ERO Resources Corp.

August 24, 2012

To: Bureau of Reclamation, U.S. Department of the Interior

From: ERO Resources Corporation

Re: Arkansas Valley Conduit Geology and Paleontology Assessment

Introduction

This geology and paleontology report for the proposed Arkansas Valley Conduit (AVC) Project provides an assessment of the potential for proposed project facilities to impact existing and potential geologic and/or paleontological resources, including oil and natural gas, coal, minerals, construction materials, and fossil remains. In addition, a reconnaissance-level evaluation of geologic hazards in the project area, including landslides, faults and folds, corrosive soils, shallow bedrock, expansive soils, seismicity, and soil stability was conducted based upon the best available information. More intensive geotechnical field investigations will be completed by the Bureau of Reclamation (Reclamation) prior to feasibility-level engineering design.

Study Area

Proposed project facilities that would result in ground disturbance are located in Pueblo, Crowley, Otero, Bent, Kiowa, and Prowers counties, Colorado. The study area encompasses areas potentially affected by project activities for water treatment plants, pump stations, and water conveyance pipelines. The alternatives analyzed are consistent with alternative descriptions described in Chapter 2 of the Draft Environmental Impact Statement (DEIS).

Analysis Methods

The potential impacts on geologic and paleontological resources and the effects of geologic hazards (specifically landslides, faults and folds, and seismicity) on the project was based on existing geologic maps and other published materials and downloaded geographic information system (GIS) data from U.S. Geological Survey (USGS) and Natural Resources Conservation Service (NRCS) databases.

The significance criteria used to describe the intensity of anticipated effects on geologic and paleontological resources in the project area are described in Table 1.

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Table 1 – Geology and Paleontology Effects and Intensity Description

Impact Intensity	Intensity Description
Negligible	The impact on geological and/or paleontological resources would be noticeable, but would have only a slight impact on the integrity of the feature or deposit.
Minor	The impact on geological and/or paleontological resources would be obvious, and may alter the integrity of the feature or deposit. The effects would be localized.
Moderate	The impact on geological and/or paleontological resources would be more noticeable, and may alter the integrity of the feature or deposit. The effects would be widespread.
Major	The impact on geological and/or paleontological resources would be readily apparent, and would alter the integrity of the feature or deposit. The effects would be widespread.

Affected Environment and Environmental Consequences

Geology

Regional Geology

The study area is in the High Plains physiographic region east of the southern Rocky Mountains. The surface geology in the study area consists of fairly flat-lying, structurally undisturbed sequences of sedimentary rocks of Cretaceous age, predominantly Pierre Shale and rocks of the Niobrara Formation (Smoky Hill Shale and Fort Hays Limestone). Other rocks in the study area include the Carlile Shale, Greenhorn Limestone, Graneros Shale, and Dakota Sandstone (Tweto 1979). Much of the bedrock is overlain by Quaternary (recent) deposits of alluvial sand and gravel, windblown eolian sand and loess, and residual soils weathered from the underlying bedrock (Scott 1968; Sharps 1976; Scott et al. 1976; Moore et al. 2002).

Mineral Resources

No known metallic mineral resources, coal-bearing formations, or other industrial mineral deposits would be affected by construction on or near the study area (Colorado Division of Reclamation, Mining and Safety 2011). Portions of the study area are located in areas with proven oil and gas reserves, particularly in Bent, Prowers, and Kiowa counties. Numerous oil and natural gas wells have been identified within ¼ mile of proposed corridors (Colorado Oil and Gas Conservation Commission 2012). There is a potential for these wells or infrastructure associated with these wells (e.g., pipelines, tank batteries, or separators) to be encountered during the proposed construction activities. However, project facilities in these areas are unlikely to have an adverse effect on future oil and gas resource development.

All alternatives would cross areas with currently mined or potential sand and gravel deposits. Sand and gravel deposits are most abundant along the Arkansas River and its tributaries (Schwochow 1981; Schwochow et al. 2000).

Unique Geologic Features

No known unique geologic features would be affected by construction under any of the alternatives.

Geologic Hazards

Geologic hazards with the potential to affect the proposed project facilities are discussed below and include corrosive soils, shallow bedrock, expansive soils, landslides, faults and folds, and seismicity.

Corrosive Soils

Corrosive soils are a concern because of their potential effects on buried pipelines and other infrastructure. Soil corrosion is an electrochemical process that is responsible for the corrosion of metals in contact with soil. Soils with high moisture content, high electrical conductivity, high acidity, and high dissolved salts are the most corrosive.

Based on the known geology in the study area, potentially corrosive soils are likely. All of the proposed alternatives would be affected in varying amounts by corrosive soils depending on the subsurface materials encountered (Table 2). The No Action Alternative would encounter the least amount of corrosive soils. The Pueblo Dam North Alternative has the potential to encounter the highest amount of corrosive soils.

Shallow Bedrock

Shallow bedrock in the study area is defined as competent bedrock (solid rock that underlies unconsolidated deposit that displays limited evidence of weathering throughout the rock mass) that is less than 60 inches from the ground surface. Areas with shallow bedrock could create difficulties with excavating and trenching pipeline corridors and building foundations, potentially requiring excavation methods such as ripping or drilling and blasting.

Areas of shallow bedrock are likely throughout the study area. Construction of the proposed pipeline under all alternatives would be affected by the presence of shallow bedrock (Table 2). The No Action Alternative would encounter the least amount of shallow bedrock and the Comanche South Alternative has the potential to encounter the highest amount of shallow bedrock.

Table 2 – Geologic Hazards in Pipeline Corridor Study Area

Alternative	High Corrosivity to Steel (acres)	Shallow Bedrock (acres)	Expansive Soils (acres)	Total Study Area (acres)
1—No Action	2,407	78	65	2,965
2—Comanche South	10,842	511	831	12,616
3—Pueblo Dam South	11,055	364	882	12,848
4—JUP North	11,596	364	2,688	14,172
5—Pueblo Dam North	11,767	393	2,723	14,355
6—River South	9,978	186	671	11,815
7—Master Contract Only	2,407	78	65	2,965

Acreages shown are based on each alternative's temporary pipeline construction easement; actual disturbed areas would be less.

Expansive Soils

Expansive soils are a concern because of their potential effects on buried pipelines, building foundations, and other infrastructure. Soil expansion is generally caused by

wetting of certain clay minerals in dry soils. Arid or semiarid areas, such as Colorado, with seasonal changes in soil moisture experience a greater frequency of expansion than areas with higher rates of precipitation (Hart 1974).

Areas of expansive soils are present throughout the study area. Soils derived from the Pierre Shale in the western portion of the study area have the greatest potential for expansion. Therefore, the alternatives that would cross through this formation and the weathered residual soils above it would have a higher potential effect from expansive soils. All of the proposed alternatives would be affected in varying amounts by expansive soils (Table 2). The No Action Alternative would encounter the least amount of expansive soils and the Pueblo Dam South Alternative has the potential to encounter the highest amount of expansive soils.

Landslides

Landslides are the downward and outward movement of earth materials on a slope. The USGS delineated areas of historical landslide incidence and areas susceptible to landslides based on the topography and geology of the surface and subsurface (Radbruch-Hall et al. 1982).

According to the USGS map, the western portion of the study area is in an area with a low incidence and a moderate susceptibility for landslides. The eastern portion of the study area is in an area with a low incidence and susceptibility for landslides. No pipeline alignments would be located in areas with a high susceptibility for landslides.

Faults and Folds

Active geologic faults and folds are of concern because of the risk of damage to project facilities caused by movement of the ground along faults or folds. The Colorado Geological Survey (CGS) created a database of faults and folds that are known or suspected to have moved during the late Cenozoic (about the last 23.7 million years, i.e., that cut Miocene or younger rocks). The current tectonic environment of Colorado initiated near the beginning of the Miocene Epoch (Kirkham et al. 2004-2007).

According to the CGS database, no active faults have been identified that cross the study area. The nearest active fault to the study area, the Cheraw Fault, extends from about 5 miles northwest of the town of Cheraw a distance of 28 miles toward the northeast and away from the study area. The most recent activity along this fault was about 8,000 years ago (early Holocene). This fault is unlikely to affect the proposed project facilities.

Seismicity

The USGS created a map that displays areas of equal seismic hazard that are defined by the probability of having a certain level of ground shaking, or horizontal acceleration, during an earthquake (USGS 2009). The map shows levels of ground shaking that have a 1-in-10 chance of being exceeded in a 50-year period. The data are presented as peak acceleration values in %g (percentage of g, where g is acceleration due to gravity, or 9.8 meters/second^2). In general, ground motion with a peak acceleration value of 0.001g is perceptible by people, 0.02g causes people to lose

their balance, and 0.50g is very high but well-designed buildings can survive if the duration of ground motion is short.

The study area is in a region with very low peak acceleration values of 0.03g (or 3% of g) to the west of Pueblo, 0.02g between Pueblo and La Junta to the east, and 0.01g to the east of La Junta. Based on these very low peak acceleration values in the study area, the risk of a seismic event that would cause damage to proposed project facilities is very low.

Paleontology

Fossils are classified as nonrenewable scientific resources and are protected by various laws, ordinances, regulations, and standards across the country. Professional standards for the assessment and mitigation of adverse impacts on paleontological resources have been established by the Society of Vertebrate Paleontology (1995). The Colorado Historical, Prehistorical, and Archaeological Resources Act of 1973 (C.R.S. 24-80-401 to 411, and 24-80-1301 to 1305) defines permitting requirements and procedures for the collection of prehistoric resources, including paleontological resources, on state lands, and actions that should be taken in the event that resources are discovered in the course of state-funded projects and on state-owned/administered lands.

The western and central portions of the study area are underlain by sedimentary rocks that potentially contain paleontological resources. The Pierre Shale is an upper Cretaceous marine formation that is well known for its invertebrate fossils, including commonly occurring ammonites and baculites. These fossils are known to exist in Pueblo, Otero, and Crowley counties (Sharps 1976; Scott et al. 1976). Construction of any pipeline corridor in these counties could have the potential to expose fossils in the Pierre Shale.

Best Management Practices

Geology

In order to address potential geologic hazards that may have an effect on proposed project facilities, standard engineering practices would be incorporated into project facility designs.

Paleontology

As required by the Colorado Historical, Prehistorical, and Archaeological Resources Act of 1973, Reclamation would develop a plan to address the mitigation of construction-related adverse effects on any identified paleontological resources on state-owned/administered lands crossed by proposed project facilities.

Conclusion

Based on these findings, the AVC project is expected to have minimal impact on existing or future mineral resources. No adverse impact on unique geologic features are anticipated for any of the alternatives. Geologic hazards such as corrosive soils, shallow bedrock, and expansive soils would be addressed using appropriate material and construction techniques. The potential for landslides, faults, folds, or seismic activity to affect pipeline or facility construction is limited and any special construction measures needed to address these issues would be developed during final

design. Construction activities could encounter invertebrate fossils, which are common in the Pierre Shale in the western portion of the study area. The potential for discovering significant fossils is low and a mitigation plan would be developed to address any important paleontological resources discovered during ground-disturbing activities on state-owned/administered lands. Because geology and paleontology impacts are expected to be negligible and would be addressed with construction measures and best management practices, no further environmental consequences analyses were conducted as part of the AVC EIS.

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