox Valley, based on the drilling results. Groundwater exists within the aquifer to the southeast within the zone of faulting shown on Figures 2.2, 2.3, and 4.1. Faulting is not shown to extend south of the mesa crest. The southern boundary of the aquifer therefore is not known. If the aquifer is limited to the southeast to the known extent of the faulting, then the southeastern boundary may be represented, under the worst case condition, as a *low-flow* boundary where the matrix feeds the fracture system upon depressurization. Accordingly, the conceptual model provides for two scenarios regarding aquifer boundaries: (1) the first scenario recognizes that the aquifer is bounded by the salt uplift to the northeast as a *no-flow* boundary, but the aquifer extends beneath Davis Mesa to the southwest, and (2) the second scenario assumes conservatively a second *no-flow* boundary south of the mapped fault traces.

The conceptual hydrogeologic model of the Site also includes empirical differentiation of aquifer properties within the fracture system. In the south central part of the Site, the aquifer behaves as confined, with moderate hydraulic permeability and low storativity. In the southwestern portion of the Site, the aquifer behaves as an unconfined system with moderate permeability and higher storage.

The basis for this conceptual hydrogeologic model is provided in the following sections.

4.2 Geologic Structure of the Aquifer

The aquifer within and in proximity to the Site is in sedimentary rocks of the Chinle and Moenkopi formations, the presence of which has been documented in the southern flank of the Paradox Valley (Figures 2.2 and 2.3). These sedimentary formations have been significantly influenced by uplift associated with salt anticline formation, collapse due to subsequent dissolution of the evaporites, and erosion of the sedimentary rock, characteristic of the entire Paradox Basin.

The geological structure that dominates the Paradox Valley is a northwest trending salt anticline (Figure 2.2) of the Hermosa formation. The uplifted evaporites truncate the sediments of the Chinle and Moenkopi formations, terminating the aquifer in approximately the center of the Site. The estimated northern extent of the aquifer is shown on Figure 1.1.

The uplift of the anticline resulted in extensive northwest trending faulting paralleling the axis of the valley (Cater 1954, 1955). Most of the blocks formed by faulting are downthrown toward the valley. Some of the blocks form small horst and graben structures. Figures 2.2 and 2.3 present regional faults southwest of the Site along the mesa. Figure 4.1 presents traces of local faults within the Site as determined from geophysical surveys and lithologic profiles of wells.

Geophysical cross sections at the Site reveal a series of faults oriented southeast-northwest, approximately parallel to the mesa which forms the southwestern boundary of Paradox Valley (Figures 2.4, 2.5, and 4.1). The prevailing width of the fault blocks identified in the geophysical survey approximates 800 feet. Cross sections C-C’ and D-D’ (Figures 2.4 and 2.5) also demonstrate a substantial change in water level across the fault immediately to the north of well MW-5. This change in water level suggests the presence of a fault influencing groundwater movement within the Chinle and Moenkopi formations.

In addition to the faults present within the Site, geologic maps demonstrate extensive faulting to the southwest of the Site (Cater 1954, 1955). The series of faults to the southwest due to the displacement of strata may represent the practical limit of the aquifer under the mesa in terms of groundwater development.

The faults are not known to be mineralized in the drilling areas, and there is no significant fault gouge noted in the logs. As such, the faults and associated fracture systems are believed to behave as conduits for flow, not barriers.

4.3 Groundwater Occurrence and Lithology of Aquifer

As previously described, the only significant water bearing strata encountered at the Site are the Chinle and Moenkopi formations. The thickness of saturated sections of these formations ranges from 40 feet in the southeastern portion of the Site to 80 feet in the in the southwestern areas. No saturation was detected at depths greater than 40 to 80 feet below the static water levels.

The Chinle formation within the Paradox Valley is composed of reddish or orange siltstone with layers of sandstone and limestone pebbles. In places, the lower section of the Chinle formation contains quartz conglomerates, which are of interest hydrologically. The Moenkopi formation has characteristics similar to the overlying Chinle formation. The Moenkopi formation contains arkosic beds that may contain and conduct water. The beds comprising both the Chinle and Moenkopi formations are lenticular and discontinuous. Neither of the above formations contains contiguous sand or sandstone layers that could host and deliver large quantities of groundwater.

4.4 Properties of Aquifer

The hydrodynamic properties of the aquifer have been estimated from:

- Variable rate pumping tests conducted in EX-series exploratory wells;
- Constant discharge rate pumping tests in PW-series production wells; and
- Permeability testing (slug tests and rising head testing) in selected monitoring wells.

Estimated aquifer properties are summarized in Table 4.1. The hydraulic testing demonstrates relatively high hydraulic conductivity averaging 2 x 10^{-3} cm/s, significantly higher than what might be expected for intact, fine-grained sedimentary rocks. The hydraulic testing also indicates a relatively low storativity, averaging 4 x 10^{-4} (0.04%) based on estimates from observation wells during pumping tests. Most fine-grained detrital sedimentary rocks are expected to exhibit low hydraulic conductivity but high porosity (Davis and DeWiest 1966), ranging from 0.05 to greater than 0.3 (5% to 30%). Together with the relatively high hydraulic conductivity, low storativity is indicative of an aquifer comprised of fracture systems. The distribution of estimated hydraulic conductivity from the testing is narrow, with a standard deviation of 0.59 log units, discounting the test results from MW-9. This uniformity suggests extensive fracturing which is typically associated with faulting, with a high degree of networking. The test results from MW-9 returned a hydraulic conductivity below 1 x 10^{-7} cm/s, which likely represents unfractured conditions.

Short-term boundary effects were indicated in the observed responses from the Phase 3 testing. The response for PW-3 is indicative of a linear impermeable boundary, which is expected for a fractured fault-related system with a low hydraulic conductivity matrix. The response at PW-2 indicates proximity to a recharge or high storativity system encountered 30 minutes into the test. Prior to terminating the test at 2880 minutes, no additional drawdown occurred at the sustained pumping rate of 10.3 gpm. This may indicate intersection of the cone of depression and an extensively fractured system with high storativity. No boundary effects were observed during the 48-hour PW-1 pumping test.

Examination of the results of testing shows that the aquifer in the south central part of the Site has slightly different properties than the aquifer in the southwestern area, allowing partitioning of the aquifer into two regions:

- Region 1 – South-central section of the aquifer; and
- Region 2 – Southwestern section of the aquifer.

The hydrogeological conditions prevailing in the south-central region of the Site, henceforth termed hydrogeological “Region 1,” are characterized by moderate hydraulic permeability and low storativity of the water-bearing strata. The aquifer in Region 1 also demonstrates confined behavior as would be expected from a fractured system.

In the southwestern portion of the Site, henceforth termed as "Region 2," the water-bearing strata are characterized by moderate permeability, unconfined conditions, and increased groundwater storativity. Table 4.2 illustrates the contrast of aquifer properties between Regions 1 and 2.

The inferred boundary between Regions 1 and 2 is discussed in Appendix A.

The effects of aquifer boundary conditions can be observed in pumping test recovery data (residual drawdown after termination of pumping). Various methods exist for analysis of recovery data. Plotting residual drawdown versus *t/t'* (the ratio of time after pumping started to time after pumping stopped) on a semilog plot is one method for evaluating potential boundary conditions. Late time recovery data moves back toward lower values of *t/t'*. The ratio *t/t'* = 1 at infinite time after termination of pumping. A theoretical recovery curve for an infinite acting aquifer will plot as a straight line on the semilog *t/t'* plot, and will intersect the *t/t'* = 1 axis at a residual drawdown of zero. Intersection of recovery data with the *t/t'* = 1 axis at a positive residual drawdown (water level below the pre-pumping static water level) suggests permanent depletion of a bounded aquifer system. Intersection of recovery data with the *t/t'* = 1 axis at a negative residual drawdown suggests faster recovery due to recharge.

Examination of recovery curves from pumping and observation wells presented on Figure 4.2 demonstrate that the aquifer in proximity to wells PW-1 and PW-2 has either fully recovered or, in some cases (e.g., PW-2 observation wells) recovered to an elevation in excess of the original pretest levels. This suggests that the cone of depression did not reach any no or low-flow boundaries and that water was not removed from storage to any significant degree. Test results of well PW-3 show aquifer depletion by 3 to 5 percent of the aquifer saturated thickness of 80 feet. Recovery in this area may require additional time to ascertain if tests permanently depleted some of the available storage from the aquifer.

4.5 Aquifer Recharge

Groundwater can be developed by removing water from storage (i.e., water that is stored in the porosity and fractures of the aquifer) and water that flows into and through the aquifer (i.e., recharge to the aquifer from infiltration). The amount of water that can be removed from storage is estimated using formation properties estimated from pumping test data, assuming that the short term tests were not significantly affected by recharge during the tests.

Recharge occurs in two ways:

- Infiltration through the soils directly overlying the aquifer; and
- Runoff from the watershed extending to the top of Davis Mesa, which generates focused recharge at the mountain front.

The conceptual extent of both areas that may contribute to aquifer recharge is shown on Figure 4.3. Given the extensive faulting in the area, recharge likely occurs directly through faults and associated fractures.

The percentage of precipitation that infiltrates to the aquifer varies with climatic conditions and elevation (Weir 1983). For this reason, a range of values was reviewed, ranging from 2% to 18% of annual precipitation (Walton 1970). For the present analysis, an infiltration rate of 5% of the annual precipitation has been selected. This rate of recharge is representative of recharge to the upper aquifers of the Paradox Basin (Weir 1983). This magnitude of recharge is considered conservative for our purposes, since the rate is averaged for all areas, including the arid valley floors which likely experience little to no recharge. Most recharge is likely focused at the mountain fronts.

Estimated precipitation in the project area varies from 12.6 to 14.7 inches per year. For design of project facilities, weather data from Uravan located at an elevation 470 feet lower than the project Site was utilized, which includes an average precipitation of 12.6 inches per year. A representative precipitation of 12.6 inches per year is considered appropriate for the project Site. However, the upper limit of 14.7 inches per year is assumed representative for an elevation of 6,500 ft above mean sea level (amsl) (Figure 2.6, from Weir 1983), corresponding to the top of the mesa. Given the ranges applied to the area contributing to recharge, annual precipitation, and percentage of annual precipitation recharging the aquifer, the rate of aquifer recharge may range from 13 gallons per minute (gpm) to 27 gpm. Table 4.3 summarizes potential aquifer recharge. This recharge is estimated to contribute to the long-term sustainability of groundwater withdrawal from the aquifer in addition to water that can be removed from storage.

5.0 PREDICTIVE ANALYSIS OF WATER SUPPLY

The predictive analysis of future groundwater availability was made with the following considerations:

- Analysis extended for a 5-year period. This time limitation is proper considering that assumptions advanced in the current analysis will need to be verified during future operation of the well field;
- The existing set of production wells (PW-1, PW-2, and PW-3) will be supplemented by two additional proposed wells (PW-4 and PW-5) to be installed in the area west of the Site (Figure 1.1); and
- The complexity of the aquifer stemming from faulting, lithological composition, and diverse hydraulic properties has been accounted for in the predictive analysis of the aquifer properties.

5.1 Modeling Scenarios

Considering the presence of faults and the variability of aquifer response to pumping, the predictive analysis of groundwater pumping rates considered the following range of aquifer configurations:

- *Scenario 1* – Aquifer is bounded on one side to the northeast by the salt dome and extends below Davis Mesa to the southwest. This scenario yields the highest available pumping rates. However, the assumption of an unrestricted aquifer presence under the mesa is not completely substantiated, considering that the southwestern extent of the aquifer may be limited to the faulting documented by the USGS (Cater 1954 and 1955). Nevertheless, the pumping rates defined for this scenario are considered an upper range of groundwater availability from aquifer storage.
- *Scenario 2* – Aquifer is bounded on two sides: to the northeast by the salt dome uplift, and to the southwest at the limits of the mapped faulting, which is mathematically represented as a no-flow boundary. Under this scenario, the aquifer is assumed to be a strip 4,500 feet wide. Although not fully substantiated, bounding of the aquifer on two sides is a conservative representation of the Site's hydrogeology resulting in the lower range of groundwater withdrawal rates. This boundary is likely a low-flow boundary, not no-flow, thus the predictions are considered conservative. The regional influence of this boundary on the Moenkopi/Chinle aquifer can only be properly assessed during long-term groundwater development.

Considering the scenarios presented above, the sustainable pumping rates for a 5-year period were estimated. The results are presented in Table 5.1.

5.2 Water Available from Aquifer Recharge

The pumping rates presented in Table 5.1 may be considered conservative because they consider water available from aquifer storage only. However, the aquifer is known to receive recharge. As discussed in Section 2.3.1 and 4.4, recharge will be derived from direct infiltration into the aquifer underlying the project area, and from runoff and focused recharge from Davis Mesa. As shown in Table 4.3, average recharge from areas directly overlying the aquifer may reach 13 gpm, and average recharge from runoff from Davis Mesa may reach 27 gpm. Hence, the potential recharge to the aquifer within the project area is estimated at a rate of approximately 40 gpm.

Either all or an undetermined portion of the recharge can be withdrawn from the aquifer due to the dynamic hydraulic behavior of the system. As a result, higher pumping rates than those presented in Table 5.1 may be attainable.

5.3 Conclusions

The complexity of the aquifer and the lack of historic data addressing groundwater supply in the eastern part of Paradox Valley dictate the necessity to consider a range of possible scenarios bearing on rate and sustainability of groundwater supply. The scenario of a one-side bounded aquifer (Scenario 1) is optimistic, yet considered possible. Under this scenario, the water supply may reach 135 gpm from aquifer storage and up to 40 gpm from aquifer recharge for a 5 year period. Hence, the rate of groundwater supply for the project may reach a rate on the order of 175 gpm.

The scenario of an aquifer bounded on two sides (Scenario 2) is, in our opinion, a more conservative representation of the Site hydrogeology. Therefore, sustainable water production from aquifer storage is estimated to be 64 gpm. However, if aquifer recharge is considered, the sustainable pumping rates may be higher, on the order of 100 gpm.

Since the aquifer productivity is sensitive to the presence/absence of features such as faults, lithology and placement of wells, the actual pumping rates will need to be confirmed following observation of aquifer response to pumping.

6.0 USE OF THIS REPORT

This report has been prepared exclusively for the use of Energy Fuels Resources Corporation (EFRC) for the specific application to the Piñon Ridge Project. The engineering analyses reported herein were performed in accordance with accepted engineering practices. No third-party engineer or consultant shall be entitled to rely on any of the information, conclusions, or opinions contained in this report without the written approval of Golder and EFRC.

The site investigation reported herein was performed in general accordance with generally accepted Standard of Care practices for this level of investigation. It should be noted that special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing program implemented in accordance with a professional Standard of Care may fail to detect certain subsurface conditions. As a result, variability in subsurface conditions should be anticipated and it is recommended that a contingency for unanticipated conditions be included in budgets and schedules.

Golder sincerely appreciates the opportunity to support EFRC on the Piñon Ridge Project. Please contact the undersigned with any questions or comments on the information contained in this report.

Respectfully submitted,

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