BUREAU OF RECLAMATION

Appendix I

Geology, Soils and Paleontology

Draft Environmental Assessment
Dry-Redwater Rural Water Project, Montana
Missouri Basin Region

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, Native Hawaiians, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Appendix I

Geology, Soils and Paleontology

Draft Environmental Assessment
Dry-Redwater Rural Water Project, Montana
Missouri Basin Region

Prepared by

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Regional Geology

Geomorphic Province Setting

The Project study area is in the Great Plains physiographic province (Jensen and Varnes 1964) and topographically the area is predominantly an undulating grassy treeless prairie upland which rises gradually to the north. The Missouri River, within the Project study area, marks the southernmost advance of Pleistocene glaciation in eastern Montana, which is expressed in a sharp change in topography. North of the Missouri River, the resultant glaciated topography is relatively smooth with level to rolling uplands dissected by coulees and gullies. South of the Missouri River, unglaciated topography is characterized by low hills, rugged breaks, and badlands. There are very few glacial geomorphic features evident in the Project study area today other than a few moraines deposited at the continental ice sheet front at the end of the Pleistocene and "erratic" boulders (drop stones from the continental glaciation).

Geologic Formations

The geologic formations are controlled by the depositional history in northeastern Montana during Mesozoic and Cenozoic Eras. These formations (see Geologic Formations Description section below) record the depositional history that includes a shallow seaway, shoreline, and wet lowlands. A modern depositional example is the coastline along the northwestern part of today's Florida (Milnar 1998). Over Mesozoic time the Project study area was submerged under the shallow seaway and when the seaway retreated western rivers flowed to towards the east, depositing sandstone, siltstone, and mudstone into large deltas and swamps. the area included wetlands, coastal shoreline, and coastal plains.

The depositional history is repetitive with fine-grained sediments being overlaid by coarse-grained materials, with the Bearpaw Formation shale overlain by the Hell Creek and Fox Hills Formations of sand and gravel; and fine-grained sediments of the Lebo Member and Tongue River Member of the Fort Union Formation, and the sands and gravels of the Flaxville Gravel Formation. The Hell Creek Formation and the Fort Union Formation are rich in vertebrate, invertebrate and plant fossils.

Regional Seismicity

The state of Montana is the fourth most active seismic area in the U.S. (Hyndman and Thomas 2020) with most of the activity occurring in western Montana. Regionally, the Project study area has seismicity but not to the same level. Historically the only seismic event of note in northeastern Montana is the May 16, 1909, event, which is the largest historical earthquake in the northern Great Plains of the U.S. and Canada (Stickney 2020).

Regionally, the Project study area is located to the east of the Intermountain Seismic Belt, recognized as a first-order feature of western U.S. seismicity (Stickney 2020). This feature is a 932-mile-long belt of shallow seismicity that extends from northwest Arizona to northwest Montana. The northern Intermountain Seismic Belt in western Montana is a 62-mile-wide zone of shallow seismicity crossing from Yellowstone National Park to the northwest of the state. Outside the Intermountain Seismic Belt, widely scattered seismicity occurs including the 1909 event in the Project study area. All historical earthquakes in Montana of magnitude 5 or larger have occurred within the Intermountain Seismic Belt except for the 1909 earthquake. Earthquake catalogs are a critical component for understanding and characterizing Montana's seismic hazards because these earthquakes are not spatially associated with recognized faults. The one exception is the 1959 M7.3 Hebgen Lake earthquake that generated surface rupture. However, late Quaternary faults in western Montana attest to numerous prehistoric earthquakes accompanied by surface rupture.

Very few faults have been mapped in the Project study area. The only fault of note is the enigmatic Weldon-Brockton-Foid fault zone that traverses the Project study area with a northeast trend. In the U.S. Geological Survey (USGS) Quaternary Fault and Fold Database of the U.S. (USGS 2017) this fault zone is a Class B (inactive). All known active major fault zones in Montana are in the Great Falls Tectonic Zone several hundred miles to the west of the Project Study Area. Therefore, it is highly unlikely that high magnitude earthquakes would occur in the Project Study area and the seismic risk can be assigned to a low rating.

The only known seiche within the DRWA service area occurred on Fort Peck Reservoir when the 1938 landslide occurred in response to construction of Fort Peck Dam. The Fort Peck landslide is the only large landslide of note; however, landslides throughout the Project study area are often associated with the shale and bentonite rock units, especially in the Bearpaw Shale formation.

Within the Project study area, two counties (Garfield and McCone) have up to date web sites providing earthquake information (www.des.mt.gov accessed April 2024). Otherwise, the only available seismicity guidelines applicable to the Project are contained in the International and Universal Building Codes.

Geologic Formations Descriptions

Bearpaw Formation (Kbs)

This formation was deposited when the Western Interior Seaway covered the Project study area and deposited sands and muds. Marine fossils (e.g., oysters, clams, cephalopods, mollusks, fish, large marine reptiles) are abundant. The Bearpaw Formation is exposed in the Project study area, south of the Missouri River along the northwest corner of McCone County, and northwest and southwest Garfield County. (Collier and Knetchtel, 1939, Jensen and Varnes, 1964). This formation is subject to erosion and is often exposed to form badlands topography.

Fox Hills Formation (Kfh)

Near shoreline deposits of sand and shale comprise this formation. Both terrestrial and marine fossils are found in this formation. There are no major coal deposits in this formation. Within the Project study area, outcrops are evident south of the Missouri River, and it is well exposed in the Big Dry Creek and Prairie Elk Creek drainages. This formation is subject to erosion and is often exposed to form badlands topography.

Hell Creek Formation (Khc)

This formation has interbedded fresh and brackish sandstone, clay, mudstone, and coalbeds deposited by fluvial channels, deltas, and occasional swamps. In the Project study area this formation is well exposed within the Big Dry Creek and Hell Creek drainages. From 1902 to 1906, geologist Barnum Brown mapped Hell Creek and named the sedimentary unit the Hell Creek formation. The Hell Creek watershed is located in the western part of the study area (Collier and Knetchtel, 1939).

Fort Union Formation

This formation covers most of eastern Montana and is the most prolific coal-bearing formation in the state (Gunderson and Wheaton, 2020). This formation is divided into three members from oldest to youngest: Tullock (Tft), Lebo (Tfle), and Tongue River (Tfr). the Fort Union Formation is a thick sequence of interbeds consisting of pebble conglomerates, sandstone, siltstone, shales, and sometimes thick coalbeds. The deepest part of this formation is in Garfield County where it is 450 feet deep. The Tongue River member has the most coalbeds with approximately 26 coalbeds of any significance with some coalbed thicknesses being 80 feet thick. Coalbeds, generally, have a higher hydraulic conductivity than interbedded sandstones and therefore the coalbeds are aquifers providing agricultural and domestic water in the Project study area. This formation contains a variety of paleontological resources and underlies large portions of Garfield County

Flaxville Gravels (Tgr)

The sand and gravel deposits associated with this formation are associated glacial events and is sometimes a good aquifer source. Aquifers can be buried in stream channels such as these.

Quaternary Geology

Colluvium, alluvium, and landslides are common Quaternary geologic units in the Project study area. Rivers deposited the gravels and sands as sedimentary rock units. Rockfall, rock topple, and landslides are found in the breaks, primarily associated with both channelized and sheet erosion.