# 3. AFFECTED ENVIRONMENT

## 3.0 INTRODUCTION

Chapter 3 describes the condition of the human and natural environment in the CD-C project area. Under NEPA, the human environment is the natural and physical environment and the relationship of people to that environment. The affected environment for individual resources was delineated based on the area of potential direct and indirect environmental impacts for the project and associated cumulative effects area.

The environmental baseline information summarized in this chapter was obtained from the review of published sources, unpublished data, communication with government agencies, and review of field studies of the area. The level of information provided in this chapter is commensurate with the potential impacts to the resource described.

# ■ PHYSICAL ENVIRONMENT

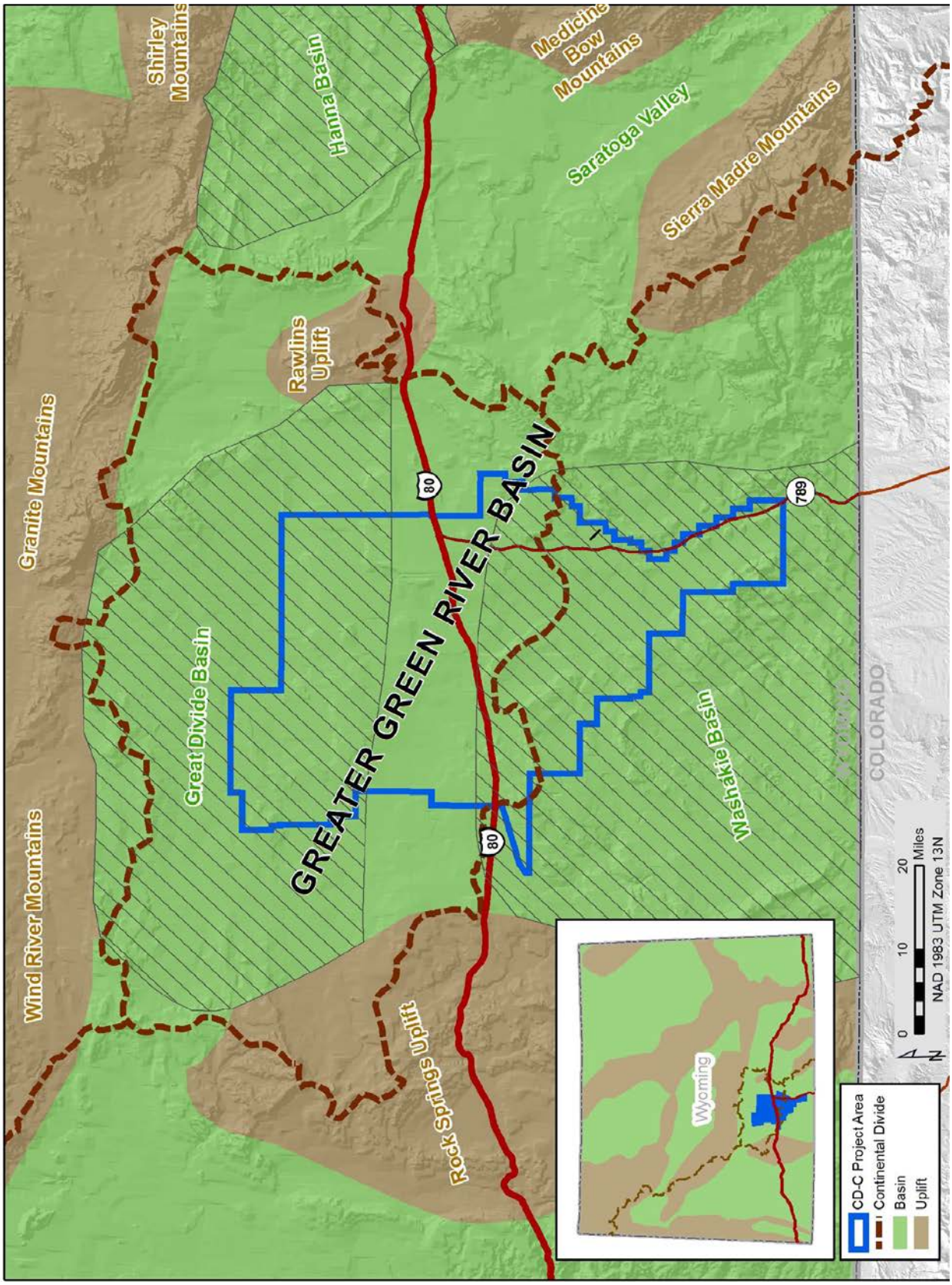
## 3.1 GEOLOGY

### 3.1.1 Physiography

The project area straddles the Continental Divide and lies within the Great Divide and Washakie Basins, subsidiary basins of the Greater Green River Basin of south-central Wyoming (**Map 3.1-1**). Important natural landmarks in the area and their corresponding elevations are shown in **Table 3.1-1**.

**Table 3.1-1. Important natural landmarks in the CD-C project area (north to south)**

| Landmark | Location | Elevation (feet) |
|---|---|---|
| Lost Creek Butte | NW ¼ Section 24, T23N:R95W | 6,745 |
| Stratton Knoll | N ½ Section 28, T23N:R91W | 6,879 |
| Ruby Knolls | Sections 26 and 27, T22N:R92W | 7,165 |
| Windy Hill (mesa) | Sections 1–5, 7–12, and 18, T21N:R91W | 7,125 |
| Latham Point | SW ¼ Section 32, T21N:R92W | 7,235 |
| Tipton Buttes | NE ¼ Section 27, T20N:R96W | 7,094 |
| Cow/Horse Butte | SE ¼ NE ¼ Section 5, T19N:R91W | 7,170 |
| High Point | SW ¼ SW ¼ SE ¼ Section 17, T19N:R92W | 7,321 |
| Sugarloaf | SE ¼ SW ¼ Section 5, T18N:R92W | 7,088 |
| Pine Butte | Center of NW ¼ Section 10, T17N:R92W | 6,808 |
| Baldy Butte | SW ¼ NW ¼ SW ¼ Section 12, T17N:R92W | 6,920 |
| North Flat Top | SW ¼ Section 35 T15N:R93W and NW ¼ Section 2, T14N:R93W | 7,822 |
| East Flat Top | Center of the E ½ Section 18, T14N:R92W | 7,560 |




**Map 3.1-1. Structural basins of south-central Wyoming and the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

The Continental Divide splits the project area into approximately northern and southern halves and, to a greater or lesser degree, parallels the I-80 highway and utilities corridor. Along and just north of the I-80 corridor, Five Mile Ditch, Latham Draw, and Hansen Draw drain the western part of the Great Divide Basin, whereas Buck Draw and Creston Draw drain to the northeast, off Latham Mesa. Farther north and northwest, the physiography of the project area is dominated by eolian features, and most watercourses are short and drain into small to very large interior basins. North of Tipton, the topography of the Red Desert Basin, the Lost Creek Basin, Chain Lakes Flat, and Battle Springs Flat is typified by eolian flats and dry playas lying in broad topographic depressions surrounded by areas of vegetated sheet or dune sand. These larger depressions are developed between elevations of about 6,450 and 6,600 feet. Dozens of smaller, internally drained basins occur near and south of the I-80 corridor, most notably including the Wamsutter and Frewan Depressions (at about 6,600 to 6,700 feet in elevation), and basins southeast of the Creston I-80 exit (S ½ T20N:R92W and SE ¼ SW ¼ T20N:R91W). Hundreds of smaller, internally drained basins occur throughout the project area, especially in places in which the surface rock or soil has been covered by dunes or a veneer of windblown sand.

In the eastern part of the project area, Fillmore Creek is a primary drainage north of the Continental Divide. Its principal tributaries include Coal Gulch, Coal Bank Wash, and Badwater Creek. Muddy Creek—tributary to the Little Snake River—is the dominant drainage south of the Divide. Its tributaries include Holler Draw, Chicken Springs Creek, and Soap Hole Wash that flow south off the Continental Divide, supplemented by the south-flowing Barrel Springs Draw and Antelope Creek, and the east-flowing Windmill Draw, Red Wash, Blue Gap Draw, Robbers Gulch, Little Robbers Gulch, and the North Fork of Cottonwood Creek. Surface elevations within the project area range from a high of 7,822 feet on North Flat Top in the NW ¼ Section 2, T14N:R93W, to a low of 6,340 feet in the lower drainage of Muddy Creek in Section 32, T14N:R91W, making project area relief about 1,482 feet. The slope of the land along the floodplain of Muddy Creek within and marginal to the project area is a gentle 400 feet in 26.2 miles, or about 0.29 percent. Limited areas of exposed rock forming rugged badland hills border the Muddy Creek valley to the east and west, and some of these badland hills exhibit slopes of up to 13.7 percent for short distances. The region of greatest physical relief in the study area—along North Flat Top in Section 35, T15N:R93W—has a slope of 18.9 percent, or about a 1,000-foot rise in elevation per mile. The majority of the project area, however, shows gentler slopes of 1.7 to 4.2 percent (about 90–220 feet/mile).

The project area is dominated by semiarid desert that receives an average of 7.1 inches of annual precipitation, ranging from 3.8 inches to 13.6 inches. Annual temperature ranges from -40 ºF in winter to more than 100 ºF in summer (WRCC 2014). Sagebrush (*Artemisia* sp.*)* is the dominant vegetation and grows in patches and thickets. Along the larger drainages sagebrush is supplemented by bunch grasses, cheatgrass, greasewood, rabbitbrush, lichens, cottonwood, and a variety of other plants (Roehler 1993). Vegetation is wholly absent in several areas of badlands, and gullying can be severe in areas of headward erosion derived from badland areas, in places where the overlying sediment has been disturbed, or on poorly vegetated slopes greater than 2 percent. Much of the lower reach of Muddy Creek is entrenched in a floodplain gully system up to 20 feet in depth.

### 3.1.2 Regional Geologic Overview

The project area lies within the southern and eastern parts of the Great Divide and Washakie structural basins, sub-basin regions of the Greater Green River Basin of southernmost central Wyoming (**Map 3.1-1**). Structurally, rocks in the area dip in a curving fashion to the west, southwest, and south of the structural high of the Sierra Madre Range, and to the south off the Wamsutter Arch, into the Washakie structural basin.

The west flank of the Sierra Madre is bounded by a major eastward-dipping reverse fault system, along which it was elevated over the eastern edge of the Greater Green River Basin (including the Washakie Basin) during the Laramide Orogeny of the late Cretaceous to early Tertiary period. These reverse faults

are not exposed at the surface, but rather lie buried beneath early Tertiary sediments that fill the basin. The Washakie and Greater Green River basins to the west, into which the surface rocks dip, are bounded by east-west oriented structural highs, the Wamsutter Arch to the north and Cherokee Ridge to the south, respectively. The structural axis of Cherokee Ridge trends along the Wyoming/Colorado state line and separates the extreme southeastern arm of the Greater Green River Basin of Wyoming from the Sand Wash Basin of Colorado. Numerous faults occur along Cherokee Ridge, many of which show evidence of recurrent motion throughout the last 20 million years. None of these, however, show indication of Quaternary movement (Case *et al*. 1994).

Geologic mapping by the U.S. Geological Survey (USGS) and Wyoming Geologic Survey (Weitz and Love 1952, Love 1970, Love and Christiansen 1985, Love *et al*. 1993, Roehler 1973, 1977, 1985; Honey and Hettinger 2004; Hettinger and Honey 2005) documents that the project area has surface sedimentary exposures of Quaternary, Tertiary, and Late Cretaceous age. These deposits are in turn underlain in the subsurface by Phanerozoic-age sedimentary rocks of Cretaceous to Cambrian age, which are in turn underlain by Precambrian metamorphic bedrock that comprises part of the ancient North American craton (continental core) and exceeds two billion years in age.

Information on geologic units preserved at the surface and in the subsurface within the project area is provided in **Table 3.1-2**; a generalized stratigraphic column of these rocks is provided in **Figure 3.1-1.**

**Table 3.1-2. Surface and subsurface geologic deposits in the CD-C project area**

| Geologic Deposit | Geologic Age | Environment/Lithology | Resources (PFYC=Potential fossil yield class) |
|---|---|---|---|
| **SURFACE DEPOSITS** | | | |
| Unnamed Quaternary deposits | Holocene-Pleistocene | Eolian/fluvial/colluvial/ landslide. Sand, gravel, clays, weathered-in-place residuum from exposed outcrops | None reported within area, economic deposits of wind-blown sand reported 20–30 miles NNE of the town of Baggs, Wyoming, just east of the project area |
| Green River Formation<br>• Laney Shale<br>• Godiva Rim Member<br>• Wilkins Peak Member<br>• Tipton Tongue<br>• Luman Tongue | Early – Middle Eocene | Lacustrine: near shore line/saline flats. Oil shale, carbonaceous shale, calcareous shale sandstone, mudstone, limestone, marlstone, oolitic and pisolitic limestone, stromatolites, trona, halite | Vertebrate (including abundant fish and flamingo), invertebrate and plant fossils (BLM PFYC 5 for Formation). Oil shale, Halite and trona east of Rock Springs. |
| Battle Spring Formation | Paleocene to early Eocene | Terrestrial/alluvial fan/fluvial. Arkosic (feldspar-rich) sandstone | Possible vertebrate fossils, but correlation uncertain (BLM PFYC 2-3); Gravel and uranium in Great Divide Basin |
| Wasatch Formation<br>• Cathedral Bluffs Tongue<br>• Main Body<br>• Niland Tongue<br>• Ramsey Ranch Member | Early Eocene | Terrestrial: fluvial/flood plain/swamp, drab to varicolored mudstone, sandstone, carbonaceous shale and coal | Vertebrate, invertebrate, and plant fossils (BLM PFYC 5); coal; petroleum in Table Rock fields; uranium reported in adjacent areas near Wamsutter, Creston, and Latham |
| Fort Union Formation | Paleocene | Terrestrial: fluvial/flood plain/swamp, chiefly somber-colored sandstones, mudstones, carbonaceous shales and coals | Vertebrate, invertebrate, and plant fossils (BLM PFYC 3); petroleum in Table Rock and Wild Rose fields; coal, coalbed methane |
| Lance Formation | Late Cretaceous | Terrestrial: fluvial/ floodplain/swamp, brown and gray sandstone, shale and mudstone, coals, and carbonaceous shales | Vertebrate, invertebrate and plant fossil (BLM PFYC 5); coal; coalbed methane, petroleum in Barrel Springs, Blue Gap, Bush Lake, Emigrant Trail, Great Divide, Hay Reservoir, Robbers Gulch, Wamsutter, and Wild Rose fields |
| **SUBSURFACE DEPOSITS**[1] | | | |
| Fox Hills Sandstone | Late Cretaceous | Near-shore and marginal marine gray shale and interbedded grayish-orange sandstone | Petroleum in Table Rock Field, other production may be included with Lance Formation; potential petroleum reservoir rock |

*Source: Geologic mapping by the USGS and Wyoming Geologic Survey (Weitz and Love 1952, Love 1970, Love and Christiansen 1985, Love et al 1993, Roehler 1973, 1977, 1985; Honey and Hettinger, 2004; Hettinger and Honey, 2005.*

[1] Deposits not exposed at the surface or at shallow enough depth to be impacted by surface disturbance are not rated as having paleontological potential.

**Table 3.1-2. Surface and subsurface geologic deposits in the CD-C project area,** *continued*

| Geologic Deposit | | Geologic Age | Environment/Lithology | Resources (PFYC=Potential fossil yield class) |
|---|---|---|---|---|
| Lewis Shale | | Late Cretaceous | Marine shale and sandstone | Petroleum in Baldy Butte, Barrel Springs, Bastard Butte, Battle Springs, Blue Gap, Bush Lake, Coal Gulch, Continental Divide, Cow Creek, Creston, Delaney Rim Unit, Echo Springs, Emigrant Trail, Fillmore, Frewen, Gale, Great Divide, Hay Reservoir, Lost Creek Basin, Lost Creek, Nickey, Red Desert, Robbers Gulch, Salazar, Sentinel Ridge, Siberia Ridge, Standard Draw, Stock Pond, Strike, Table Rock, Table Rock SW, Tierney, Wamsutter, and Wild Rose fields |
| Mesaverde Group | Almond Formation | Late Cretaceous | Marine, terrestrial, deltaic: white and brown sandstone, sandy shale, coal, carbonaceous shale | Petroleum in Baldy Butte, Barrel Springs, Battle Springs, Blue Gap, Bush Lake, Coal Gulch, Creston, Creston Southeast, Delaney Rim Unit, Echo Springs, Emigrant Trail, Fillmore, Five Mile Gulch, Frewen, Hay Reservoir, Monument Lake, Nickey, Red Desert, Robbers Gulch, Sentinel Ridge, Shell Creek, Siberia Ridge, Standard Draw, Stock Pond, Strike, Table Rock, Table Rock SW, Tierney, Wamsutter, Wells Bluff, and Wild Rose, Windmill Draw fields; coal; coalbed methane |
| | Ericson Sandstone (a/k/a Pine Ridge or Williams Fork Formation) | Late Cretaceous | Marine: coastal plain, estuary/beach, white sandstone, lenticular conglomerate, coal | Petroleum in Battle Springs, Continental Divide, Creston, Echo Springs, Fillmore, Five Mile Gulch, Gale, Lost Creek Basin, Monument Lake, Sentinel Ridge, Siberia Ridge, Standard Draw, Stock Pond, Strike, Table Rock, Wamsutter, Wells Bluff, Wild Rose, and Windmill Draw Fields |
| | Rock Springs (a/k/a Allen Ridge or Iles) Formation | Late Cretaceous | Terrestrial, coastal plain white to brown sandstone, shale, mudstone, coal | Petroleum in Wamsutter Field; other production may be included in Mesaverde (undivided); potential petroleum reservoir rock |
| | Blair (=Haystack Mountains) Formation | Late Cretaceous | Marine | Petroleum in Creston and Table Rock Field; other production may be included in Mesaverde (undivided) |
| Steele Shale (includes Shannon, Sussex Sandstones) | | Late Cretaceous | Marine: gray shale, with numerous bentonites, sandstone | None reported, potential petroleum source and reservoir rock |
| Niobrara Formation | | Late Cretaceous | Marine: light-colored limestone, gray limey shale | None reported, potential petroleum source and reservoir rock |
| Frontier Formation | | Late Cretaceous | Marine: deltaic, gray sandstone and sandy shale | Petroleum in Cow Creek and Table Rock fields; potential petroleum source and reservoir rock |

**Table 3.1-2. Surface and subsurface geologic deposits in the CD-C project area,** *continued*

| Geologic Deposit | Geologic Age | Environment/Lithology | Resources (PFYC=Potential fossil yield class) |
|---|---|---|---|
| Mowry Shale | Late Cretaceous | Marine: silver-gray, hard siliceous shale, with abundant fish scales and bentonites | None reported, potential petroleum source rock |
| Muddy Sandstone | Early Cretaceous | Marine: deltaic, gray to brown sandstone, conglomeratic | Petroleum in Cow Creek Field; potential petroleum reservoir rock |
| Thermopolis Shale | Early Cretaceous | Marine, black, soft, fissile shale | None reported, potential petroleum source rock |
| Cloverly Formation (=Dakota & Lakota Sandstones) | Early Cretaceous | Terrestrial, variegated mudstone, bentonitic, conglomeratic sandstone | Petroleum in Cow Creek Field; potential petroleum reservoir rock |
| Morrison Formation | Jurassic | Terrestrial, varicolored mudstones, white sandstone, bentonite | None reported; potential petroleum reservoir rock |
| Sundance Formation | Jurassic | Marine, green-gray glauconitic sandstone and shale, underlain by red and gray non-glauconitic shale and sandstone | None reported; potential petroleum reservoir rock |
| Nugget Sandstone | Triassic to Jurassic | Eolian, gray to red, massive to cross-bedded sandstone | Petroleum in Cow Creek and Table Rock fields; potential petroleum reservoir rock |
| Chugwater Formation | Triassic | Terrestrial/mud flat, red shale and siltstone, sandstone | Potential petroleum reservoir rock |
| Goose Egg Formation | Permian to Triassic | Marine, gray to olive dolomitic siltstone; red sandstone and siltstone, gypsum, halite, purple to white dolomite and limestone | None reported |
| Tensleep Sandstone | Pennsylvanian | Marine, white to gray sandstone with limestone and dolomite | Potential reservoir rock. |
| Amsden Formation | Mississippian to Pennsylvanian | Marine, red and green shale and dolomite, persistent red to brown sandstone at base | None reported |
| Madison Limestone | Mississippian | Marine, blue-gray massive limestone and dolomite | Petroleum in Table Rock Field |
| Flathead Sandstone | Cambrian | Marine/shoreline, red, banded, quartzose sandstone | None reported |
| Unnamed metamorphic rocks | Precambrian | Igneous/metamorphic, granitic and/or intrusive | None in area but Sierra Madre contain ores of uranium, copper, silver, lead, zinc, gold, and barium; and industrial (building and decorative) grades of quartzite, marble, and granite |

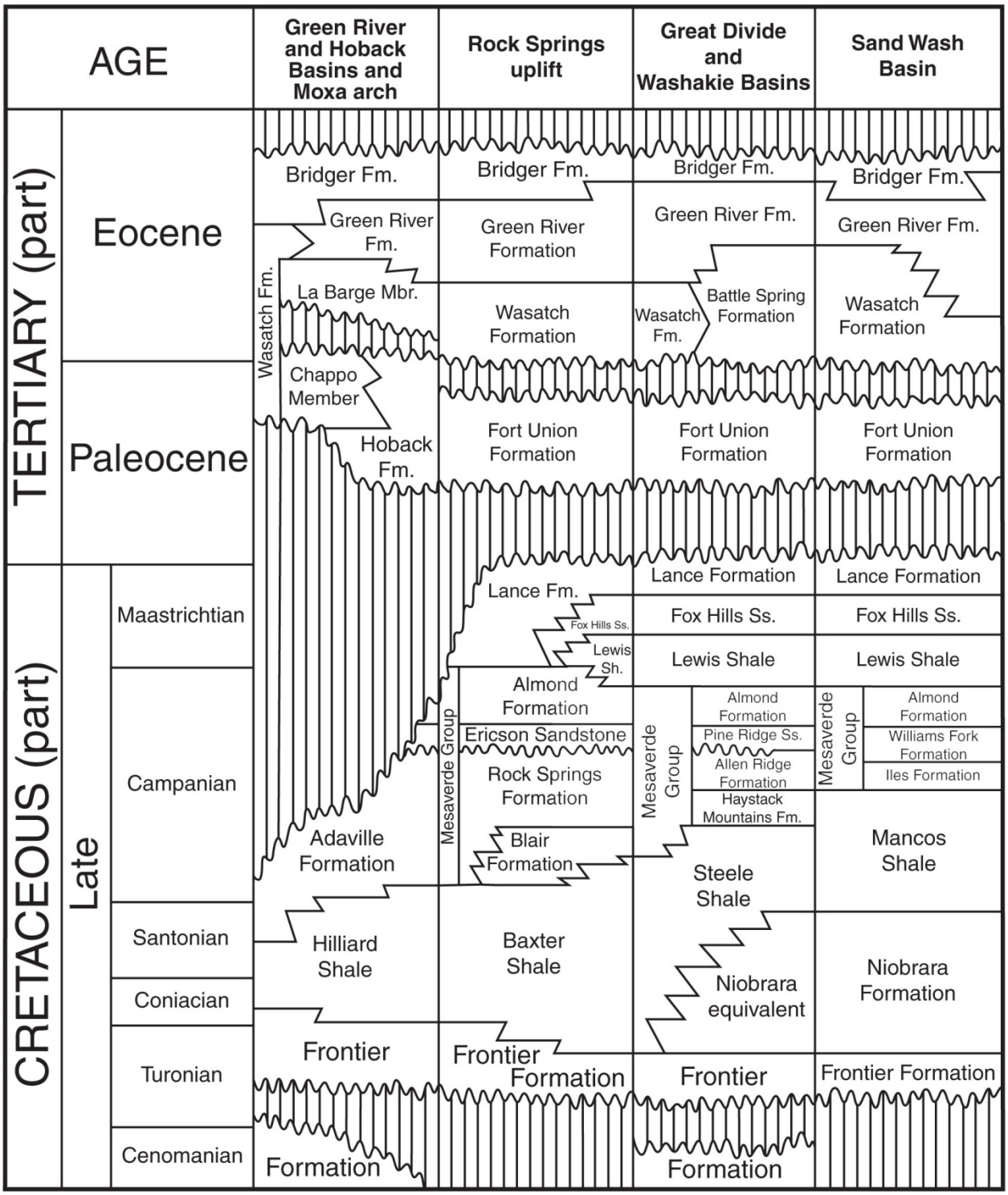



**Figure 3.1-1. Generalized stratigraphic column**

The Battle Spring Formation (shown in the upper right quadrant of this chart) is a coarse-grained deposit that accumulated along the southern flank of the Granite Mountains. It is equivalent to the Wasatch and Green River Formations and possibly part of the Fort Union Formation directly beneath.

Rock terminology for the Cretaceous (Mesaverde Group, a subsurface unit in the project area) is complicated in that scientific studies of these rocks reference a number of different formations within the project area. Although the Wyoming Chart of Stratigraphic Nomenclature lists the Almond, Ericson, Rock Springs, and Blair formations within the Mesaverde Group in the Washakie Basin, alternative terminology has been used for these same rocks by authors describing the coals of the Mesaverde. Rock equivalent names for the Ericson Sandstone include the Williams Fork Formation or Pine Ridge Sandstone; for the Rock Springs Formation, the Allen Ridge Sandstone or Iles Formations; and for the Blair Formation, the Haystack Mountain Formation.

Additional details on surface deposits are provided in **Section 3.1.3**. Petroleum production targets are generally in the Mesaverde Group (undivided) in the following fields: Baldy Butte, Barrel Springs, Bastard Butte, Battle Springs, Blue Gap, Coal Gulch, Continental Divide, Cow Creek, Creston, Delaney Rim Unit, Echo Springs, Emigrant Trail, Fillmore, Five Mile Gulch, Frewen, Hay Reservoir, Lost Creek Basin, Monument Lake, Red, Red Desert, Robbers Gulch, Salazar, Sentinel Ridge, Shell Creek, Siberia Ridge, Stock Pond, Strike, Table Rock, Tierney, Wamsutter, Wells Bluff, Wild Rose, and Windmill Draw.

### 3.1.3 Quaternary Deposits

Quaternary deposits in the project area include widespread deposits of alluvium, colluvium, and slope wash; eolian sand dunes; and residuum developed on formations of Cretaceous (Lance Formation), Paleocene (Fort Union Formation), and Eocene (Battle Spring, Green River, and Wasatch Formations) ages.

Extensive deposits of windblown sand blanket bedrock exposures of Tertiary rocks in T15-17N:R93W, with more isolated deposits occurring in T15N:R92W (Love and Christiansen 1985). These deposits range in thickness up to about 30 feet, and the sediment has been partly stabilized by vegetation, dampness, and weak cementation in some areas. Relatively pure, naturally size-sorted eolian sand is an economic resource, and sand-quarry pits have been developed in Section 9, T15N:R92W and just to the southeast of that area, outside the project boundaries (Harris 1996). The northern part of the project area is dominated by eolian deposits and an eolian-created topography. The Red Desert, Lost Lake, and String Lake Basins are deflated playas surrounded by loess deposits.

Deposits of alluvium, at least up to 30 feet thick, are developed in the bed and floodplain of Muddy Creek in the central and southeast parts of the project area, and much thinner alluvial accumulations occur in the beds of tributary streams near where they join Muddy Creek. The alluvium consists for the most part of medium to fine sand, mud, and mudstone rip-up clasts, all derived from the surrounding badland hills. Chert pebbles, sandstone clasts, and weathered Eocene soil (paleosol) nodules commonly occur as part of streambed loads. Pebble to cobble-sized gravel forms some of the ancient terrace sediment above Muddy Creek on its east side, and these deposits are exploited locally as road metal or in making concrete filler (for example, in the SW ¼ SE ¼ Section 21, T18N:R91W). The site of the lauded “Rawlins Mammoth,” discovered in 1961, is located near Chicken Springs in the NW ¼ SW ¼ SE ¼ Section 1, T18N:R91W.

Drapes of colluvial sediment, consisting mainly of mud with a lesser amount of fine sand and lag accumulations of Eocene soil nodules, border nearly all the badland hills and are derived from them.

Terrace gravel and gravel deposits of Holocene and perhaps Pleistocene age occur sporadically throughout the area along the former course of Muddy Creek and at higher elevations. Older high-level terrace gravels suggest that Muddy Creek and its subsidiary tributaries drained northward into the Great Divide Basin in the past and that its present southward drainage into the Little Snake River was the result of stream piracy.

### 3.1.4 Tertiary—Battle Spring Formation

The Battle Spring Formation (Pipiringos 1961) is a fluvial deposit of middle Eocene age that forms a foundation for most of the buttes and mesas bordering the playas in the project area north of the Continental Divide. The unit consists of gray, orange, and red mudstones, volcanic mudstones, carbonaceous mudstones, orange and brown sandstones, and stringers of gravel conglomerate, and it is especially well exposed in the area of Ruby Knolls and on the east side of Frewan Mesa. The Battle Spring Formation has yielded a small fauna of fossil vertebrates, including the fragmentary bone of a crane or a large, flightless bird discovered during reconnaissance fieldwork for this project.

### 3.1.5 Tertiary—Green River Formation

Within the project area, the Eocene Green River Formation (chiefly of middle Eocene age) is restricted to the area around the I-80 corridor (between Wamsutter and Tipton Buttes) and to the extreme southwest, where it makes up the upper part of the escarpment forming Flat Top Mountain. From oldest to youngest, the Green River consists of the Luman Tongue, the Tipton Tongue, Wilkins Peak Member (lower part only), Godiva Rim Member, and the Laney Member. Sediments comprising the Green River Formation accumulated in environments in and adjacent to Lake Gosiute (and its predecessor Lake Luman) in response to the rise and fall in lake level during the Early Eocene. Environments of deposition included fluvial, paludal, freshwater lacustrine, saltwater lacustrine, pond and playa lake, evaporate pans, mudflat, and volcanic and fluviovolcanic (Roehler 1993).

The Luman Tongue forms the base of the Green River Formation on the southern edge of the Great Divide Basin. The tongue is composed chiefly of organic-rich oil shales, carbonaceous shales, limestones, sandstones, and mudstones that accumulated in Lake Luman above deposits of the Ramsey Ranch Member of the Wasatch Formation (**Section 3.1.6**). The Luman deposits interfinger laterally to the north and south with varicolored (chiefly red) floodplain deposits of the Wasatch Formation. At its maximum extent, Lake Luman occupied an area of about 6,650 square miles.

The Tipton Tongue (including the Scheggs and Rife beds) of the Green River Formation conformably overlies the Niland Tongue of the Wasatch Formation, and is composed chiefly of marlstone, calcareous shale, and oil shale. The Scheggs Bed is predominantly oil shale and lesser algal limestones, sands, and muds that accumulated in lake and lake-shore environments during the first major expansion of ancient Lake Gosiute. Deep-lake oil shale in the Scheggs Bed preserves abundant fossils of ostracods and shallow-water lake sediments containing abundant stromatolites, the remains of calcareous algal reefs. The stromatolites exhibit a wide variety of bizarre forms that are related to ecological conditions such as water depth, temperature, salinity, and sedimentation rate, as well as other factors. The Rife Bed forms the top of the Tipton and consists chiefly of organic-rich oil shale, interbedded with a lesser amount of algal limestone, dolomite, sandstone, and mudstone. The oil shale of the Rife accumulated in the deepest parts of the lake during a 500,000-year period when Lake Gosiute dwindled to about half its former size (about 7,500 square miles) during deposition of the Scheggs Bed. The salinity of the lake must have increased dramatically as evidenced by thin layers of saline minerals such as nahcolite and disseminated crystals of shortite that occur in the upper part of the bed. Algal limestone and sands accumulated in shallower and shoreline areas.

The Wilkins Peak Member consists of many layers of cyclic sediments that include, in ascending order: oil shale, trona, halite, and mudstone that accumulated in Lake Gosiute. Only the lower part of the member is present in the project area. This part of the member consists chiefly of shales, sandstones, and trona and halite that accumulated in brackish Lake Gosiute as the lake shrank in size. The Godiva Rim Member consists chiefly of gray-brown kerogenous shale, ostracode-bearing sandstone, siltstone, and limestone that overlie and interfinger with the Cathedral Bluffs Member of the Wasatch Formation and is overlain and interfingers with the LaClede Bed of the Laney Shale.

The Laney Shale (including the LaClede and Hartt Cabin beds) forms the top of the Green River Formation and records in its sediments the greatest expansion of ancient Lake Gosiute followed by its final contraction and desiccation. At its peak the lake in which the Laney accumulated occupied more than 75 percent of the Greater Green River Basin, or about 15,000 square miles (Bucheim 1981,1986, Bucheim *et al.* 1977).The Laney Shale (including the LaClede and Hartt Cabin Beds) conformably overlies and interfingers with the Cathedral Bluffs Tongue of the Wasatch Formation, and is dominated by calcareous shale, oil shale, and shaley marlstone.

In the Piceance Basin of Colorado, the Green River Formation contains massive amounts of economically important oil shale, and elsewhere the formation is also known to yield economically important deposits of trona and gilsonite. The Green River Formation is well known for its locally abundant remains of well-preserved fossil fish and much rarer specimens of other fossil vertebrates.

### 3.1.6 Tertiary—Wasatch Formation

The lower Eocene Wasatch Formation is the most extensively exposed geologic unit in the project area, with a distribution exceeding that of any other rock unit. Bedrock exposures of the Wasatch Formation, however, are generally limited to the steep, east-facing escarpments bordering much of the west side of Muddy Creek, especially beneath Flat Top Mountain, along “The Bluffs” north of Baggs, and in west-dipping cuestas north and south of the townsite of Dad. Other exposures are locally developed along and marginal to deeply incised streams on south Mexican Flats.

Within the project area, the Wasatch Formation is divided into the Main Body, Ramsey Ranch Member, Niland Tongue, and the Cathedral Bluffs Tongue. Regionally, the Main Body of the Wasatch Formation consists of up to 2,130 feet of variegated mudstone and sandy mudstone, gray sandstone, carbonaceous shale, and coal (Bradley 1964; Sullivan 1980; Roehler 1985) that were deposited in alluvial channels and back swamps, and on floodplains. Toward the basin center, the Main Body of the Wasatch conformably overlies the Paleocene Fort Union Formation, but farther east it overlaps the Fort Union and lies with angular unconformity on both the Fort Union Formation and the Upper Cretaceous Lance Formation. The floodplain deposits of the Main Body have two distinct color patterns. Around the basin edges the floodplain deposits range from red to varicolored, with some shade of red dominating. In the central parts of basin these red floodplain deposits are replaced laterally by green to gray floodplain deposits. Green to gray coloration appears to have been the result of accumulation of sediments in areas that were permanently water saturated, where iron compounds were reduced. In addition to floodplain deposits the Main Body of the Wasatch Formation includes some freshwater limestones that accumulated in ponds and marshes in low-lying areas and some coarse-grained sands and conglomerates that accumulated along the basin margin in alluvial fan environments. Deposits of the Main Body accumulated contemporaneously with deposits of the Ramsey Ranch Member of the Wasatch Formation and Luman and Tipton tongues of the Green River Formation.

The Ramsey Ranch Member consists of carbonaceous shale, coal, limestone, gray and green or red variegated sandstone and mudstones that accumulated in swamps, shallow lakes and ponds, and floodplains and rivers during the early stages of the development of Lake Gosiute. The member contains important deposits of oil shale, uranium, and coal.

The Niland Tongue of the Wasatch Formation consists of brown sandstone, drab mudstone, and carbonaceous shale that conformably overlie the Luman Tongue of the Green River Formation. The Niland Tongue has the same aerial distribution as the Luman Tongue of the Green River Formation. Where the Luman Tongue is absent the name Niland Tongue is discarded and those rocks are not separated from the underlying Main Body of the Wasatch.

The Cathedral Bluffs Tongue forms the uppermost rocks of the Wasatch Formation, overlying the Tipton Shale of the Green River Formation, and closely resembles those of the Main Body in the dominance of variegated mudstone and gray sandstone.

Economically important uranium deposits occur in coals of the Main Body and Ramsey Ranch Member of the Wasatch Formation north of Wamsutter, just west of the project area (Masursky 1962), and in the region around Creston and Latham (Harris *et al.* 1985; Harris and King 1993). Uranium is also known in arkoses of the Battle Springs Formation of the central Great Divide Basin (Pipiringos 1961), a unit approximately equivalent to the Cathedral Bluffs Tongue of the Wasatch within the report area.

Fossil vertebrates are locally abundant in the Wasatch Formation, including all the subunits that comprise the formation in the CD-C project area.

### 3.1.7 Tertiary—Fort Union Formation

Within the project area, the Paleocene Fort Union Formation is developed in a curved, westerly dipping outcrop. Regionally, the unit lies with erosional or angular unconformity atop the Upper Cretaceous Lance Formation (Roehler 1993). The best Fort Union exposures occur in the northeast part of the area, in Section 23, T18N:R92W; however, good but smaller and less-continuous Fort Union exposures occur beneath Wasatch-capped buttes developed just east of Muddy Creek, between the townsites of Dad and Baggs, Wyoming.

Regionally, the Fort Union Formation consists of up to 3,400 feet of drab mudstone, sandy mudstone, sandstone, carbonaceous shales, and coal. These rocks were deposited in alluvial channels and flood-basin backswamps (Sanders 1975), and up to 1,500 feet of Fort Union rocks are exposed in the Riner area, between Red Rim and Creston Junction (Sanders 1974).

Honey and Hettinger (2004) and Hettinger and Honey (2005) have mapped three members of the Fort Union Formation in the Blue Gap and Peach Orchard 7.5-minute quadrangles. These include, from youngest to oldest, the Overland, Blue Gap, and China Butte Members. The China Butte Member includes many mapped coalbeds included in five coal-bearing zones. These include the Fillmore Ranch, upper and lower Muddy Creek, Olsen Draw, and Red Rim coal zones.

The Fort Union Formation in the project area, as well as in all of south-central Wyoming, constitutes an enormous, largely untapped reserve of coal. However, most of this resource occurs in thin and/or discontinuous beds (Smith *et al.* 1972; Sanders 1974, 1975; Beaumont 1979; Edson 1979; Hettinger and Brown 1979; Honey and Roberts 1989; Honey and Hettinger 1989a; Honey 1990; Jones 1991; Hettinger *et al.* 1991; Hettinger and Kirchbaum 1991) that are exceedingly difficult to mine economically. Sanders (1974, 1975) reports thin and discontinuous Fort Union coalbeds that thicken up to 9.8 feet in places, and units 5–25 feet thick are developed in the upper 600–700 feet of the formation just northeast of the project area. Edson (1979), Honey and Hettinger (1989a), Honey and Roberts (1989), and Honey (1990) named and/or numbered Fort Union coalbeds within and north and west of the project area, and provided subsurface correlations of coal-bearing units. Honey and Roberts (1989) recorded up to 75 feet of total coal thickness in the lower part of the Fort Union Formation in the Baggs area, and Honey and Hettinger (1989b) documented individual coalbeds up to 27.7 feet thick in the Fillmore Ranch Coal Zone (Edson 1979), within the project area.

The most recent coal-mining activity within the project area is in the Fort Union Formation at Cherokee Mine Number 1, in the SW ¼ SW ¼ NE ¼ Section 2, T19N:R92W, about 6 miles south of Creston Junction.

Fossil vertebrates are well known from the China Butte Member of the Fort Union Formation within the study area, the most noteworthy locality being Swain Quarry, in the NE ¼ Section 3, T15N:R92W (Rigby 1980). Apart from Swain Quarry, the UW Geological Museum has one locality in the project area—Fort Union rocks—and an additional 13 Fort Union sites have been developed in recent years by M.C. McKenna and J.G. Honey.

The contact of the Fort Union Formation with the underlying Upper Cretaceous Lance Formation is everywhere marked by a pronounced angular unconformity and generally a thick-channel sandstone

(Roehler 1993). It is unknown if the Tertiary-Cretaceous boundary is preserved in the area, but earliest Paleocene (Puercan age) rocks certainly are (see **Section 3.3 Soils**).

### 3.1.8 Upper Cretaceous—Lance Formation

Few exposures of Lance rocks extend into the project area, and the Lance Formation/Fort Union Formation contact in part forms the project area's eastern boundary over a short distance. However, patches of Lance are exposed in a few areas, notably in the SE ¼ Sections 13, 23, and 34, T17N:R92W, and in the E ½ Section 4, T16N:R92W.

The Lance Formation is a largely alluvial deposit made up of about 2,890 feet of interbedded gray sandstone and sandy mudstone, carbonaceous shale, and coal (Hettinger *et al.* 1991; Hettinger and Kirschbaum 1991). Honey and Hettinger (2004) and Hettinger and Honey (2005) recognize two subunits of the Lance Formation in the Blue Gap and Peach Orchard 7.5-minute Quadrangles. These include an upper Red Rim Member and an underlying unnamed member. The Red Rim Member is chiefly conglomeratic sandstone. The underlying unnamed member contains several coal units. The thickest of these, which is about six feet thick, occurs about 25 to 45 feet above the base of the formation.

Regionally, the Lance overlies the Fox Hills Sandstone (Smith 1961, Gill *et al*. 1970, Hettinger *et al*. 1991, Roehler 1993), which is included in the Lewis Shale on many maps. To the east the Fox Hills may be absent, and the Lance directly overlies the Lewis Shale (Weitz and Love 1952, Love and Christiansen 1985). Further eastward, Lance rocks correlate with the Medicine Bow Formation (Merewether 1971) and farther west, the Lance thins to less than 197 feet on the west side of the Washakie Basin (Roehler 1985).

The Lance Formation is well-known for its dinosaur remains and, within the project area, Lance rocks have yielded sparse remains of fish, crocodilians, and mammals (Honey 2003.

### 3.1.9 Geologic Hazards

Of known naturally occurring geologic hazards, fault-generated earthquakes, floods, landslides, or other mass movement, the most likely to affect the project area are mass movements that could be initiated on steep slopes. Flooding may be a hazard adjacent to steeply dipping rock outcroppings where high runoff may be expected; however, there are few such areas within the project boundaries.

There are no known faults with evidence of Quaternary movement mapped within the project area (NEIC 2003, WGS 2003); however, a number of unmapped faults are known to exist in the Washakie Basin area in southern Sweetwater and Carbon Counties. Further field investigation would be necessary to determine if any of these faults should be deemed active.

Only one earthquake has been recorded within the project area. The earthquake, with a 4.3 Richter magnitude occurred April 4, 1999 and its epicenter was located near Baldy Butte in T17N:R92W (41.45˚N:107.74˚W). It was felt in Rawlins, Sinclair, Baggs, Wamsutter, and Rock Springs. Residents of Rawlins reported that pictures fell off walls. The most noteworthy damage occurred between Baggs and Creston Junction, and at Wamsutter (Case *et al*. 2002). The owner of a ranch house located approximately 30 miles north of Baggs reported that cinder-block walls in the basement of the home cracked, separated, and may have required replacement. A motel and associated residence in Wamsutter also suffered cracks in the cinder-block walls of the basement. No other earthquake epicenters have been recorded in or immediately adjacent to the area in the past 100 years, indicating that earthquakes are probably an unusual event and that the area may not be very seismically active (Case *et al.* 2002).

The project area is in Seismic Zone 1 of the Uniform Building Code. Effective peak accelerations (90 percent chance of non-exceedance in 50 years) in this zone can range from 5%g–10%g, where g = the gravitational acceleration constant (see Glossary). Probabilistic acceleration maps for Wyoming indicate that in the project area: (1) for the 500-year map (10 percent probability of exceedance in 50 years), the estimated peak horizontal acceleration is about 8%g; (2) for the 1,000-year map (5 percent probability of

exceedance in 50 years) it is about 15%g; and (3) for the 2,500-year map (2 percent probability of exceedance in 50 years) it is about 20%g. These accelerations are roughly comparable to intensity VI earthquakes (Case *et al.* 2002). An intensity VI earthquake can result in fallen plaster and damaged chimneys

Honey and Hettinger (2004) have mapped landslide deposits covering about a quarter-section along the north side of Cottonwood Creek in Section 31, T14N:R92W and Section 6, T13N:R92W of the Peach Orchard 7.5-minute topographic quadrangle. These deposits are of limited extent and occur along the contact between the Main Body of the Wasatch Formation and overlying Tipton Tongue of the Green River Formation.

## 3.2 PALEONTOLOGIC RESOURCES

### 3.2.1 Paleontological Resource Preservation Act

The Paleontological Resources Preservation Act (PRPA) was signed into law as part of the Omnibus Public Lands Management Act of 2009, Public Law 111-011 (123 Stat. 1173; 16 USC 470aaa) (OPLMA 2009). It states that these resources on federal land (except Indian land) shall be managed and protected "using scientific principles and expertise" and also requires the development of "appropriate plans for the inventory, monitoring, and scientific and educational use of these resources" in accordance with applicable agency laws, regulations, and policies. These plans emphasize interagency coordination and collaborative efforts where possible with non-federal partners, the scientific community, and the general public. In addition, programs to increase the public's awareness about the significance of paleontological resources are to be established.

The PRPA formally defines paleontological resources as "any fossilized remains, traces, or imprints of organisms, preserved in or on the earth's crust, that are of paleontological interest and that provide information about the history of life on earth," and as such include the fossilized remains of plants and animals as well as their traces.

### 3.2.2 Potential Fossil Yield Classification (PFYC) System

The PFYC system is described in BLM Instruction Memorandum [IM] No. 2008-009, *Potential Fossil Yield Classification System for Paleontological Resources on Public Lands* (BLM 2007d). The IM is summarized here and is included in its entirety in **Appendix D, Paleontological Resources Program Guidance**. The system is based on the premise that the probability of finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Under the system, geologic units are classified according to the relative abundance of fossils and their sensitivity to adverse impacts, with a higher class number indicating a higher potential.

The PFYC system provides baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification is an intermediate point in the analysis, used to assist in determining the need for further mitigation assessment or actions.

The descriptions for each class (provided below) serve as guidelines rather than as strict definitions. Note that the definition of *fossil* may be redefined in the Rules and Regulations Section of the PRPA, which is still in draft.

**Class 1 – Very Low**. Geologic units that are not likely to contain recognizable fossil remains.

- Units that are igneous or metamorphic, excluding reworked volcanic ash units.
- Units that are Precambrian in age or older.

The probability for impacting any fossils is negligible.

**Class 2** – **Low**. Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

- Vertebrate or significant invertebrate or plant fossils not present or very rare.
- Units that are generally younger than 10,000 years before present.
- Recent eolian deposits.
- Sediments that exhibit significant physical and chemical changes (i.e., diagenetic alteration).

The probability for impacting fossils is low.

**Class 3** – **Moderate** or **Unknown**. Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential.

- Often marine in origin with sporadic known occurrences of vertebrate fossils.
- Vertebrate fossils and scientifically significant invertebrate or plant fossils known to occur intermittently; predictability known to be low.
- (or)
- Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

***Class 3a – Moderate Potential.*** Units are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered.

***Class 3b – Unknown Potential.*** Units exhibit geologic features and preservational conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known.

**Class 4** – **High**. Geologic units containing a high occurrence of significant fossils.

***Class 4a –*** Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres.

***Class 4b –*** These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted. Areas of exposed outcrop are smaller than two contiguous acres; outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions; other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action.

**Class 5** – **Very High**. Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.

***Class 5a –*** Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two contiguous acres.

***Class 5b –*** These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances.

The probability for impacting significant fossils is high.

### 3.2.3 Known Paleontological Resources in the CD-C project Area

Known paleontological resources (frequently referred to here as *fossils* or *fossil resources*) within sedimentary deposits in the project area record the history of animal and plant life in Wyoming during the early part of the Cenozoic Era (Paleocene and Eocene Epochs) and the latest part of the Mesozoic (Cretaceous Period) Era. Current mapping documents six geologic deposits exposed at the surface in the project area. These include, from youngest to oldest: (1) unnamed deposits of Quaternary (Holocene to Pleistocene) age, (2) the middle Eocene Battle Spring Formation, (3) the middle and early Eocene Green River Formation, (4) the Wasatch Formation of early Eocene age, (5) the Fort Union Formation of Paleocene age, and (6) the Lance Formation of Latest Cretaceous age.

With the exception of the Holocene deposits that are probably too young to contain fossils, all sedimentary rock units exposed as bedrock in the project area are known to produce or have the potential to produce scientifically significant fossil resources. Scientifically significant fossils have been recovered from the Wasatch (Morris 1954; Honey 1988; Roehler 1972, 1991a–b, 1992a–c, 1993; Roehler *et al.* 1988), Fort Union (Rigby 1980, Winterfeld 1982), and Lance Formations (Dorf 1942, Estes 1964, Clemens 1986, Clemens *et al*. 1979, Breithaupt 1982 and 1985, Weishample 1992, Archibald 1993, Lillegraven 2002, Honey 2003) within the project area or immediately adjacent areas.

Specifically, 15 fossil localities are known to occur within the project area in the Lance Formation and 17 fossil localities are known to occur within the Fort Union Formation. The Lance Formation localities occur in the Separation Peak (T20N:R90W), Fillmore Ranch (T18N:R20W), Doty Mountain (T17N:R91–92W), Peach Orchard Flat (T15N:R91W) and Blue Gap (T15N:R91W) 7.5-minute Quadrangles. The Fort Union Formation localities occur in the Separation Peak (T20N:R90W), Fillmore Ranch (T19N:R91W), Duck Lake (T16–17N:R91-91W), Mexican Flats (T16N:R92W) and Blue Gap (T15–16N:R91–92W) 7.5-minute Quadrangles. Localities from both the Lance and Fort Union Formations produce a wide variety of fossil remains, including those of mammals, reptiles, amphibians, and fish. Of great importance is the occurrence within the Fort Union Formation of some of the oldest known Paleocene-age fossil vertebrates in the world, which are considered to be of Puercan age (earlier Paleocene) and are very rare (Honey 2003).

Literature review and the field survey documented the occurrence of known scientifically significant fossils within the CD-C area in the following formations: (1) the middle Eocene Battle Spring Formation (PFYC 3b [unknown]), (2) the middle and early Eocene Green River Formation (PFYC 5, very high), (3) the Wasatch Formation of early Eocene age (PFYC 5, very high), (4) the Fort Union Formation of Paleocene age (PFYC 3a, moderate), and (5) the Lance Formation of Latest Cretaceous age (PFYC 5, very high).

### 3.2.4 Taphonomy and the Occurrence of Fossils

Taphonomy is the study of the origin and nature of accumulations of fossil materials or their traces. In general, vertebrate fossils are much rarer than invertebrate fossils, but there are sites where extraordinary accumulations of fossil vertebrates are found.

Knowledge of the geologic context of vertebrate fossils collected at a site is critically important in evaluating the reason fossils occur where they do. The geological context of a deposit contains information about whether the deposit formed under marine (ocean), lacustrine (lake), or fluvial (riverine) conditions. In the project area, five geological formations have high potential for yielding fossil vertebrates. From oldest to youngest, these are: (1) the Lance Formation (Upper Cretaceous), (2) the Fort Union Formation (Paleocene), (3) the Wasatch Formation (lower Eocene), (4) the Green River Formation (middle Eocene), and (5) the Battle Spring Formation (middle Eocene). None of these formations is of marine origin, and only the Green River Formation was deposited under largely lacustrine conditions. The

Lance, Fort Union, Wasatch, and Battle Spring formations are dominantly of fluvial (river, stream, and associated floodplain) origin.

In lacustrine environments, fossil vertebrate remains might accumulate in shales deposited under open-water conditions or, closer to shore, in units containing coarser clastic material. Fluvial sediments (those deposited by streams) represent two basic environments: the channel and the floodplain. Channel deposits are generally dominated by sandstone and/or gravel conglomerate, whereas floodplain sediments consist chiefly of mudstones. Because they were subjected to periodic drying during intermittent deposition, rocks comprising floodplain deposits are commonly color-variegated. The thicknesses of the colored horizons reflect the relative maturity (relative time to form) of the ancient soils (Bown and Kraus 1980a and 1980b).

In fluvial rocks, the accumulation of vertebrate material may be either active or passive. Active accumulation involves the concentration of bones by running water. All fossil vertebrate concentrations formed by active accumulation are made up of remains that have been transported after death, although they need not have been transported very far.

Passive accumulation includes all mechanisms of concentrating fossil material in fluvial environments in which the remains of the organism are not transported to a large extent after death. Examples of passive accumulation include: (1) the slow buildup of bones in quicksand deposits, (2) the preservation of remains as a result of ash-falls, and (3) the gradual accumulation of the remains of dead animals in the upper (A) horizons of soils (paleosol accumulations). Because paleosols are ubiquitous in ancient fluvial sequences, and because floodplains with forming soils occupy more than 98 percent of the area of any basinal area of fluvial accumulation, the vast majority of vertebrate fossils accumulate as part of passive paleosol accumulations (Bown and Kraus 1980b). Paleosols, like modern soils, form between times of major (depositional) events. The amount of vertebrate remains that accumulates during these events can be staggering. If only three bones/year accumulated on a given soil surface in a paleosol that formed for 50,000 years, that soil might be expected to yield 150,000 individual bones.

### Lance Formation

The presence of fossil localities of scientific significance in the Lance Formation is well established and has a long history (Breithaupt 1982). One of the earliest discoveries was the remains of a horned dinosaur (ceratopsian) discovered about 15 miles southeast of Point of Rocks near the old Black Butte Stage Station in 1872. These remains were identified as the new species *Agathaumus sylvestris* by Cope in 1872 and represent the first dinosaur remains found in strata now referred to as the Lance Formation.

Within the project area, the Upper Cretaceous Lance Formation consists of up to 2,900 feet of interbedded gray sandstone and sandy mudstone, carbonaceous shale, and coal. The Lance Formation is well-known for its dinosaurian remains (Breithaupt 1982); however, the only Lance fossil vertebrates found within the project area are some rare fish and crocodilian remains, as well as a few mammal teeth collected from anthills (Honey 2003). The provenance of these remains is uncertain, but they probably came from poorly developed paleosols.

### Fort Union Formation

The Fort Union Formation is exposed within the project area as up to 3,400 feet of drab mudstone, sandy mudstone, sandstone, carbonaceous shales, and coal. Fossil vertebrates—especially mammals—are well-known from Fort Union rocks in and adjoining the study area (Rigby 1980; Honey 2003), the most noteworthy localities being Swain Quarry, in Section 3, T15 N:R 92 W, and another site in the basal part of the formation discovered by J.G. Honey, the paleontologist cited in the reference above. Swain Quarry yields principally mammal teeth from a sandstone, and both that site and the new site discovered by Honey are almost certainly gradual active accumulations of bones on point bars of meandering streams. Winterfeld (1982) has recorded the occurrences of fossil vertebrates in greenish to greenish-gray Fort

Union mudstones. As these deposits are relatively thin and tabular in nature, it is quite likely that they represent the "A" horizons of relatively mature damp paleosols, and are therefore *passive accumulations*.

### Wasatch Formation

The Ramsey Ranch Member, Main Body of the Wasatch Formation and the Niland and Cathedral Bluffs Tongues of the Wasatch comprise bedrock exposures of the Wasatch Formation within the project area.

Numerous fossil vertebrates, invertebrates, and trace fossils are known from the Main Body throughout southern Wyoming (Granger 1916; Gazin 1952, 1956, 1962; 1965; McGrew and Roehler 1960; West 1973), including deposits previously referred to as the Knight and Almy "formations" by Veatch (1907). These fossils include somewhat more primitive forms of rodents, carnivores, early horses, artiodactyls, and condylarths than those in the stratigraphically younger Cathedral Bluffs Member and range between early to middle early Eocene (early to late Wasatchian) in age.

Fossil vertebrates are locally abundant in the Wasatch Formation, including all the subunits that comprise the formation in the project area. Fossils are most abundant where they have weathered from immature through mature paleosols. However, about 10 miles north of Baggs, Wyoming, sandstones of the Cathedral Bluff Member that interfingers with the Tipton Shale have produced fossils of 11 mammalian species including primates, condylarths, tillodonts, dinocerates, and perissodactyls (Roehler 1988) as well as the fossils of mollusks, ostracodes, and burrows, worm trails, and an unidentified tubular impression. The mollusks include very abundant shells of the gastropods *Goniabasis* and *Viviparus* as well as freshwater unionid bivalves. These fossil-bearing sandstones represent deposition in a delta system prograding into Lake Gosuite. West of the project area, Wasatch vertebrates are described as coming from drab, carbonaceous mudstones containing the remains of terrestrial mollusks (Savage *et al.* 1972; Gazin 1962; Savage and Waters 1978; Williams and Covert 1994). These deposits appear to be damp paleosols.

The most important Wasatch Formation fossil vertebrate locality within the study area is the so-called "Dad Local Fauna" (Gazin 1962), which was collected from the east-facing exposures of the Main Body of the formation developed on bluffs north and south of the townsite of Dad. Collection records at the University of Wyoming Geological Museum document 11 fossil vertebrate sites in the Wasatch Formation within the project area. These sites are considered to encompass the lateral extent of fossils that are interpreted to have been deposited during the same event (Vietti 2014) and their locations are not available to the public.

### Green River Formation

The Laney Shale (including LaClede and Hartt Cabin beds), Godiva Rim, Wilkins Peak (lower part only) members and Tipton (including the Scheggs and Rife beds) and Luman tongues comprise bedrock exposures of the Green River Formation within the project area (Roehler 1991a, 1991b, 1992a, 1992b, 1992c, 1993).

Apparently, the only fossils known from the Godiva Rim Member are ostracodes. The Laney Shale is quite fossil-rich in places and is well-known for its fossil fish. Fossil gastropods, bivalves, and fish are common in the LaClede Bed. Small planorbid gastropod fossils of *Gyralus militaris* are extremely abundant and widespread in one particular layer (about a foot thick) that is recognized as a stratigraphic marker bed, the Gyralus Marker Bed. Impressions of plants and insects also occur in some shales of the LaClede Bed. Stromatolites—the remains of ancient reefs—also characterize the unit. Some of the stromatolites may be as much as 25 feet high and 10 feet wide. The Hartt Cabin Bed produces abundant fossil vertebrates, mostly fish, but also reptiles and mammals, along the eastern edge of the Washakie Basin at Willow Creek.

Plant, invertebrate, and vertebrate fossils have been reported from the Wilkins Peak Member elsewhere in Wyoming (Grande 1984, 1989; Olsen 1987, 1992). Roehler (1974) noted a fossil bird locality in the member south of Rock Springs at Scrivner Butte. Another fossil bird locality occurs a few

miles away in the Four J Rim Quadrangle. This locality has yielded the dissociated skeletons, including skulls, of the wading bird *Presbyornis.* The number of individual birds preserved in the layer may number into the many thousands. Hundreds of fossil flamingo bones, apparently the remains of a large nesting colony, have been collected from a locality developed in rocks of the lower part of the member at a locality discovered near Oregon Buttes in gray-green lake claystone (McGrew and Feduccia 1973). The locality was originally described as occurring in the Cathedral Bluffs Member of the Wasatch Formation, but its location in lake sediments means that the locality actually occurs in the Wilkins Peak Member.

The Scheggs Bed preserves the fossil remains of ostracodes, gastropods, such as *Goniabasis tenera* and *Viviparus* sp., and the large unionid bivalve *Lampsilis*. Fish fossils also occur abundantly along outcrops of the Scheggs Bed (Roehler 1991a, 1991b, 1992a, 1992b, 1992c, 1993). One fossil mammal locality occurs in the Scheggs Bed and this locality, discovered in an ostracodal limestone along Parnel Creek a few miles north of Rock Springs, (T24N:R102W) produced the mold of a jaw of the early horse Hyracotherium, with incisors and molar impressions. Roehler (1992c) noted that fossil fish are locally abundant in the Rife Bed in the Sand Wash and Washakie basins.

Fossils of freshwater molluscs are abundant throughout the Luman Tongue and the assemblages of fossils are commonly characterized by the large prosobranch gastropods *Goniabasis tenera* and *Viviparus* sp. and by the large unionid bivalve, *Lampsilis* sp. Fish, ostracod, and trace fossils are also common in the unit.

### Battle Spring Formation

The Battle Spring Formation was named by Pipiringos (1955) for up to 3,300 feet of arkosic sandstone that "… intertongues with … the Red Desert, Niland, and Cathedral Bluffs tongues of the Wasatch Formation, and the Lumen and Tipton tongues and Laney Shale Member of the Green River Formation" (Pipiringos 1961). Love and Christiansen (1985) mapped Battle Spring rocks as far south as I-80 west of Rawlins, and included in it several hundred feet of gray, green, gold, and red mudstones, thin arkosic ribbon sandstones, and carbonaceous shales. No fossil vertebrates have been reported from Battle Spring rocks within the project area; however, bone fragments, including one of a fossil bird, were found in red mudstones (paleosols) during a reconnaissance survey for this study.

## 3.3 SOILS

Soils in the CD-C project area vary widely, but are predominantly formed from residuum on bedrock-controlled uplands and alluvium in playas (BLM 1999). Residuum refers to unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place. The project area is a semiarid desert that, at Wamsutter, in the center of the project area, receives an average of 7.1 inches of precipitation annually, ranging from 3.8 inches to 13.6 inches (WRCC 2014). Across the project area, average annual precipitation varies, with precipitation gradients that range from 7-9 inches to 15-19 inches. (TRC [Texas Resource Consultants] 1981; Wells *et al.* [Wells] 1981)

Two Order 3 soil surveys were previously completed by the BLM in cooperation with the Soil Conservation Service [now known as the Natural Resources Conservation Service, NRCS] for most of the CD-C project area (TRC 1981; Wells et al. 1981). For areas not covered by the existing soil surveys, Order 3 field mapping was completed by KC Harvey Environmental, LLC during May 2007. During the field mapping, existing soil-mapping units from the TRC and Wells 1981 surveys were extended into the unmapped areas of the project area using aerial imagery. The data collected by the TRC and Wells (1981) was supplemented with the KC Harvey data to complete the mapping of the project area. The proposed soil map unit boundaries in the unmapped areas were then verified in the field by sampling the soils to a depth of 60 inches with a Giddings probe (Giddings Machine Company, Colorado).

A total of 387 soil complexes, associations, taxadjuncts, and variant map units occur within the 1,070,086 acres that comprise the CD-C project area. A total of 286 soil series comprise the 387 map units.

The majority of the project area is used as rangeland for domestic livestock grazing, wildlife habitat, and recreation. A small portion of the area is used for production of native hay, both irrigated and dryland, and utilization of wood for fence posts and firewood (TRC 1981; Wells *et al.* 1981). Since the 1940s, development of the area's natural gas resources has become a dominant land use.

### 3.3.1 General Description of Major Soil Types

Soils in the project area were formed from erosion of bedrock exposed at the surface and from lacustrine, alluvium, loess, and eolian deposits (BLM 1999). The parent material in the project area is dominated by tertiary shales and sandstones and uplifted cretaceous sedimentary rock (Munn and Arneson 1998). Soils on the tertiary bedrock are poorly developed with little clay accumulation. Sandy soils occur on stabilized sand dunes and in areas with active dunes. Saline soils exist in playas, and sodic soils occur on alluvial fans derived from high-sodium parent materials. The project area contains soil orders of alfisols, inceptisols, mollisols, and aridisols. All soils within the project area have a frigid temperature regime. Soil texture is a mix of fine-loamy, coarse-loamy, and sandy materials. Slopes are generally level to undulating (zero–10 percent) and are separated by areas with steeper slopes (10–40 percent) to vertical slopes (rock outcrops).

### 3.3.2 Soil Limitations

To assess the potential limitations of the CD-C project area soils, five areas of concern were addressed: water erosion, wind erosion, runoff potential, local road construction limitations, and reclamation potential. These were evaluated using soils information from the two soil surveys completed by the BLM (TRC 1981; Wells *et al.* 1981). Results are summarized in **Table 3.3-1** and a discussion of each category is provided below.

Information from individual soil map units was used to evaluate the soil limitations. If multiple soil series existed within a single map unit, rankings were assigned based on the soil series that comprised the greatest acreage within the unit. To provide the most unbiased ranking, assignments were made using the relative size of the included soil series rather than the most limiting or the least limiting soil series within the map unit.

To ascertain the distribution of potential soil limitations for existing natural gas disturbances, the number of current wells drilled in each of the rating class areas for each limitation was determined.

**Table 3.3-1. Potential soil limitations in the CD-C project area**

| Potential Limitation | Rating Class/Limiting Features | Acres | % Total Area | % of Disturbance in Each Class[2] |
|---|---|---|---|---|
| Water Erosion | Slight | 748,850 | 69.9 | 72.8 |
| | Moderate | 230,713 | 21.5 | 21.5 |
| | Severe | 45,808 | 4.3 | 3.0 |
| | Not Rated / Water | 45,552 | 4.3 | 2.8 |
| Wind Erosion | Slight | 100,534 | 9.4 | 13.6 |
| | Moderate | 859,633 | 80.3 | 77.7 |
| | Severe | 65,204 | 6.1 | 5.9 |
| | Not Rated / Water | 45,552 | 4.3 | 2.8 |
| Runoff Potential | Low | 19,686 | 1.8 | 0.5 |
| | Low To Moderate | 21,416 | 2.0 | 0.9 |
| | Moderate | 362,499 | 33.8 | 6.6 |
| | Low to High | 67,473 | 6.3 | 35.5 |
| | Moderate to High | 237,355 | 25.0 | 29.6 |
| | High | 299,336 | 28.0 | 24.6 |
| | Not Rated / Water | 33,158 | 3.1 | 2.3 |
| Road Construction | Moderate | 680,344 | 63.5 | 63.8 |
| | Moderate / Severe | 703 | 0.1 | 0.0 |
| | Severe | 348,732 | 32.6 | 33.5 |
| | Not Rated / Water | 41,145 | 3.8 | 2.7 |
| *Rationale*[1] | Shallow to Bedrock | 55,597 | 5.2 | 3.2 |
| | Low Strength Soils Present | 902,656 | 84.4 | 87.3 |
| | Shrink-Swell Soils Present | 8,544 | 0.8 | 1.3 |
| | Soils Too Sandy | 52,110 | 4.9 | 5.4 |
| | Wet Conditions | 9,671 | 0.9 | 0.0 |
| | No Rationale | 40,934 | 3.8 | 2.7 |
| Reclamation Potential | Good | 221,785 | 20.7 | 13.7 |
| | Fair | 269,565 | 25.2 | 26.2 |
| | Poor | 537,228 | 50.2 | 57.4 |
| | Not Rated / Water | 40,934 | 3.8 | 2.7 |
| *Reclamation* | High Soil Salinity Levels | 449,199 | 42.0 | 54.4 |
| *Rationale*[1] | Large Stones Present | 4,678 | 0.4 | 0.4 |
| | Soils Too Clayey | 288,034 | 26.9 | 23.0 |
| | Soils Too Sandy | 57,433 | 5.4 | 5.5 |
| | Wet Conditions | 4,972 | 0.5 | 0.0 |

[1] *For the Road Construction Limitation and Reclamation Rationale, the limiting features should not sum to the total project acreage, as a single soil could be limited by several of the features listed.*

[2] *The percentage of disturbance in each class is estimated as the percentage of current wells located in each category.*

### 3.3.2.1 Water Erosion

To assess the potential for soil erosion caused by water, the soil erosion factor (K) obtained from data recorded by TRC and Wells in 1981 and soil slope data were used to rank the CD-C project area soils for

susceptibility to erosion. Slope data were derived from the digital elevation model for the project area (NASA 2007). The K indicates the susceptibility of a soil to sheet and rill erosion (Institute of Water Research 2002). It is one of the six factors used in the Revised Universal Soil Loss Equation to predict the average annual rate of soil loss by water erosion. The K is based on percentage of silt, sand, organic matter, soil structure, and hydraulic conductivity. The soil-surface horizon K was used to group the project area soils into water-erosion classes.

The values for K factors and slope ranges used to group the soil into slight, moderate, and severe water-erosion classes are provided in **Table 3.3-2**. The K value and percent slope data were queried to determine the surface area relative to the slight, moderate, and severe erosion classes. These data were plotted on **Map 3.3-1** to illustrate the potential for water erosion in the CD-C project area. Overall, the susceptibility to water erosion is slight, with 748,850 acres or 69.9 percent of the project area rated as having slight water-erosion potential (**Table 3.3-1**). Only 4.3 percent of the project area, or 45,808 acres, is rated as having a severe water-erosion potential. The large percentage of area classified as having slight water-erosion potential is controlled by the flat slopes that occur throughout the project area.

**Table 3.3-2. Water erosion classes determined by Erosion Factor (K) and Slope in the CD-C project area**

| Erosion Factor (K) | WATER EROSION CLASS | | |
|---|---|---|---|
| | Slight | Moderate | Severe |
| | *Slope (%)* | | |
| <0.2 | <20 | 20 to 40 | >40 |
| 0.2 to 0.32 | <15 | 15 to 35 | >35 |
| >0.32 | <10 | 10 to 20 | >20 |

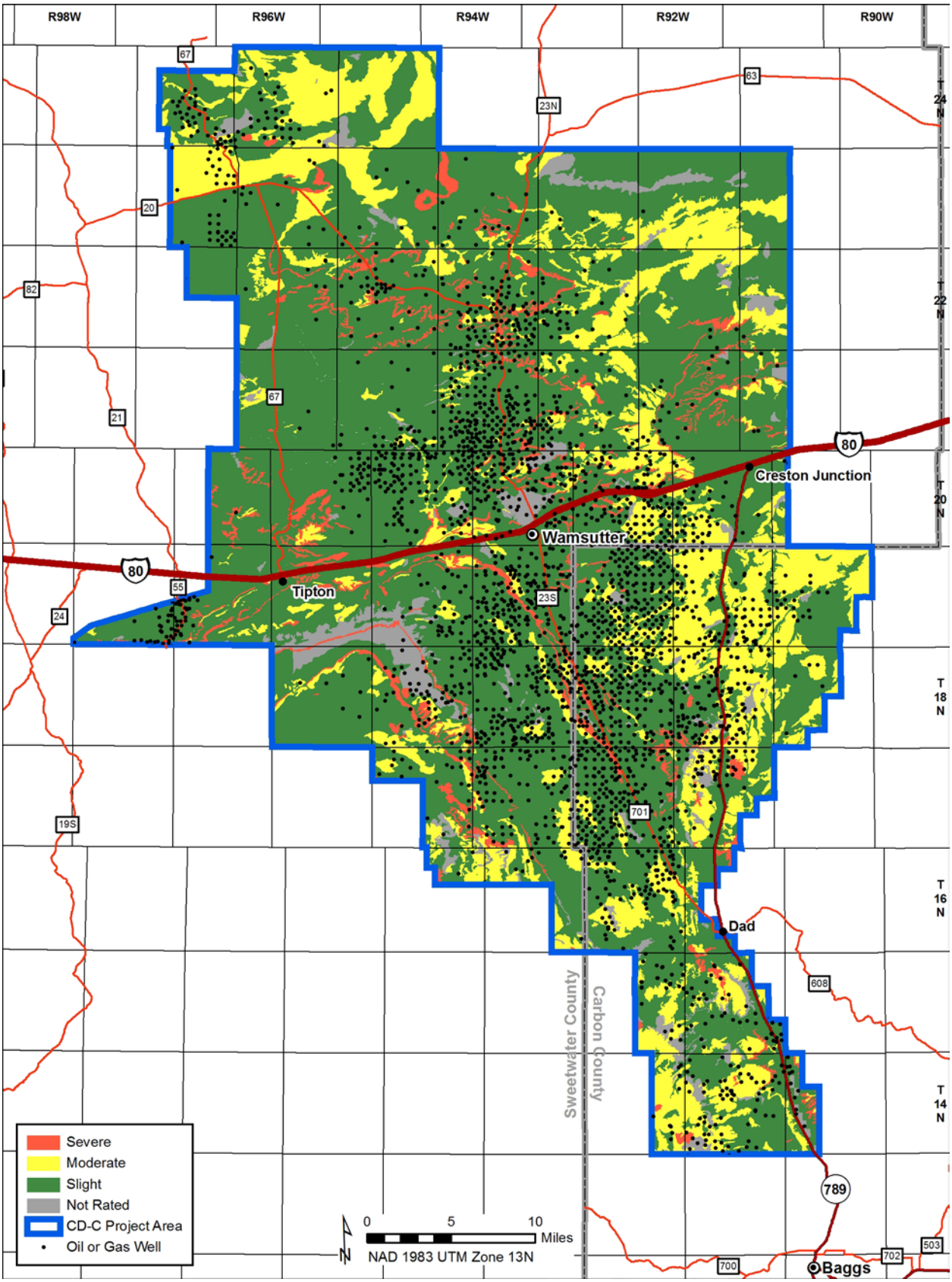
According to 2009 data, 72.8 percent of the total wells currently drilled within the CD-C project area are located within soils that have a slight risk for water erosion.

#### 3.3.2.2 Wind Erosion

To assess the potential of soil erosion by wind, the wind-erodibility class was obtained from data recorded by TRC (1981) and Wells *et al*. (1981). Wind-erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. Soils are grouped according to percent sand, silt, and clay; calcium carbonate content; presence of surficial coarse fragments; and surface-wetness conditions.

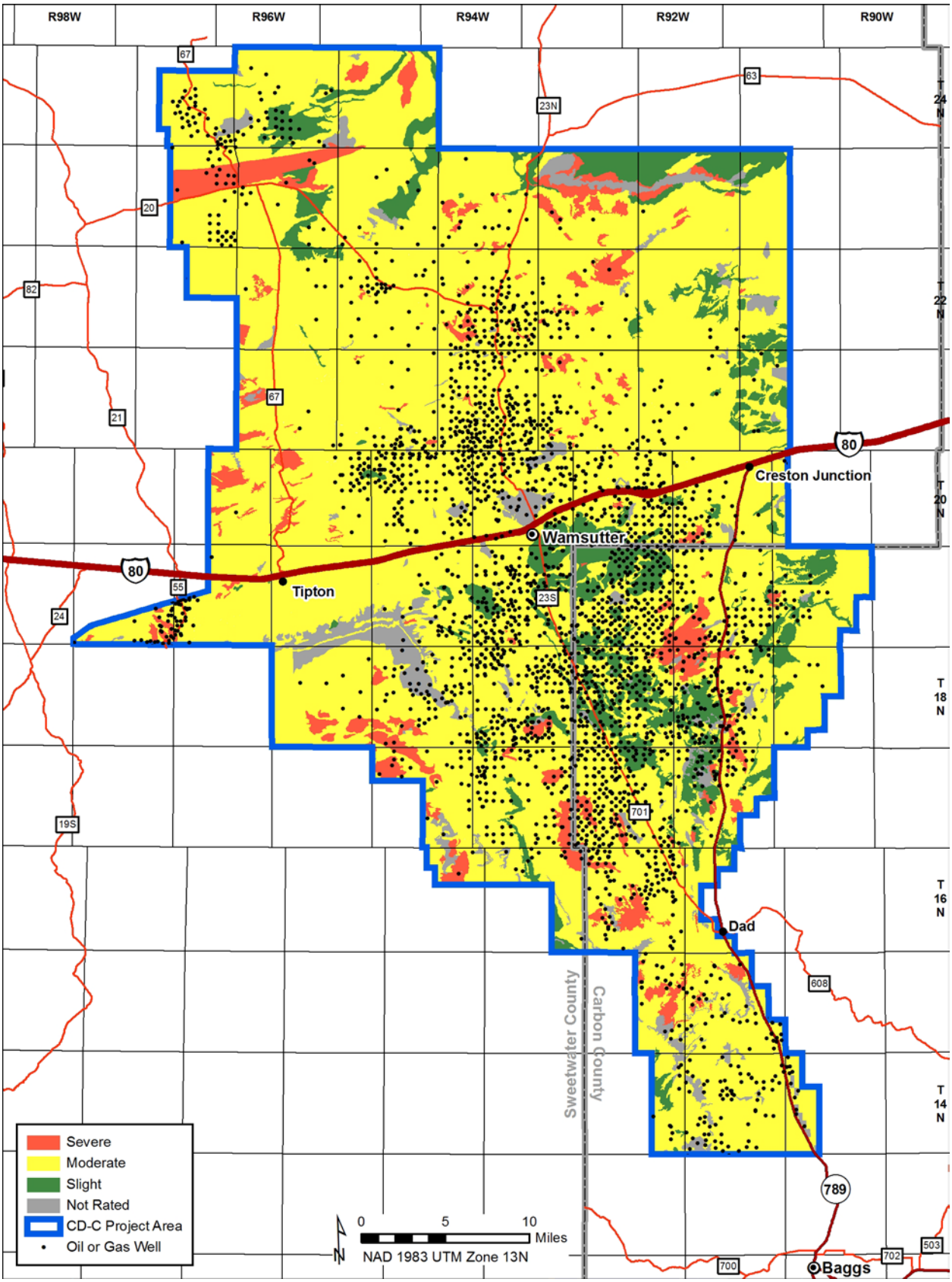
The potential for wind erosion in the CD-C project area is shown on **Map 3.3-2**. Soils within the 1 and 2 wind-erodibility groups are classified as a severe limitation for wind erosion; soils in the 3, 4, and 4L wind-erodibility groups are considered as a moderate limitation for wind erosion; and soils in the 5, 6, 7, and 8 wind-erodibility groups have a slight limitation for wind erosion (TRC 1981, Wells *et al.* 1981). A moderate limitation because of wind erosion exists for 80 percent of the total project area or 859,633 acres (**Table 3.3-1**). Only 9.4 percent or 100,534 acres and 6.1 percent or 65,204 acres, respectively, are rated to have slight and severe limitations to wind erosion, respectively.

According to 2009 data, 78 percent of the total wells currently drilled within the CD-C project area are located within soils that have a moderate limitation for wind erosion.




**Map 3.3-1. Water-erosion potential of soils for the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.




**Map 3.3-2. Wind-erosion potential of soils for the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

#### 3.3.2.3 Runoff Potential

To assess the potential for surface runoff, the hydrologic soil group was obtained from TRC (1981) and Wells *et al.* (1981). The hydrologic soil group classifies soils according to their runoff-producing characteristics, which include depth to the water table, infiltration rate, permeability after prolonged wetting, and depth to the lowest permeable layer. Also, site-specific factors relating to management practices are considered, such as compaction, crusting, organic matter, and vegetative cover. The hydrologic group rating only considers the potential for runoff when soils are thoroughly wet and does not consider the slope of the soil.

The potential for surface runoff in the CD-C project area is shown on **Map 3.3-3**. Soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). Only soils in their natural condition in group D are assigned to dual classes. Soils within Hydrologic Soil Group A are considered to have a low runoff potential, Hydrologic Soil Group B soils have a moderate runoff potential, and Hydrologic Soil Groups C and D soils are considered to have a high runoff potential. Dual classes (e.g., A/D or Low to High) are used for certain wet soils that can be adequately drained. The first letter is for drained condition and the second is for undrained condition within the same map unit. Surface-runoff potential was predominantly moderate, composing 34 percent of the project area or 362,499 acres (**Table 3.3-1**). A rating of high runoff potential was given to 299,336 acres or 28 percent of the CD-C project area.

According to 2009 data, 36 percent of the total wells currently drilled within the CD-C project area are located within soils that have a moderate runoff potential.

#### 3.3.2.4 Road Construction

To assess the degree of limitation to the construction of roads, unsurfaced road ratings were obtained from TRC (1981) and Wells *et al.* (1981). Road rankings were based on depth to bedrock, soil strength, shrink/swell potential, soil texture, large surface stones, slope, and surface wetness.

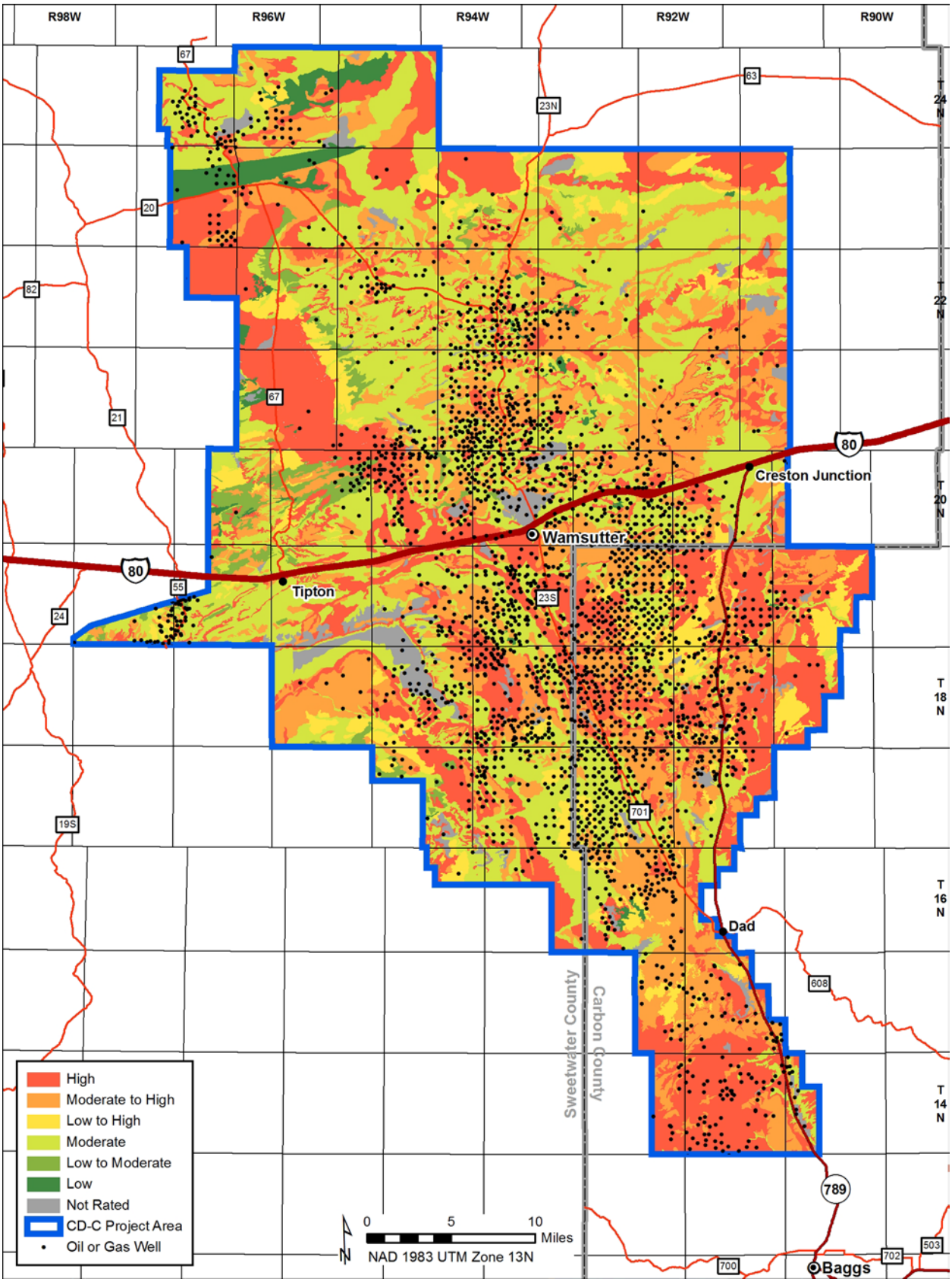
The potential limitation for the construction of roads in the CD-C project area is shown in **Map 3.3-4**. The CD-C project area is predominantly rated as having a moderate limitation for road construction, with 63.5 percent, or 680,344 acres, having this rating (**Table 3.3-1**). The limiting features to road construction are provided in Table 3.3-1. Soil strength, depth to bedrock, and sandy soil textures are the main limitations to construction in the CD-C project area.

According to 2009 data, 64 percent of the total wells currently drilled within the CD-C project area are located within soils that have moderate limitations to road construction.

#### 3.3.2.5 Reclamation Potential

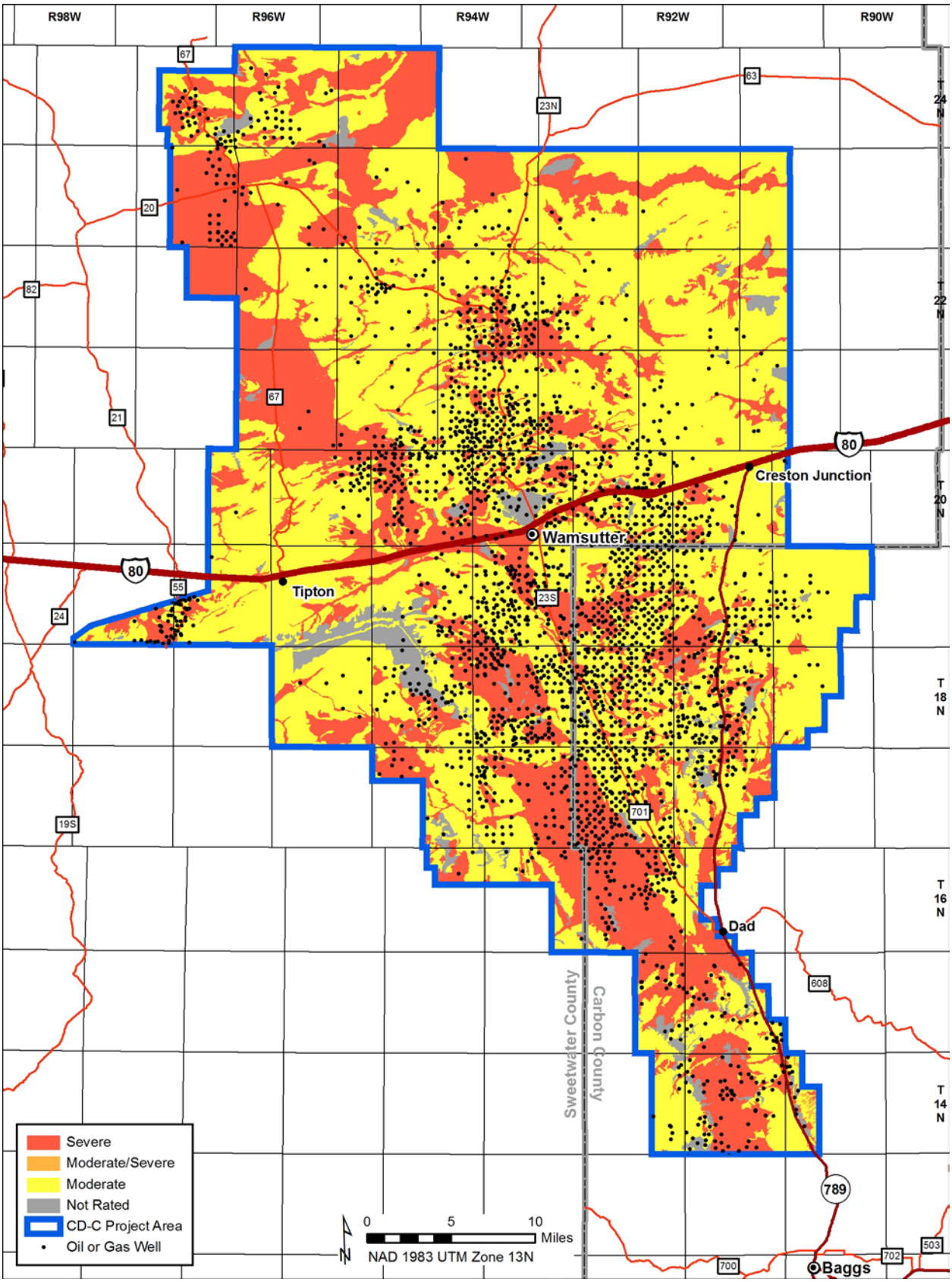
Reclamation is the return of disturbed land as near to its predisturbed condition as is reasonably practical (BLM 2007g). The BLM's long-term objective of final reclamation is to set the course for eventual ecosystem restoration, including the restoration of the natural vegetation community, hydrology, and wildlife habitats. In most cases, this means returning the land to a condition approximating or equal to that which existed prior to the disturbance. The Operator must achieve short-term stability, visual, hydrological, and productivity objectives of the surface-management agency and must take steps to ensure long-term objectives will be reached though natural processes (USDI and USDA 2006).

To determine reclamation potential of the CD-C project area soils, the topsoil rating presented in the soil surveys prepared by TRC (1981) and Wells et al. (1981) was used as a direct correlation of the soil reclamation potential. Soils having good, fair, or poor topsoil ratings are classified on **Map 3.3-5** as having good, fair, and poor reclamation potential, respectively.



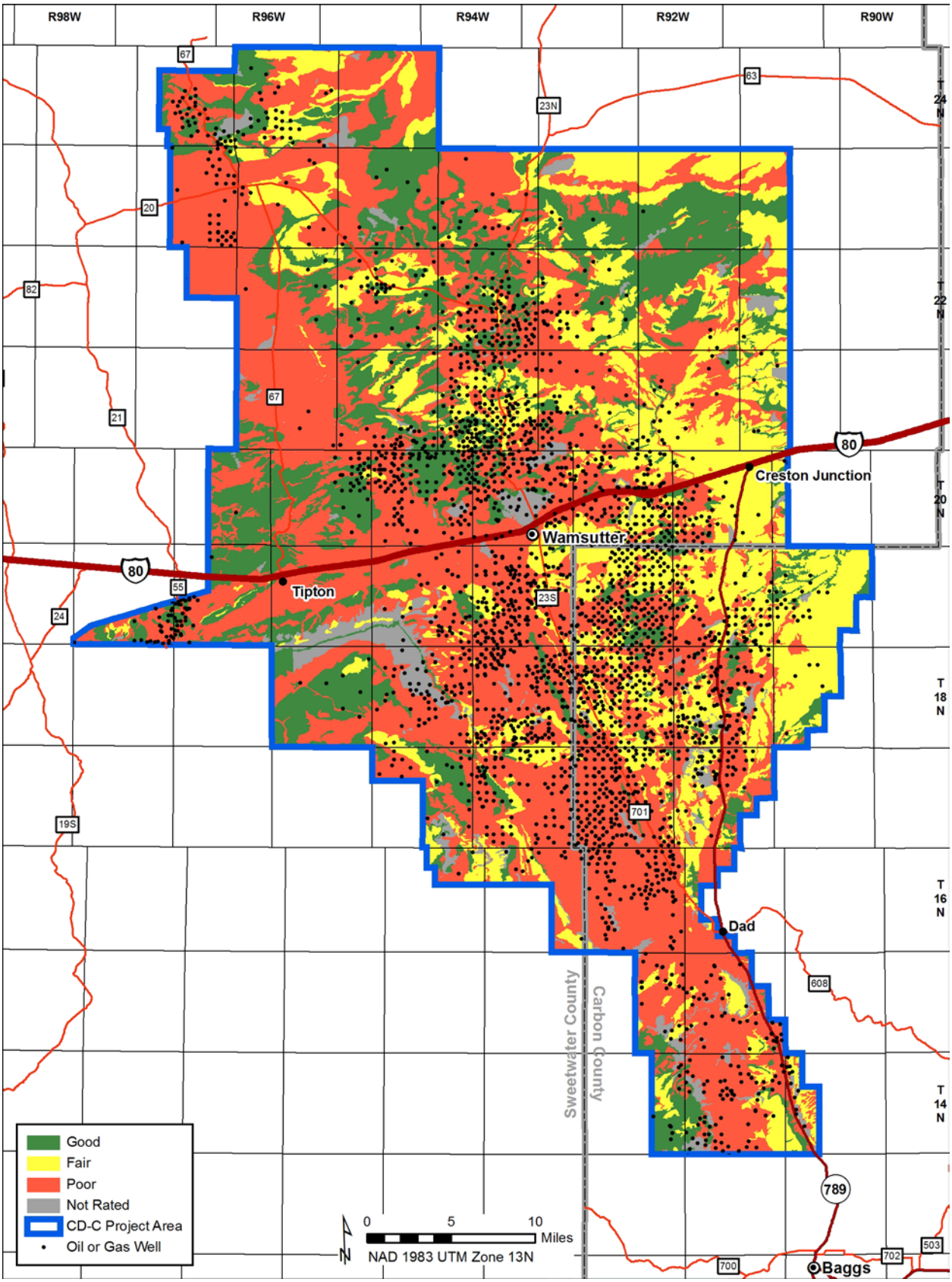

**Map 3.3-3. Runoff potential of soils in the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.




**Map 3.3-4. Potential road construction limitations of soils in the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.




**Map 3.3-5. Reclamation potential for soils in the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

The soil classifications defined in the soils survey are influenced by many factors such as rainfall, slope, and aspect in addition to the physical and chemical composition of the soil. The direct correlation used between topsoil rating and soil reclamation potential indirectly considers the factors that would be favorable or unfavorable for soil reclamation.

The reclamation potential of the CD-C project area is primarily poor, with 537,228 acres or 50 percent of the total project acreage having this rating (Map 3.3-5, **Table 3.3-1**). Locations identified as "No Rating" on Map 3.3-5 generally consist of rock outcrops or rock surfaces that did not include a topsoil rating since topsoil is not present in these locations.

Rankings of fair and good were given to 25 percent or 269,565 acres, and 21 percent or 221,785 acres of the CD-C project area, respectively. The limiting features to reclamation are provided in **Table 3.3-1**. Saline/sodic soil conditions and either clayey or sandy soil textures are the main limitations to reclamation of the CD-C project area.

According to 2009 data, 57 percent of the total wells currently drilled within the CD-C project area are located within soils that have poor reclamation potential. For the currently drilled well locations with limitations to reclamation, the main limitation to reclamation is saline/sodic soil conditions.

### 3.3.3 Watershed-Based Land Health Assessment

The RFO has finished conducting Standards and Guidelines Assessments for all the watersheds within the Field Office. These are watershed-based land health assessments mandated by the Director of the BLM on a 10-year basis at which time progress towards management objectives will be evaluated. From 1998 through 2000, the RFO conducted Standards and Guidelines Assessments on an allotment basis; however, in 2001, in order to meet this 10-year timeframe, larger-scale watershed-based reports were undertaken. The Upper Colorado River and the Great Divide Basin were the first two watershed reports completed (2002 and 2003, respectively), and were reassessed in 2011 and 2012, respectively. Standard 1 – Watershed Health, states that "[w]ithin the potential of the ecological site (soil type, landform, climate, and geology), soils are stable and allow for water infiltration to provide for optimal plant growth and minimal surface runoff" (BLM 2013b). Standard 1 is considered met if upland soil cover generally exceeds 30 percent and obvious signs of soil erosion are not apparent and if stream channels are stable and improving in morphology. Key watershed health-related issues identified by the Standards and Guidelines Assessment for the Upper Colorado River and Great Divide Basin include erosion from improved and unimproved roads, and short- and long-term erosion from oil and gas field development. During the 2012 field season, the four watersheds described within the Great Divide Basin/Ferris and Seminoe Mountains assessment report (BLM 2013b) were assessed and it was determined that the four watersheds meet Standard 1. The largest of the four watersheds, the Great Divide Basin, includes the northern portion of the CD-C project area.

During the 2011 field season, project area watersheds within the Upper Colorado River Basin were assessed (BLM 2012i). It was determined that the majority of the watershed is meeting Standard 1. The four locations not meeting Standard 1 are remaining active head-cuts on lower Holler Draw (1,400 acres), upper and lower Cottonwood Creek (300 acres), and Wild Cow Creek (2,000 acres). Two of the locations, Wild Cow Creek and Cottonwood Creek, are located within the project area. The head-cuts are due to long-term gradient readjustment processes (following historic livestock overgrazing). Livestock management is no longer contributing to the non-attainment of this standard.

## 3.4 WATER RESOURCES

Water resources in the CD-C project area include both surface water and groundwater. A majority (approximately 70 percent) of the project area is located within the Great Divide Basin (hydrologic unit code [HUC] 14040200). Approximately 29 percent of the project area is within the White-Yampa Basin (HUC 140500) and 1 percent is within the Upper Green Basin (HUC 140401). Watershed boundaries within the project area are shown on **Map 3.4-1**. Surface water in the Great Divide Basin drains internally, with no surface hydrologic outlet. The Upper Green and White-Yampa watersheds are part of the Upper Colorado Basin (HUC 14).

Groundwater resources in the project area include unconfined (water table) and confined aquifers. The unconfined aquifers are generally shallow, blanket-type deposits of Quaternary or Tertiary age and are generally found within 400–600 feet of the ground surface. Alluvial deposits fall into this category. Confined aquifers are bound by relatively impermeable rocks and are generally in the deeper formations, such as the Mesaverde Group. Most of the geologic formations of pre-Oligocene age in the project area contain water under confined pressure (Welder and McGreevy 1966). Conventional oil and gas wells would be completed in the Almond Formation in the Mesaverde Group at depths between 8,000 and 12,000 feet.

### 3.4.1 Climate and Precipitation

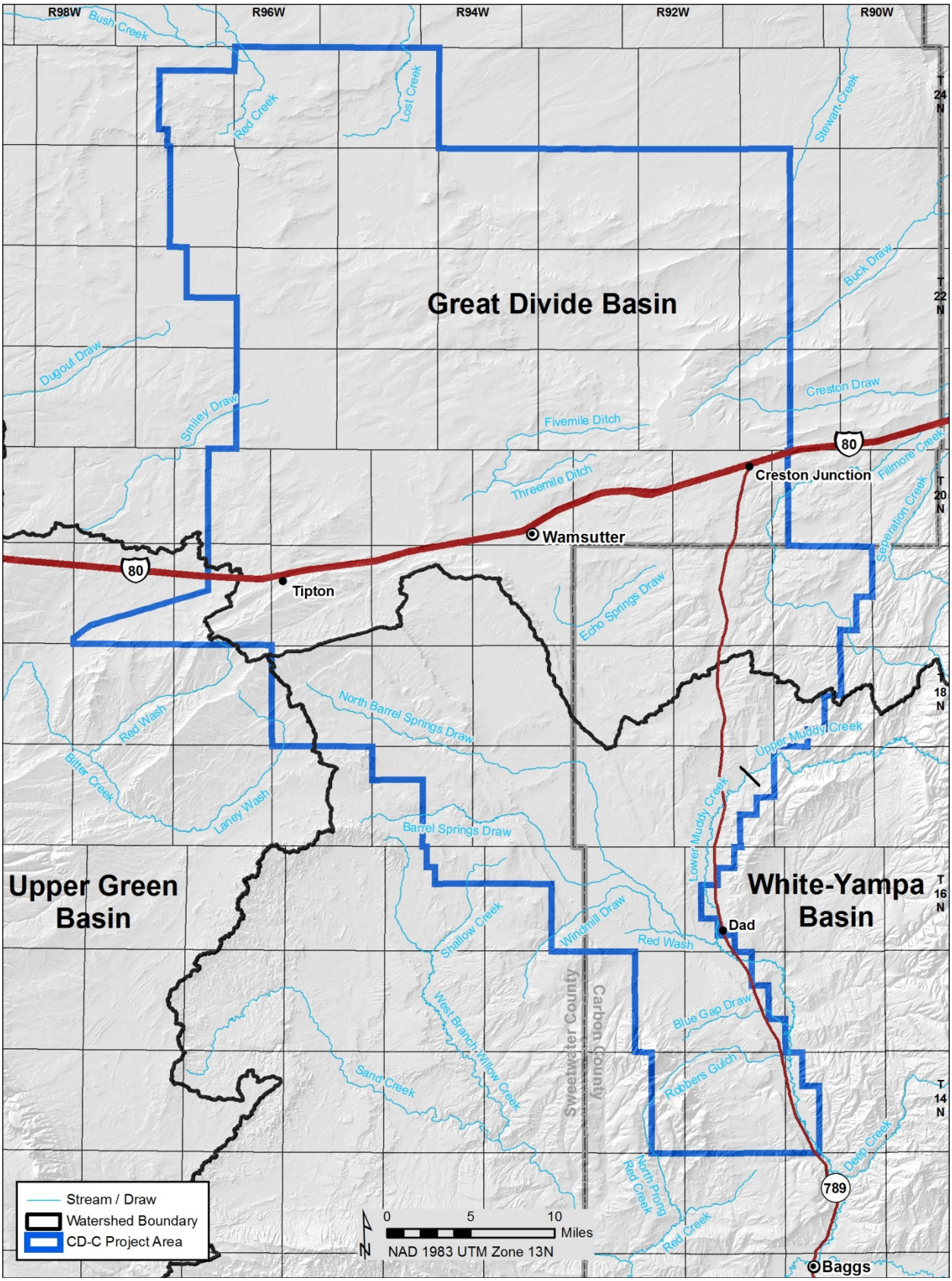
Climate and precipitation, as detailed in **Section 3.5** (**Air Quality**), greatly influence the character and condition of the surface and groundwater resources. The project area is located in a continental dry, cold-temperature-subarctic climate (Trewartha 1968). The climate is characterized by precipitation deficiency, where potential evaporation exceeds precipitation. Temperatures are generally cold, with fewer than eight months of the year having an average temperature greater than 50° F. Summer days are warm, summer nights are cool, and winters are cold. Strong and prolonged winds periodically sweep the project area throughout the year, being especially prevalent in winter.

These climatic conditions (low precipitation and high evaporation rates) result in the prevalence of surface water features in the project area with ephemeral or intermittent flows. The climatic conditions are reflected in the limited amount of shallow groundwater and the prevalence of confined aquifer systems. Recharge to the groundwater systems generally occurs at higher, distant elevations, with limited local recharge to the shallow aquifers.

### 3.4.2 Surface Water

There are three major drainage basins associated with the project area (**Map 3.4-1**). The Continental Divide runs east and west across the central portion of the project area. Drainages in the project area south of the Continental Divide flow into the Upper Green Basin or the White-Yampa Basin. Tributaries to Bitter Creek drain the portion of the project area within the Upper Green Basin. Bitter Creek flows to the Green River, which flows to the Colorado River, and ultimately to the Pacific Ocean. Tributaries to the Little Snake River drain the portion of the project area within the White-Yampa Basin. The Little Snake River flows to the Yampa River, which flows southwest to its confluence with the Green River in Colorado. Drainage north of the Continental Divide is contained in the Great Divide Basin. As mentioned above, the Great Divide Basin is internally drained, with no surface hydrologic outlet.

Just over 1 percent of the project area is within the Upper Green Basin. Tributaries to Bitter Creek (Red Wash and Laney Wash) begin in the project area and flow out of the area to the southwest (**Map 3.4-1**). Surface water hydrology data are limited for the portion of the project area within the Upper Green Basin due to the dry nature of the climate and resulting minimal stream-flow in the area.




**Map 3.4-1. Major watersheds and drainages within the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

Very small portions of the White-Yampa Basin within the project area are drained by Willow Creek/Shallow Creek (tributaries to Sand Creek) and the North Prong of Red Creek. The remainder of the White-Yampa Basin within the project area is drained by Muddy Creek and its tributaries. Muddy Creek is the dominant water feature within the project area and it flows into the perennial Little Snake River, immediately south of the project area (**Map 3.4-1**).

Most surface water flow within the Great Divide Basin is ephemeral (occurring only in response to localized rainfall or snowmelt) or intermittent (flowing water during certain times of the year, when groundwater provides water for stream flow). The only streams in the Great Divide Basin with perennial flow are the upper portion of Separation Creek, in the Atlantic Rim area, and Lost Soldier Creek, in the Green Mountain area. Lost Soldier Creek is not within the project area. A majority (approximately 85 percent) of the Great Divide Basin drainage area within the project area drains internally, not leaving the project area. Approximately 10 percent of the Great Divide Basin drainage area within the project area receives run-on from other areas in the basin (Bear Creek, Red Creek, Lost Creek, and Stewart Creek to the north, and Smiley Draw to the west). Surface water from the remaining 5 percent of the project area in the Great Divide Basin drains to the east off the project area by way of Creston Draw, Buck Draw, and Fillmore Creek, which are tributaries to Separation Creek. Major surface water features within the Great Divide Basin associated with the project area are shown on **Map 3.4-2**.

#### 3.4.2.1 Surface Water Location and Quantity

Detailed information regarding surface water quantity within the project area is provided in **Appendix F, Water Resources Supplemental Data.** Historic flow data are available near the project area from one station on Muddy Creek (USGS Station 09259000) and one station on the Little Snake River (USGS Station 09257000). More recent flow data are available from two stations: one station monitored between 2004 and the present on Muddy Creek below Young Draw, Near Baggs, WY (USGS Station 09258980) and another station, monitored between 2010 and the present, on Muddy Creek above Olson Draw, near Dad, WY (USGS Station 09258050). Historic flow data in the Great Divide Basin are available near the project area from two stations on Separation Creek (USGS Stations 09216525 and 09216527). Although all five of these stations are outside of the project area, they represent the nearest USGS flow monitoring stations.

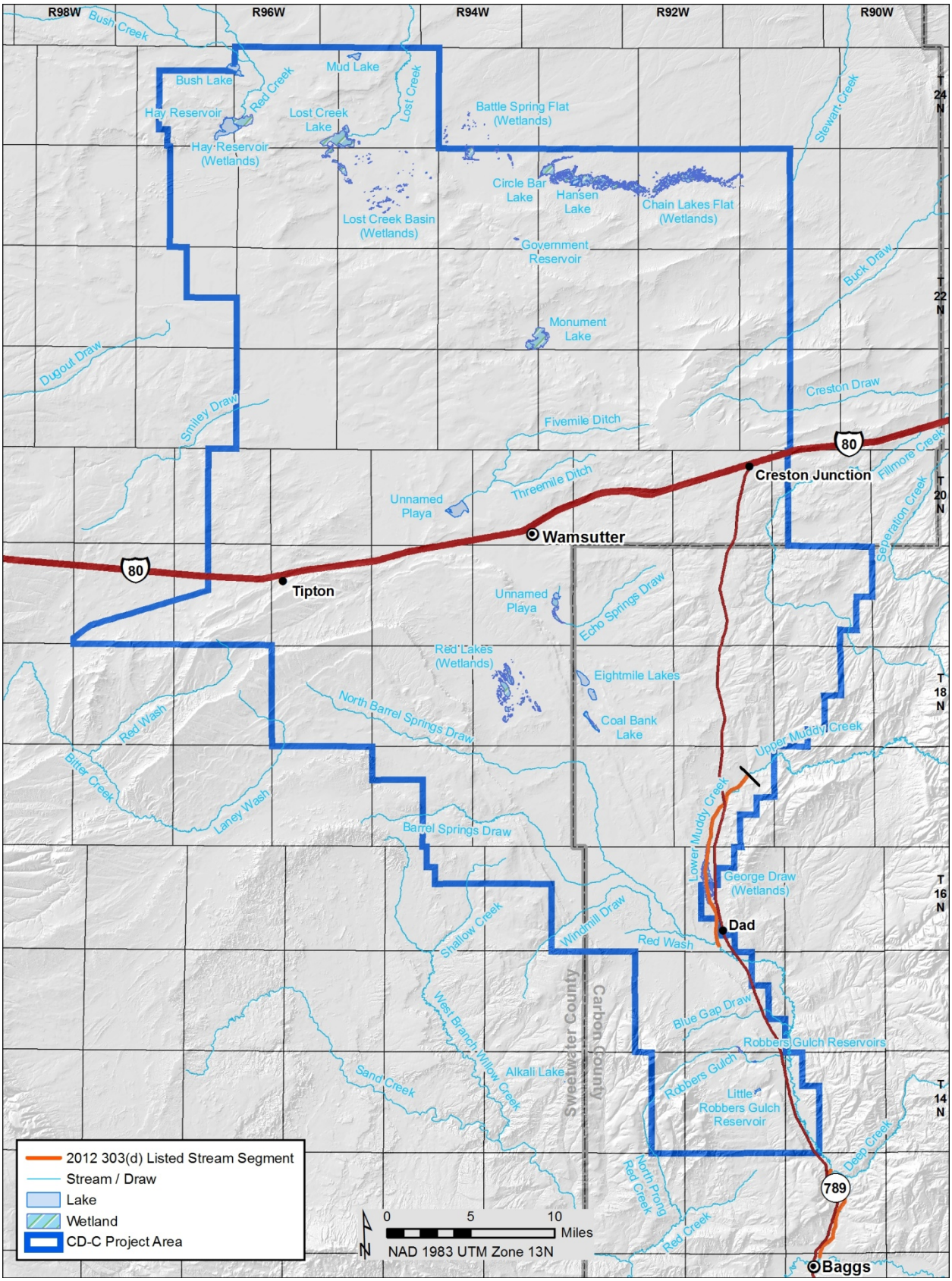
**Upper Green Basin**

A very small portion of the project area drains into the Upper Green Basin (**Map 3.4-1**). Less than one percent of the project area is drained by tributaries to Bitter Creek (HUC 14040105). Bitter Creek is a perennial stream that flows into the Green River approximately 50 miles west of the project area and is managed through the Rock Springs BLM office, in conjunction with the Sweetwater County Conservation District. Historical flow data (1975-1981) are available from one monitoring station on Bitter Creek (USGS Station 09216545). Flow data from this station varied widely, from zero to 333 cubic feet per second (cfs).

**White-Yampa Basin**

Approximately 29 percent of the project area is drained by the White-Yampa Basin (**Map 3.4-1**). Watersheds within the White-Yampa Basin that are associated with the project area include the Muddy Creek Sub-basin (HUC 14050004) and the Little Snake Sub-basin (HUC 14050003).

Muddy Creek begins in the Sierra Madre Range, east of the project area. Muddy Creek and its ephemeral tributaries, including Barrel Springs Draw (and its tributaries North Barrel Springs Draw and Windmill Draw), Blue Gap Draw, Robbers Gulch, and Red Wash, are included in this sub-basin. Muddy Creek flows west to WY 789, where it enters the project area. It then flows south, meandering in and out of the project area, to its confluence with the Little Snake River near Baggs, Wyoming, approximately 6 miles




**Map 3.4-2. Surface water features in the CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

south of the project area (**Map 3.4-1**). The Muddy Creek watershed encompasses approximately 1,200 square miles ($mi^2$) and ranges in elevation from about 6,300 to about 8,200 feet.

Muddy Creek is a high-elevation, cold-desert stream. Streamflow varies with location along the drainage. Muddy Creek exhibits perennial flow for the majority of its length, and in some years flows intermittently because of irrigation water removal south of the George Dew/Red Wash wetlands complex. In years with high runoff amounts, Muddy Creek flows perennially throughout its length. Snowmelt (typically April to mid-June) produces significant runoff from higher elevations of the watershed, east of the project area. The intermittent stream flow that is present in some reaches below the George Dew/Red Wash wetlands complex is due to contributions from springs, seeps, and flowing wells. High-flow events can occur in response to precipitation events during the summer and fall months.

Flow in the tributaries to Muddy Creek is predominantly ephemeral, responding to localized snowmelt and rainfall events, but tributaries may also experience some intermittent flow due to contributions from springs and seeps. Tributary channels are generally dry and prone to flashy, periodic flood events from isolated thunderstorm systems from May to October.

Beatty (2005) divided Muddy Creek into two major segments: upper Muddy Creek and lower Muddy Creek (**Map 3.4-1**). The upper segment is identified as that portion of the watershed upstream of a large headcut stabilization structure that is located in Section 11, T17N: R92W. This structure is located just downstream of where Muddy Creek crosses the Atlantic Rim project area boundary and just upstream of where Muddy Creek crosses WY 789 (Map 3.4-1). The four primary tributaries mentioned above are within the lower segment, which extends from the large headcut stabilization structure to the Little Snake River confluence. Lower Muddy Creek is highly erosional and has abundant channel incisions (Beatty 2005). Channel substrates in the lower segment consist of very fine-grained sediments (sands, silts, and clays). A large wetland complex (George Dew/Red Wash) occurs on the reach of Muddy Creek that lies west of WY 789 (**Map 3.4-2**). This wetland area consists of impoundments, artificially constructed channels, vertical drop structures, headgate structures for water diversion, overflow spillways, and a braided stream-channel network.

The historical mean flow rates at two USGS Stations (09259000 and 09258980) on Muddy Creek near Baggs were 14.8 cubic feet per second (cfs) and 18.0 cfs, respectively. Calculated median flows at the same two stations were 2.8 cfs and 1.1 cfs (USGS 2011a). Median flows are generally more representative of the central tendency of the data because high and low flow can dramatically impact the average whereas the median is less affected. Because precipitation varies significantly from year to year, annual runoff values can vary significantly. Based on the 1,200 $mi^2$ drainage area and a 2004-2013 average annual runoff of 15,867acre feet per year, the unit runoff for the Muddy Creek at USGS Station 09258980 is about 0.2 inch per acre per year (USGS 2014a), which indicates relatively little runoff.

The Upper Muddy Creek Watershed/Grizzly Wildlife Habitat Management Area (WHMA) is located primarily east of the CD-C project area (**Map 3.9-**5). The western-most portion of the WHMA lies within the CD-C project area. The goal of the WHMA is to "manage habitat for the Colorado River fish species unique to the Muddy Creek watershed" (BLM 2008a). The WGFD has been working with the BLM, the grazing permittee, and the Little Snake River Conservation District (LSRCD) to implement conservation measures in the Upper Muddy Creek Watershed/Grizzly WHMA. According to the Rawlins RMP, the area is open to oil and gas leasing with intensive management of surface-disturbing and disruptive activities (BLM 2008a).

Willow Creek/Shallow Creek (tributaries to Sand Creek) and the North Prong of Red Creek are drainages in the Little Snake Sub-basin that drain a small portion of the project area. Sand Creek and the North Prong of Red Creek flow into the Little Snake River approximately 8 miles from the southwest corner of the project area boundary (**Map 3.4-1**). Willow Creek/Shallow Creek and the North Prong of Red Creek are unclassified ephemeral drainages. No flow data are available for Willow Creek or the North Prong of

Red Creek. The Little Snake River originates in the Sierra Madre Range and flows southwest into Colorado. The historical (1910–1923 and 1938–1971) mean flow rate at USGS Station 09259000 on the Little Snake River near Dixon was 514.3 cfs. Calculated median flow at the same station was 100.0 cfs (USGS 2011a). Because precipitation varies significantly from year to year, annual runoff values can vary significantly. Based on the 988 $mi^2$ drainage area above USGS Station 0925700 and a 1911-1971 average annual runoff of 372,355 acre feet per year, the unit runoff for the Little Snake River at USGS Station 09257000 is about 7.1 inches per year (USGS 2011a).

**Great Divide Basin**

The northern 70 percent of the project area is within the Great Divide Basin, a closed basin that is bounded by the Continental Divide on all sides and has no surface hydrologic outlet (USGS 1976; Seaber et al. 1987). The Great Divide Basin is a relatively shallow depression with isolated buttes, pan-like depressions, and sparse vegetation. In general, streams within the Great Divide Basin are ephemeral, but can be intermittent in sections (Lowham et al. 1976). The only streams in the Great Divide Basin with perennial flow are the upper portion of Separation Creek, in the Atlantic Rim area and Lost Soldier Creek, in the Green Mountain area. Numerous ephemeral streams flow toward the center of the Basin and terminate in natural or artificially constructed impoundments or disappear due to losses to diversions, evaporation, and/or infiltration (seepage). There are some spring-fed systems such as the Battle Springs Flat and unique alkaline wetland systems around Chain Lakes. Since a majority of the project area is within the Great Divide basin and since it is a closed basin, a majority of the surface water flow originating in the CD-C project area terminates within the project boundary.

The Chain Lakes wetlands are located in the north central portion of the CD-C project area (**Map 3.4-2**). They are managed cooperatively by the WGFD and BLM as the Chain Lakes WHMA. The Chain Lakes WHMA consists of 30,560 acres of public lands in a checkerboard pattern. This area is one of the lowest topographic regions (6,500 feet in elevation) within the Great Divide Basin, resulting in numerous shallow lakes that are alkaline due to the lack of external water outlets. The annual precipitation of less than 7 inches, high evaporative loss rates, and surface salt crusting also contribute to shaping this community. The lakes and adjacent moist soils support a variety of plant and animal species adapted to this environment. The goal of the Chain Lakes WHMA is to "*manage the unique, fragile, and rare alkaline desert lake system and wildlife habitat values associated with the lake system*" (BLM 2008a). According to the approved Rawlins RMP, the area is open to oil and gas leasing with intensive management of surface disturbing and disruptive activities (BLM 2008a).

While a majority of the surface water flow originating in the project area terminates within the project boundary, the majority of surface water leaving the project area in the Great Divide Basin flows into Separation Creek via Fillmore Creek and Creston Draw. Separation Creek flows adjacent to and east of the CD-C project area to Separation Lake. Separation Creek is, for most of its length, an ephemeral stream. It exhibits perennial flow in its upper reaches. Average flows documented at the two stations near Riner are 1.3 to 1.8 cfs. Estimated annual runoff volume for downstream reaches of Separation Creek is 2,500 acre-feet (ac-ft) (Larson and Zimmerman 1981). Fillmore Creek is an ephemeral stream (WDEQ 2001) that flows only in response to snowmelt or rainstorms, with snowmelt as the biggest contributor. Springs provide minor flow in the upstream reaches.

Several other small ephemeral streams flow out of the project area but also have no outlets from the Great Divide Basin.

**Reservoirs, Lakes, and Ponds**

According to the Wyoming State Engineer's Office (SEO) database, there are 286 reservoirs with valid water rights within the project area (SEO 2011). Approximately 96 percent (274) of these water bodies have an appropriated use of livestock. Major reservoirs within the CD-C project area are shown on **Map**

**3.4-2**. A complete list of valid surface-water rights associated with reservoirs, lakes, and ponds is included in **Appendix F, Water Resources Supplemental Data.**

**Wetlands**

Wetlands are aquatic features defined as "*those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas*" (33 CFR 328.3(b)). The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promote the development of characteristic wetland (hydric) soils (EPA 2007). Vegetation in wetland environments is highly productive and diverse and provides habitat for many wildlife species. These systems as a whole play important roles in controlling floodwaters, recharging groundwater, and filtering pollutants (Niering 1985).

The U.S. Army Corps of Engineers (USACE) administers a regulatory program under Section 404 of the Clean Water Act (CWA), which requires a permit for the discharge of dredged or fill materials into Waters of the U.S., including jurisdictional wetlands. This regulatory program requires that an inventory of all Waters of the U.S, including wetlands, be performed; permits be acquired prior to dredging or filling jurisdictional wetlands; and impacts to jurisdictional wetlands and other Waters of the U.S. be adequately mitigated. In addition, there are a number of isolated wetlands in the CD-C project area which may not be considered jurisdictional Waters of the U.S.; however, they are still Waters of the State and are protected as such.

Formal wetland delineations have not been confirmed by the USACE for the project area. A preliminary evaluation of potential wetlands within the project area was completed using National Wetland Inventory (NWI) mapping. According to the NWI mapping, prominent natural wetland systems are found near internally drained sub basins in the northern portion of the project area within the Great Divide Basin (Hay Reservoir area, Lost Creek Basin, Battle Springs Flat, and Chain Lakes Flat) and artificially constructed/enhanced wetlands occur along Muddy Creek (George Dew/Red Wash wetland complex) in the southern portion of the project area (**Map 3.4-2**). There are also a large number of small wetlands linked to natural or artificially constructed impoundments throughout the project area. The vegetation types associated with riparian/wetlands habitats are discussed in **Section 3.6.2.9**.

### 3.4.2.2 Surface Water Use

As of July 2014, the SEO had a total of 347 permitted surface water rights on record within and 1 mile adjacent to the project area (SEO 2014). Per Wyoming law, a water right requires that the water be put to a beneficial use. Stock watering is the beneficial use associated with 293 of the surface water rights. Surface water rights were also associated with irrigation use (28), wetlands and fisheries (17), reservoir supply (7), industrial/oil (10), domestic (5), wildlife (1), and unspecified (3). (SEO beneficial uses are different from WDEQ water quality designations, which are discussed below).The total for permitted uses exceeds the number of permitted surface water rights due to the fact that many of the surface water rights were permitted for multiple uses. A complete list of valid surface-water rights is included in **Appendix F.**

WDEQ classifies Wyoming surface water resources according to the water body's use designation. More detailed information regarding surface-water use classifications is presented in **Appendix F**.

Ten lakes and reservoirs within the project area are classified for use by WDEQ (**Map 3.4-2**). None of the lakes or reservoirs in the project area are classified for *outstanding value* (Class 1). The highest classification on lakes and reservoirs within the project area is *drinking water* (Class 2A). One reservoir (Little Robbers Gulch Reservoir) is within this classification and is protected as a cold water game fishery. The highest classification for five of the lakes/reservoirs is *drinking water* (Class 2AB.). The highest use classification for the remaining four water bodies is *other aquatic life* (Class 3B).

Seventeen streams and springs within the project area and two near the project area are classified by the WDEQ. The streams and springs within the project area include Robber's Gulch, Blue Gap Draw, Red Wash, Windmill Draw, Barrel Springs Draw, North Barrel Springs Draw, Shallow Creek, Lower Muddy Creek, Upper Muddy Creek, Echo Springs Draw, Laney Wash, Creston Draw, Buck Draw, Lost Creek, Red Creek, Bush Creek, and Smiley Draw. None of the streams in or near the project area are classified for *outstanding use* (Class 1). The Little Snake River, located near the project area, is classified for use as *drinking wate*r (2AB). The highest classification for two streams within or near the project area is *non-game fish* (2C). The highest classification for 14 of the 19 streams/springs is *other aquatic life* (Class 3B). The highest classification for the remaining two streams is for *non-aquatic life use* (Class 4B/C).

#### 3.4.2.3 Surface Water Quality

In the arid high plains of southwestern Wyoming, surface-water quality, like stream flow, is variable both spatially and temporally. Perennial stream water is generally of better quality than that of the ephemeral and intermittent streams. The quality of runoff is largely dependent upon the amount of salts, sediments, and organic materials that accumulate in dry stream channels between periods of runoff. Factors that can govern the amount of buildup of these materials are a basin's physical characteristics, land uses, and season of the year. More detailed information regarding water quality is presented in **Appendix F**.

According to **Section 3.3 Soils**, the project area contains many types of topsoil that are saline or sodic. These soils, when eroded as a result of runoff events, can make salt available for dissolution into surface waters. Approximately 70 percent of the entire project area was rated as having slight water erosion potential, approximately 22 percent had moderate water erosion potential, and just over 4 percent had severe water erosion potential (the remaining 4 percent was not rated). Nearly 73 percent of existing project area disturbance is located on lands with slight water erosion potential, nearly 22 percent on lands with moderate water erosion potential, and 3 percent on lands with severe water erosion potential (the remaining 3 percent was not rated) (**Section 3.3.2 Soil Limitations**).

Various federal, state, and local entities (e.g., USGS, BLM, EPA, WDEQ, the Sweetwater County Conservation District [SWCCD], and LSRCD) have monitored surface-water quality in and around the project area. Surface water samples have been analyzed for physical and chemical properties, salinity, and major ions. From this pool of existing water quality data, representative surface-water quality data were selected for inclusion in this EIS based on selecting sites on significant surface water courses and the availability of multiple samples from a particular site. Surface water quality data were evaluated from ten water-quality monitoring stations. These data were also compared to current WDEQ surface water standards where applicable. Detailed information regarding surface-water quality within the project area is provided in **Appendix F**.

Surface water quality information in the Upper Green and White-Yampa sub-basin is available near the project area from two stations on the Little Snake River (USGS Stations 09257000 and 09259050), four stations on Muddy Creek (USGS stations 09258900, 09258050, 09258980, and 09259000), one station on Lower Barrel Springs Draw (USGS Station 09216310), and one station on Bitter Creek (USGS Station 09216545). Six of the seven sampling stations in the Upper Green and White-Yampa sub-basin are outside of the project area but indicate water quality of streams leaving the project area. Historic surface-water quality data in the Great Divide Basin are available for Fillmore Creek (USGS Station 09219240), the Chain Lakes (Station 481), and Separation Creek (USGS Station 09216527). The first two sampling stations listed are within the project area. Separation Creek is adjacent to and east of the project area.

**Baseline Water Quality Data**

Baseline surface-water quality data at selected sites associated with the project area are presented in **Table 3.4-1**.

**Table 3.4-1. Surface-water quality at selected sites associated with the CD-C project area**

| | Number of Samples[2] | pH, Standard Units | Conductance, µmhos/cm (Mean) | Conductance, µmhos/cm (Min) | Conductance, µmhos/cm (Max) | TDS (Mean) | TDS (Minimum) | TDS (Maximum) | Suspended Solids[3] (Mean) | Suspended solids[3] (Minimum) | Suspended Solids[3] (Maximum) | Turbidity, NTU (Mean) | Calcium (Mean) | Magnesium (Mean) | Potassium (Mean) | Sodium (Mean) | Bicarbonate (Mean) | Sulfate (Mean) | Chloride (Mean) | Iron (Mean) | Hardness ($CaCO_3$) (Mean) | Dissolved Oxygen (Mean) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Snake River (09257000) | 107 | 8.1 | 259(34) | 82 | 460 | 158(9) | 46 | 260 | 154(101) | 4 | 1,180 | 13 | 30 | 8 | 2 | 11 | 159 | 25 | 3 | 0.07 | 111 | 9 |
| Little Snake River (09259050) | 100 | 8.1 | 366(90) | 87 | 855 | 243(17) | 87 | 540 | 228(25) | 6 | 852 | 167 | 34 | 12 | 2 | 26 | 190 | 54 | 2 | 0.16 | 151 | 10 |
| Muddy Creek [1] (09258050) | 44 | 8.2 | 873(42) | 416 | 1,320 | 615(40) | 257 | 987 | 124(35) | 10 | 1,370 | 56(1) | 93 | 39 | 4 | 49 | nm | 280 | 10 | 0.01 | 394 | 9.5 |
| Muddy Creek (09258900) | 3 | 8.6 | 1,350(2) | 600 | 2,100 | 913(2) | 396 | 1,430 | 6,198(2) | 195 | 12,200 | 1,260 | 54 | 44 | 7 | 200 | 373 | 380 | 65 | 0.11 | 315 | 11 |
| Muddy Creek (09259000) | 41 | 8.2 | 966(35) | 529 | 1,790 | 346(1) | 346 | 346 | 3,191(41) | 7 | 22,500 | nm | 42 | 40 | 9 | 286 | 308 | 320 | 32 | nm | 270 | 10 |
| Muddy Creek [1] (09258980) | 76 | 8.3 | 1,763(76) | 448 | 3,990 | 1,229(65) | 267 | 2,810 | 324(62) | 13 | 2,530 | 55 | 82 | 53 | 5 | 257 | nm | 516 | 115 | 0.03 | 422 | 10 |
| Lower Barrel Springs Draw (09216310) | 7 | 8.4 | 533(4) | 340 | 1,000 | 619(1) | 619 | 619 | nm | nm | nm | 17 | 28 | 2 | 5 | 205 | 500 | 100 | 12 | nm | 80 | 5.2 |
| Bitter Creek (09216545) | 155 | 8.4 | 1,755(149) | 280 | 4,500 | 1,289(78) | 295 | 2,740 | 1,843(105) | 22 | 21,900 | 305 | 40 | 27 | 3 | 348 | 369 | 590 | 39 | 0.10 | 211 | 9.7 |
| Upper Fillmore Creek (09219240) | 1 | 7.7 | 700(1) | 700 | 700 | 495(1) | 495 | 495 | 141(1) | 141 | 141 | 984 | 32 | 68 | 7 | 22 | 68 | 320 | 12 | 0.20 | nm | 5 |
| Separation Creek (09216527) | 45 | 8.2 | 1,089(39) | 220 | 2,390 | 200(1) | 200 | 200 | 490(1) | 490 | 490 | 131 | 74 | 69 | 6 | 80 | 277 | 385 | 13 | 0.08 | 467 | 8.2 |
| Chain Lakes, Hansen Lake (481) | 15 | 9.1 | 4,502(7) | 1,800 | 11,350 | 4,465(8) | 1,304 | 11,289 | 423 | 15 | 956 | nm | 13 | 8 | 13 | 1,604 | 1,400 | 1,139 | 342 | 17.1 | 67 | 6.4 |

*[1] Daily mean values analyzed through July 3, 2014.*
*[1] Daily mean values analyzed through February 14, 2012.*
*[3] Total number of grab samples analyzed; not every parameter was analyzed in every sample.*
*[4] Total concentration; except as noted here, all reported values represent dissolved concentrations.*

*NTU = Nephelometric Turbidity Units.*
*nm = Not measured.*
*(34) = Number of samples analyzed for that parameter.*
*All units are mg/L except as noted.*
*Source: WRDS 2007, USGS 2014a*

Surface water quality information in the Muddy Creek watershed was examined for this EIS at Muddy Creek (USGS Stations 09258050, 09258980, 09259000, and 09259050 stations) and Lower Barrel Springs Draw (USGS Station 09216310). The water quality was variable both spatially and temporally. Muddy Creek water quality was characterized by moderate conductance and total dissolved solids (TDS) concentrations. The predominant ions were sodium, sulfate, and bicarbonate. Lower Barrel Springs Draw had moderate conductance and TDS values.

Water quality in the Little Snake River was characterized (based on analysis at USGS Stations 09257000 and 09259050) by low conductance and TDS concentrations. The water type was calcium bicarbonate.

Water quality in the Bitter Creek watershed (based on analysis at USGS Station 09216545) was variable. Conductance and TDS values for Bitter Creek tended to be higher than those levels seen at the other stations.

Water quality in the Great Divide Basin was examined at three stations. Upper Fillmore Creek (USGS Station 09219240) had low conductance and TDS levels. Separation Creek (USGS Station 09216527) had variable conductance. TDS concentrations in Separation Creek were low. The Chain Lakes/Hansen Lake (WDEQ 481) had high conductance and high TDS levels.

Surface waters associated with the project area had moderately to highly basic pH (7.7 to 9.1). Dissolved oxygen concentrations were moderate (5.2 to 11). Hardness values varied between soft in the Chain Lakes (67 mg/L $CaCO_3$) to hard in Separation Creek (467 mg/L $CaCO_3$). Alkalinity (as expressed as bicarbonate) varied from 68 mg/L in upper Fillmore Creek to 1,400 mg/L in Chain Lakes.

Suspended solids concentrations were typically high in Muddy Creek and Bitter Creek. Suspended sediment concentrations, like TDS concentrations, were greater in the ephemeral and intermittent streams than the perennial Little Snake River. The mean suspended solid concentrations in the Great Divide Basin ranged between 141 mg/L (Upper Fillmore Creek) and 490 mg/L (Separation Creek).

Turbidity values were consistent with the suspended solids concentrations. Muddy Creek and Bitter Creek had turbidity of up to 1,260 and 305 nephelometric turbidity units (NTUs). The Little Snake River showed turbidity of up to 167 NTUs. Lower Barrel Springs Draw and Upper Fillmore Creek showed turbidity less than 100 NTUs. Turbidity at Separation Creek was 131 NTUs.

The ionic composition of the various surface water bodies associated with the project area was variable. Major ion characterization of each surface water sample was compared. A piper diagram shown in **Appendix F** illustrates the variations in major ion chemistry for all but two of the stations. Bicarbonate was the dominant anion (negatively charged ion) in the Little Snake River and Lower Barrel Springs Draw. Sulfate was the dominant anion in Muddy Creek, Bitter Creek, Upper Fillmore Creek, Separation Creek, and Chain Lakes/Hanson Lake. Chloride was not dominant in any of the samples. Calcium was the dominant cation (positively charged ion) in the Little Snake River. Sodium was the dominant cation in Muddy Creek, Lower Barrel Springs, Bitter Creek, Chain Lakes/Hanson Lakes, and Separation Creek. Magnesium was dominant in Upper Fillmore Creek and Separation Creek.

Salinity has become a major concern within the Colorado River drainage basin. The 1972 CWA required the establishment of numeric criteria for salinity for the Colorado River and in 1973, seven Colorado River basin states created the Colorado River Basin Salinity Control Forum (CRBSCF). The CRBSCF developed water quality standards for salinity including numeric criteria and a basin-wide plan of implementation. The plan consists of a number of control measures to be implemented by State and Federal agencies. In 1974, Congress enacted the Colorado River Basin Salinity Control Act. The Act was amended in 1984 to require the Secretary of Interior to develop a comprehensive program to minimize contributions from lands administered by the BLM.

Selenium, like mercury and other metals, bioaccumulates in organisms at each trophic level. Aquatic life is exposed to selenium primarily through diet. Unlike mercury or PCBs, concentrations of selenium do not increase significantly in animals at each level of the food chain going from prey to predator (EPA

2011b). The core regulatory guidelines for aquatic selenium pollution in the United States are the Aquatic Life Water Quality Criteria (Aquatic Life Criteria) derived by the U.S. Environmental Protection Agency (EPA) pursuant to the CWA of 1977. The current aquatic life chronic criterion for selenium set by the EPA and WDEQ is 5 µg/L (EPA 2011b and WDEQ 2001).

Irrigation water in the project area could be affected by the project if salinity levels increase. According to the Western Fertilizer Handbook (CPHA 2002), a useful evaluation of irrigation water describes its effect on plant growth and soils, which is primarily related to the dissolved salts in the water. Depending upon the amount and kind of salts present in the water, different plant growth and soil problems may develop. While some plants tolerate more salinity than others, all plants have a maximum tolerance. The permeability of soil to water (infiltration) is affected by both salinity (expressed as specific conductance or electrical conductivity [EC] values) and the sodium adsorption ratio (SAR). The 2002 handbook provides guidelines for interpretation of water quality for irrigation. As such, selected streams/water bodies within the CD-C project area were evaluated for irrigation suitability. Geometric means of the specific conductance (or EC) and SAR values, as determined from available water quality samples from the State of Wyoming's Water Resources Data System (WRDS) 2007 database, were used to calculate irrigation suitability of water from these streams/water bodies (WRDS 2007).

Using the 2002 handbook guidelines, irrigation water from the Little Snake River and Lower Barrel Springs Draw would not have salinity use restrictions. Upper Fillmore Creek, Muddy Creek, Separation Creek, Bitter Creek, and Willow Creek would have slight to moderate use restriction. Although water from Chain/Hansen Lakes would likely not be used for irrigation, it would have severe irrigation use restrictions related to **salinity**.

Guidelines from the 2002 handbook suggest that irrigation water from Muddy Creek and Separation Creek would have no infiltration use restrictions. The Little Snake River, Upper Fillmore Creek, Bitter Creek, Lower Barrel Springs, and Willow Creek irrigation water would have slight to moderate restrictions on use related to infiltration. Water from Chain/Hansen Lakes would have a severe restriction on irrigation use related to **infiltration**.

Based on average values, Muddy Creek was suitable to moderately suitable as an irrigation-water supply where flows are available. The George Dew/Red Wash wetland complex is the primary location where Muddy Creek is used for irrigation (the wetland complex is formed by spreader dikes along Muddy Creek) (**Maps 3.4-2** and **3.9-5**). This area is primarily used for cattle and there is a diversion for small-scale bottomland irrigation along Muddy Creek.

#### 3.4.2.4 Water Bodies with Impairments or Threats

Wyoming's surface water use classifications for the state's water bodies are contained within the Wyoming Surface Water Classification List (WDEQ–WQD 2001). Section 303(d) of the CWA requires that states identify and list waters where one or more designated uses are impaired (Threatened or Not Supporting, as designated by WDEQ [2012]). The Threatened designation means that designated uses are fully supported but that data suggest a declining trend, that if continued, will likely result in a use support determination of not fully supporting. The 2012 report—Wyoming's Water Quality Assessment and Impaired Waters List (2012 Integrated 305(b) and 303(d) Report)—includes one section of lower Muddy Creek within the project area on the list of Impaired Waters (WDEQ–WQD 2012). The portion of Muddy Creek west of WY 789 and within the CD-C project area is listed as Impaired for the uses of Cold Water Game Fishery and Aquatic Life other than Fish. The cited cause for the threat is habitat alterations brought on by historic livestock grazing. According to the 2012 report and as shown on **Map 3.4-2**, no other water bodies in the project area are on the list of impaired waters.

According to the 2012 report, "*Unstable stream channels and a loss of riparian function have been identified as problems in much of the Muddy Creek Sub-basin*." The sub-basin of the Little Snake River includes upper Muddy Creek, which is upstream of the CD-C project area, and lower Muddy Creek, which passes through the project area and enters the Little Snake River at Baggs (See Map 3.4-2). The

LSRCD, working through a Coordinated Resource Management (CRM) process with the BLM, landowners, grazing permittees, WGFD, and other stakeholders, addressed these water quality and riparian habitat problems. As part of the CRM process, LSRCD managed several Section 319 watershed improvement projects in the upper Muddy Creek drainage. Implementation measures included upland water development, cross fencing, and vegetation and grazing management. While the CRM process is no longer formally in place, the beneficial effects are still being realized.

Within the project area, several projects have been designed for Muddy Creek to address physical (riparian condition and bank stability) degradation of the stream channel, which threatens its aquatic life support. Upstream of the project area reclamation measures included planting a variety of woody riparian vegetation to help stabilize streambanks, removal of a culvert on Muddy Creek, and restoration of 0.75 mile of Muddy Creek in the upper watershed. According to WDEQ, results of this project showed considerable improvement to stream stability, aquatic habitat and riparian health, especially in the upper Muddy Creek tributaries (WDEQ–WQD 2012). As a result of these efforts, two portions of upper Muddy Creek listed as Threatened for several uses by WDEQ were removed from the list in 2012.

Two stream segments located near, but outside the project area are listed by the WDEQ–WQD (2012) as impaired waters (Threatened or Not Supporting). These include lower Muddy Creek and lower Bitter Creek. The lower portion of Muddy Creek is listed as Not Supporting due to exceedances of chloride and selenium from its confluence with Deep Creek, approximately 2.3 stream miles south of the project area, to a point 7.7 miles downstream. This segment of Muddy Creek was placed on the 303(d) list in 2010 and the designation did not change in 2012. Bitter Creek received an impaired status from the WDEQ based on the presence of elevated fecal bacteria as well as exceedance of chloride.

The impaired segment of Bitter Creek, located outside of the project area, extends from its confluence with the Green River upstream to Point of Rocks. WDEQ–WQD (2012) identified septic system contamination, urban runoff, and leaking sewage lines as likely sources of fecal bacteria although e. coli exceedances well upstream of Rock Springs during high flow events indicated that there may be a significant nonpoint source of bacteria in the upper watershed. The primary source for chloride exceedances is likely the surrounding geology and soils of the watershed (WDEQ–WQD 2012).

As indicated above, unstable stream channels and a loss of riparian function have been identified as problems within the Muddy Creek Sub-basin (WDEQ–WQD 2012). According to the 2012 report, several impacted segments of Muddy Creek have been identified as having degradation from historic livestock grazing, including a portion within the CD-C project area, from the confluence with Red Wash upstream to the confluence with Antelope Creek (WDEQ–WQD 2012). A number of grazing management BMPs are being implemented in the watershed including changes in the length, timing, and duration of grazing and implementing cross-fencing.

A small portion of the Upper Muddy Creek Watershed/Grizzly WHMA is located within the CD-C project area, along the east central project area boundary. This WHMA was established with the goal to "manage habitat for the Colorado River fish species unique to the Muddy Creek watershed" (BLM 2008a). In the Upper Muddy Creek Watershed/Grizzly WHMA, the WGFD has been working with the BLM, the grazing permittee, and the LSRCD to implement similar measures. The 2012 WDEQ report states, "… projected increases in CBM development in the Muddy Creek Sub-basin may lead to increases in surface disturbance, erosion and sediment loading." The USGS collected TDS and specific conductance data on Muddy Creek in response to concerns that natural gas development may increase TDS concentrations in the Colorado River Basin (WDEQ–WQD 2012). These data will serve as a baseline for monitoring the potential for accelerated erosion associated with oil and gas activities.

#### 3.4.2.5 Salinity Issues in the Colorado River Basin

The southern 30 percent of the project area is located in the Colorado River Basin; as such, point-source discharge permits are regulated by the State of Wyoming in accordance with its adoption and incorporation into the Water Quality Rules and Regulations of the CRBSCF (CRBSCF 2008). The

CRBSCF is composed of representatives from each of the seven Basin states appointed by the governors of the respective states. The CRBSCF was created for interstate cooperation and to provide the states with the information necessary to comply with Section 303(a) and (b) of the CWA. In 1975, the CRBSCF proposed, the states adopted, and the EPA approved water quality standards which included numeric criteria and a plan of implementation to control salinity increases in the Colorado River. The plan was designed to maintain the flow-weighted average annual salinity concentrations at or below the 1972 levels, while the Basin states continued to develop their compact-apportioned water supply (CRBSCF 2008).

According to the CRBSCF, the focus for the implementation of salinity standards in the National Pollutant Discharge Elimination System (NPDES) permit program policy "*shall be a no-salt return policy whenever practicable.*" The NPDES Program policy (revised in 2002) states that the permitting authority may permit the discharge of salt from new industrial sources upon a satisfactory demonstration by the permittee that salt loading to the Colorado River from the new construction is less than one ton per day or 366 tons per year, or the proposed discharge from the new construction is of sufficient quality in terms of TDS concentrations that the maximum TDS concentration is 500 mg/L for discharges into the Colorado River and its tributaries upstream of Lees Ferry, Arizona (CRBSCF 2008). In general, the salinity concentrations have decreased at the monitoring stations since the program was implemented (CRBSCF 2008).

As one of the seven member states of the CRBSCF, Wyoming regulates point discharge sources of salinity in the Wyoming portion of the Colorado River Basin through its Wyoming Pollutant Discharge Elimination System (WYPDES) permit program. The program is administered by the WDEQ–Water Quality Division (WQD) (WDEQ 1982).

### 3.4.3 Groundwater

The project area occurs in the Colorado Plateau and Wyoming Basin groundwater regions described by Heath (1984) and the Upper Colorado River Basin groundwater region described by Freethey (1987). More specifically, the project area is located over the Great Divide and Washakie structural basins in eastern Sweetwater and southwestern Carbon counties. The northern half of the project area is occupied by the Great Divide Basin and the southern half of the area is occupied by the Washakie Basin, with the Wamsutter Arch separating the two structural basins. Relatively recent studies by the USGS (Mason and Miller 2005; Bartos *et al.* 2006;) cataloged the groundwater resources within Sweetwater and Carbon counties, which include the Great Divide and Washakie structural basins. Groundwater resources include deep and shallow, confined and unconfined aquifers. Groundwater occurrence and flow in the project area are controlled largely by the geologic structure and precipitation in the area. Most of the saturated geologic units in the project area are heterogeneous, consisting of aquifers, semi-confining units, and confining layers.

#### 3.4.3.1 Groundwater Location and Quantity

Welder and McGreevy (1966) reported that the geologic formations capable of producing the greatest quantities of water in the project area include the following: Quaternary alluvium; Tertiary deposits in the Wasatch and Fort Union Formations; Cretaceous units, including the Mesaverde Group and the Frontier and Cloverly Formations; the Sundance-Nugget Sandstone of the Jurassic age; and the Tensleep and Madison Formations of the Paleozoic Era (**Figure 3.1-1, Section 3.1.2**). General aquifer characteristics are provided in **Appendix F**. Fisk (1967) estimated that the amount of moderately good quality groundwater (TDS concentration between 500 ppm and 1,000 ppm) within the Great Divide Structural Basin was 500 million ac-ft and 300 million ac-ft. within the Washakie Structural Basin. The available data are not adequate for estimating the quantities of groundwater stored within the individual hydrogeologic units or the aquifer systems in the Green River Watershed Basin, which includes the Great Divide and the Washakie structural basins, but estimates of producible water volumes are available for the Tertiary formation beneath the Greater Green River Basin (Cleary *et al.* 2010)

Quaternary aquifers in the Great Divide and Washakie basins are comprised of alluvial deposits along floodplains and isolated wind-blown and lake sediments. The Quaternary aquifers in the vicinity of the project area occur in alluvial deposits along Muddy Creek (Washakie Basin), in the Red Desert Flats area and around lakes (Great Divide Basin), and in wind-blown segments in the northwest and southeast of the project area. Groundwater flow within the sandy Quaternary aquifers is typically downward toward permeable underlying formations (Collentine *et al.* 1981). Intermittent drainages also often contain groundwater in the associated unconsolidated valley fills. Incised drainages serve as capture areas for wind-blown sand in reaches perpendicular to the prevailing winds. The sand-choked drainages favor rapid infiltration of rainfall and snowmelt, leading to contact springs and seeps where groundwater, perched in sandy surface deposits, escapes along contacts with less permeable bedrock. Thicknesses of Quaternary sediments range from zero to 70 feet. Well yields are typically less than 20 gallons per minute (gpm) (Welder and McGreevy 1966).

"Minor" Tertiary aquifers in the project area occur in the Laney Member of the Green River Formation (mostly in the Washakie Structural Basin). "Major" Tertiary aquifers in the project area include the Wasatch, Battle Springs, and Fort Union (Washakie and Great Divide basins). Using nomenclature of Collentine et al. (1981), "minor" and "major" aquifers are characterized based on their relative water-bearing potential. Aquifers near the surface are recharged from direct downward percolation of precipitation and snowmelt and from seepage losses from streams. Deep aquifers are also recharged by these processes in outcrop and subcrop areas and from slow leakage from overlying and underlying aquifers. Thicknesses of Tertiary deposits vary from zero to more than 4,000 feet. Wasatch Formation wells yield up to 50 gpm. The Laney Member of the Green River Formation and the Battle Springs and Fort Union formations can yield hundreds of gpm to wells (Mason and Miller 2005; Bartos *et al.* 2006). There are six wells that are designated as municipal use and supply a public water system completed in Tertiary age aquifers (all in the Wasatch Formation) within the project area. These six wells are associated with water supply for the Town of Wamsutter (Water Supply System No. WY-5600105). Using estimates of the volume of producible groundwater from Cleary *et al.* (2010), the volume of groundwater in the top 1,000 feet of the Tertiary formation under the project area is approximately 9.67 million ac-ft. Fisk (1967) estimated that the amount of moderately good-quality groundwater within the Great Divide Structural Basin was 500 million ac-ft and 300 million ac-ft. within the Washakie Structural Basin.

Upper Cretaceous aquifers include "minor" aquifers in the Lance and Fox Hills formations. "Major" aquifers of this period include the formations within the Mesaverde Group (Almond Formation, Ericson Formation, Rock Springs Formation, and Blair Formation in descending order), the Baxter Shale, and the Frontier Formation. The Mesaverde Group contains "major" aquifer units (the Almond Formation, Pine Ridge Sandstone, Allen Ridge Formation, and Haystack Mountains Formation), and is referred to as the Mesaverde Aquifer (Mason and Miller 2005; Bartos *et al.* 2006) in the Washakie and Great Divide basins. Due to water-quality variability, the Mesaverde Aquifer is considered a groundwater source only near outcrop (recharge) areas, as groundwater quality declines with distance from the outcrop. Units within the Mesaverde Group yield natural gas to conventional gas wells in the area. In the Atlantic Rim area to the east, coal seams within the Almond Formation are the target of coalbed methane (CBM) development. In areas where they occur, Upper Cretaceous strata range from a few hundred feet to 5,000 feet thick. Well yields from the "minor" aquifers are typically less than 25 gpm. Well yields of up to several hundred gpm are reported for the "major" aquifers (Welder and McGreevy 1966).

The Lower Cretaceous aquifers generally are deeply buried in the center of the Great Divide and Washakie basins, though these formations outcrop near the eastern edge of the project area. The lower Cretaceous strata consist of shale layers that act as regional aquitards or leaky confining layers (Mowry and Thermopolis shales). The Cloverly Formation is a "major" aquifer. Yields to wells range from 45 to 240 gpm (Mason and Miller 2005; Bartos *et al.* 2006). There are no wells that are designated as a domestic use or as a municipal use and supply a public water system completed in Lower Cretaceous aquifers within the project area.

The low-permeability Morrison Formation separates the Sundance-Nugget Aquifer of the Jurassic age from the Upper Cretaceous aquifers. The Jurassic-age Sundance-Nugget aquifer is comprised of permeable sandstone with minor quantities of shale, siltstone, and limestone (Collentine *et al.* 1981). The flow characteristics of the Sundance-Nugget aquifer are not well-defined. These aquifer units range from about 200 to 450 feet thick. Well yields are less than 35 gpm in the Sundance aquifer and up to 200 gpm in the Nugget aquifer (Mason and Miller 2005; Bartos *et al.* 2006). There are no wells that are designated as a domestic use or as a municipal use and supply a public water system completed in Sundance or Nugget aquifers within the project area.

According to Collentine *et al.* (1981), two "important water-bearing intervals" occur in Paleozoic-Era rocks within the project area. The Pennsylvanian age Tensleep Formation consists of fine- to medium-grained sandstone between confining layers of the Chugwater Formation (Triassic) and the Amsden Formation (Pennsylvanian) (Collentine *et al.* 1981). The Madison aquifer is comprised of limestone and dolomite bordered on the top by the fine-grained Amsden Formation and on the bottom by Cambrian rocks. Early Paleozoic rocks are notably absent from far southeast Wyoming and extremely thin on the west flank of the Sierra Madre uplift east of the project area. The zero isopach line for these Paleozoic units lies across and north of the Sierra Madre uplift indicating either non-deposition or erosion and complete removal of these units across the ancestral uplift prior to deposition of Mesozoic and Cenozoic age rocks. The truncated edge of Cambrian and Mississippian rocks lies east of the project area according to Blackstone (1963). Wells completed in the vicinity of the project area within both of these Paleozoic age aquifers, where present and of significant thickness, have demonstrated yields up to 400 gpm. There are no wells that are designated as a domestic use or as a municipal use and supply a public water system completed in Tensleep or Madison aquifers within the project area.

#### 3.4.3.2 Groundwater Use

The SEO water rights database indicates that as of 2014, there were 987 groundwater wells permitted within or 1 mile adjacent to the project area (See **Appendix F, Table F-11,** SEO 2014). Approximately 45 percent of the permitted wells (446 of 987) are related to monitoring or oil and gas recovery. Six of the 987 wells are permitted for municipal use. Permitted well uses include monitoring (330), stock (297), miscellaneous (226), coalbed natural gas (99), domestic (74), industrial (12), municipal (6), irrigation (4), and test wells (1).

Many of the wells are permitted for multiple uses so the number of permitted *uses* (1,049) exceeds the number of well permits (987 wells). Of the 74 wells with a domestic use, approximately 93 percent (69 of 74) were completed at depths of less than 1,000 feet. The other five domestic wells were completed at depths between 1,000 and 1,600 feet. The completion formations of all domestic wells are well above the Almond Formation, the targeted formation for oil and gas recovery, which occurs at depths between 8,000 and 12,000 feet in the project area. A complete list of valid groundwater rights is included in **Appendix F, Table F-11**.

Other than designated land uses described above, little information is available on groundwater use specific to the Great Divide and Washakie structural basins. In 1981, total groundwater use in the Great Divide and Washakie basins was estimated by Collentine *et al.* (1981) at between 20,000 and 24,000 ac-ft per year, approximately 30 percent of the total water use. More recent estimates of groundwater use are available on a county-wide basis. In 2000, Sweetwater County groundwater use was estimated at 57,000 ac-ft per year, approximately 30 percent of the overall water used (Mason and Miller 2005). In 2000, Carbon County groundwater use was estimated at 7,000 ac-ft per year, less than 2 percent of the overall water used (Bartos *et al.* 2006). In 2000, Carbon County groundwater use (irrigation, public supply, mining, industrial, and domestic, combined) was estimated at 7,000 ac-ft per year, less than 2 percent of the overall water used (Bartos *et al.* 2006). According to Bartos et al. (2006) oil and gas production (produced water) accounted for approximately 40 percent of the Carbon County groundwater use in 2000;

approximately 84 percent of the water produced during oil and gas recovery was considered saline (1,000 mg/L or more of dissolved solids).

#### 3.4.3.3 Groundwater Recharge and Discharge

Recharge to aquifers in the project area occurs by infiltration of precipitation on outcrop areas, infiltration of snowmelt runoff from the mountains, and seepage from streams and lakes.

Four major groundwater-recharge areas are identified in the Great Divide and Washakie structural basins. Three of these areas are outside of the project area near Rock Springs in Sweetwater County and the Atlantic Rim area in Carbon County. The fourth recharge area is the topographic high area around Creston Junction (**Map 3.4-1**). Piezometric levels in hydrogeologic units are higher in these four major recharge areas than other parts of the basin, probably because the higher altitude of these features results in slightly higher annual precipitation. Welder and McGreevy (1966) reported that most streams in the Washakie basin are "losing" streams, contributing to local groundwater recharge in the basin. The same is likely true for streams in the Great Divide Basin. Fisk (1967) estimated that the combined annual recharge for the Great Divide and Washakie structural basins was at 11,300 ac-ft. **Section 4.9.3.1, Special Status Species**, Proposed Action, includes a discussion of potential annual depletions to the Colorado River System.

Aquifers in the Great Divide and Washakie structural basins are reported to be in direct hydraulic connection across the Wamsutter Arch. Annual recharge is reported to be approximately 11,300 ac-ft in both basins. Due to the large groundwater storage capacity and the low recharge rate, estimates indicate that it would take more than 50,000 years to refill the fresh-water aquifers of the basins with groundwater if all of the groundwater was removed (Mason and Miller 2005; Bartos *et al.* 2006).

In general, groundwater discharge from the aquifers throughout the project area occurs through discharge to streams and springs, discharge to wells, evaporation, and underground flow (Mason and Miller 2005; Bartos *et al.* 2006). According to Mason and Miller (2005), groundwater from the Mesaverde formation discharges to the Little Snake River, downstream of the confluence with Muddy Creek. Much of the deeper groundwater in the basins is artesian (i.e., having a static water level which rises to an elevation above the saturated zone). This results because the major recharge areas in the basins are exposed at higher elevations, putting the confined groundwater under hydraulic pressure. Water in a confined aquifer that is under hydraulic pressure will rise above the top of the aquifer when the overlying confining bed is pierced or broken, resulting in discharge from the confined aquifer (Mason and Miller 2005). The source of some of the water within the Chain Lakes surface water features in the Great Divide Basin is thought to be artesian groundwater that flows at the surface (WGFD 2008).

#### 3.4.3.4 Groundwater Flow Direction

As discussed in Section 3.4.3.1, formations capable of producing the greatest quantity of water in the project area include the Quaternary alluvium, Tertiary deposits in the Wasatch and Fort Union Formations, Cretaceous units, including the Mesaverde Group and the Frontier and Cloverly Formations, the Sundance-Nugget Sandstone of the Jurassic age, and the Tensleep and Madison Formations of the Paleozoic Era. More detailed information regarding potentiometric surfaces of project area aquifers and groundwater flow are presented in **Appendix F**.

The Quaternary aquifers consist of unconsolidated sand and gravel formations, mainly of alluvial origin, interbedded with lake and wind-blown sediments. The Quaternary alluvium is highly permeable, absorbing rainfall and stream flow, transmitting it downward to underlying formations.

The groundwater flow direction in the Tertiary-aged Wasatch aquifer is from areas of recharge toward the basin center. In the Great Divide Structural Basin, Wasatch aquifer groundwater flows from the northwest, northeast, southwest, and southeast. In the Washakie Structural Basin, groundwater generally flows from west to east in the southern part of the Washakie Structural Basin. In the northern portion of

the Washakie Basin groundwater motion is largely static. Some groundwater flows westward from the Washakie Structural Basin along Bitter Creek and southward along Muddy Creek.

Groundwater flow direction for the Upper Cretaceous-aged aquifer within the Mesaverde Group is undefined in the northern part of the Great Divide Structural Basin. Groundwater within the aquifers of the Mesaverde Group is reported to flow from the Great Divide Basin toward the east, southeast, southwest, and west. In the Washakie Structural Basin, groundwater is reported to flow to the west and south (Mason and Miller 2005; Bartos *et al.* 2006).

Available potentiometric data are sporadic and could not be used to delineate flow patterns in the Sundance-Nugget aquifer. Potentiometric heads are highest in the uplift areas to the east, west, north, and northeast (Collentine *et al.* 1981).

The groundwater flow direction for the Paleozoic-aged Tensleep aquifer is generally from the recharge areas along the northern and eastern flanks of the Great Divide Basin. Additional recharge into the Washakie Basin may occur to the south and east of the Rock Springs uplift. Tensleep aquifer groundwater flow is from the recharge areas toward the basin centers (Collentine et al. 1981). The groundwater flow direction for the Paleozoic-aged Madison aquifer is generally west, away from the outcrops (sources of recharge) towards the Great Divide and Washakie basin centers (Bartos *et al.* 2006).

#### 3.4.3.5 Groundwater Quality

For the most part, comparisons between groundwater quality within the different structural features in the project area are difficult given the large variation in water quality within the features. In general, the quality of the groundwater underlying the Great Divide and Washakie basins is largely related to the depth of the aquifer, the type of strata in the saturated zone, the recharge rate and volume at the area sampled, and the residence time of the groundwater in the aquifer. Typically, quality of groundwater within a given hydrogeologic unit usually deteriorates with depth.

Water-quality samples collected from wells and springs within Quaternary and Tertiary hydrogeologic units that were being used to supply water for livestock and wildlife were typically of good water quality (i.e. fresh water, see below). Wells that do not produce usable water are usually abandoned, and springs that do not produce usable water typically are not developed. In addition, where hydrogeologic units are deeply buried, they usually are not tapped for a water supply when a shallower supply is available. For these reasons the groundwater quality samples from the Quaternary and Tertiary hydrogeologic units are most likely biased toward better water quality and do not represent a random sampling of the units. Although the possible bias of these data does not allow for a complete characterization of the water quality of these hydrogeologic units as a whole, it probably allows for a more accurate characterization of the units in areas where they are shallow enough to be economically used.

Most of the groundwater-quality samples used to characterize Mesozoic and Paleozoic hydrogeologic units came from the USGS Produced Waters Database (USGS 2011b). Although these samples were collected only where oil and gas production has taken place, they probably have less bias in representing ambient groundwater quality within hydrogeologic units developed as a result of this project than samples used to characterize Quaternary and Tertiary hydrogeologic units.

Detailed data regarding groundwater quality are presented in **Appendix F**. Baseline groundwater-quality data (TDS and selenium) from selected aquifers associated with the project area are presented in **Table 3.4-2**. TDS and selenium were selected for display in this table in line with the issues and concerns presented in **Chapter 1**, which included the potential to increase salinity, sediment loads, and selenium in tributaries of the Colorado River. TDS is a measure of salinity and selenium concentrations are a direct water-quality metric. Additional water quality parameters are displayed in **Table F-14**.

TDS concentrations in ground-water samples are classified according to the USGS salinity classification (Heath 1983) as follows: fresh, 0-1,000 mg/L; slightly saline, 1,000-3,000 mg/L; moderately saline, 3,000-10,000 mg/L; very saline, 10,000-35,000 mg/L; and briny, more than 35,000 mg/L.

**Table 3.4-2. Groundwater quality parameters for selected aquifers associated with the CD-C project area**

| | From Mason and Miller (2005) | | | | | From Bartos *et al.* 2006 | | | | | | Produced Water | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sweetwater Co. Quaternary Aquifer | Sweetwater Co. Wasatch Aquifer | Sweetwater Co. Mesaverde Aquifer | Sweetwater Co. Nugget Aquifer | Sweetwater Co. Madison Aquifer | Carbon Co. Quaternary Aquifer | Carbon Co. Wasatch Aquifer | Carbon Co. Mesaverde Aquifer | Carbon Co. Nugget Aquifer | Carbon Co. Madison Aquifer | Sweetwater Co. Wasatch/Ft. Union Aquifer Produced Water | Sweetwater Co. Mesaverde Aquifer Produced Water | Sweetwater Co. Nugget Aquifer Produced Water | Madison Aquifer (USGS 2011b) |
| **NO. OF SAMPLES** | 18 | 80 | 30 | -- | 17 | 32 | 11 | 130 | 15 | 11 | -- | 221 | 28 | 2 |
| **PARAMETER** | | | | | | | | | | | | | | |
| TDS (Median) (mg/L) | 1,200 | 900 | 1,000 | -- | 11,100 | 500 | 2,000 | 5,000 | 4,500 | 3,000 | 13,900 | 12,000 | 10,000 | 30,300 |
| TDS (Min) (mg/L) | 500 | 150 | 200 | 3,000 | 3,820 | 30 | 700 | 250 | 1,500 | 150 | 1,050 | 2,800 | 5,000 | 6,094 |
| TDS (Max) (mg/L) | 20,000 | 7,000 | 20,000 | 35,000 | 76,800 | 8,000 | 5,000 | 40,000 | 50,000 | 12,000 | 153,000 | 65,000 | 40,000 | 54,545 |
| Selenium (Median) (µg/L) | 32.9[1] | 0.7[2] | nm[7] | <1[3] | nm | 3.9[4] | 0.6[5] | 0.6[6] | nm | 1.4[3] | nm | nm | nm | nm |
| Selenium (Min) (µg/L) | 3.8[1] | 0.3[2] | nm | <1[3] | nm | <0.5[4] | 0.4[5] | <0.3[6] | nm | 1.4[3] | nm | nm | nm | nm |
| Selenium (Max) (µg/L) | 133[1] | 1.6[2] | nm | <1[3] | nm | 4.5[4] | <0.7[5] | 0.8[6] | nm | 1.4[3] | nm | nm | nm | Nm |

[1] *Based on 7 Samples*
[2] *Based on 8 Samples*
[3] *Based on 1 Sample*
[4] *Based on 3 Samples*
[5] *Based on 4 Samples*
[6] *Based on 6 Samples*
[7] *Not Measured.*

TDS values for 18 samples collected in Quaternary aquifers in Sweetwater County ranged from fresh to very saline with the median value within the slightly saline range. In Carbon County, 32 samples collected from Quaternary aquifers varied from fresh to moderately saline with the median value within fresh range.

TDS concentrations from 80 samples collected from the Wasatch aquifer (Tertiary age) in Sweetwater County ranged from fresh to moderately saline, with a median value within the fresh/slightly saline range. TDS values for 11 samples collected in Carbon County ranged from fresh to moderately saline, with a median value within the slightly saline range. TDS values from samples collected in Sweetwater County of water produced by oil and gas extraction from the Wasatch/Fort Union formations ranged from slightly saline to briny. TDS values of produced water from the Wasatch aquifer above 60,000 mg/L occurred at depths greater than about 2,500 feet below ground surface (Mason and Miller 2005).

TDS concentrations in 30 samples collected in Sweetwater County from the aquifers of the Mesaverde group ranged from fresh to very saline, with a median value within the fresh/slightly saline range. TDS from 130 samples collected in Carbon County from the aquifers of the Mesaverde Group ranged from fresh to briny. TDS in 221 samples of water from oil and gas production in the Mesaverde ranged from slightly saline to briny with a median value within the very saline range.

TDS concentrations from samples collected from the Nugget aquifer in Sweetwater County ranged from slightly/moderately saline to very saline/briny. TDS values for 15 samples collected in Carbon County ranged from slightly saline to briny, with a median value within the moderately saline range. TDS values from 28 samples collected in Sweetwater County of water produced by oil and gas extraction from the Nugget formation ranged from moderately saline to briny.

TDS concentrations from 17 samples collected from the Madison aquifer in Sweetwater County ranged from moderately saline to briny, with a median value within the very saline range. TDS values for 11 samples collected in Carbon County ranged from fresh to very saline, with a median value within the slightly/moderately saline range. TDS values from samples collected in Sweetwater County of water produced by oil and gas extraction from the Madison Formation ranged from moderately saline to briny.

In general, TDS concentrations typically increase with the depth below ground surface. TDS values are usually higher when the aquifer is interbedded with lake or marine deposits that contain evaporate minerals.

Selenium values obtained from samples of selected aquifers are included in **Table 3.4-2**. In comparison to the number of samples analyzed for TDS, selenium sampling results are sparse but they do provide some idea of the potential for encountering excessive selenium in produced water. EPA's current chronic criterion for selenium is 5 µg/L (EPA 2011b). WDEQ's groundwater fish/aquatic life use suitability limit for selenium is also 5 µg/L (WDEQ–LQD 2005). Both the EPA's chronic criterion and WDEQ–WQD's suitability limits for selenium were exceeded in Quaternary aquifer water samples.

Confining beds typically restrict the movement of groundwater between aquifers, hence, movement of potential contaminants between aquifers. Although there is some downward movement of the water from the shallow surficial units, most of the groundwater movement, if any, is upward from the deeper confined aquifers to the shallower unconfined aquifers. Water in a confined aquifer is under hydraulic pressure and will rise above the top of the aquifer when the overlying confining bed is pierced or broken (Mason and Miller 2005). There is potential for groundwater quality degradation due to the piercing of confining layers and vertical and horizontal migration and mixing of waters of variable qualities between the layers. Improperly completed wells, especially poor casing or cementing, could produce such a result. There are no data suggesting this is currently a problem in the CD-C project area.

#### 3.4.3.6 Springs and Flowing Wells

As described above, water in a confined aquifer is under hydraulic pressure and will rise above the top of the aquifer when the overlying confining bed is broken (spring) or pierced (well). When the hydraulic pressure is great enough, the water from a well completed in a confined aquifer can reach the surface,

resulting in a flowing well. Springs and flowing wells are important local water sources for livestock, wildlife, and wild horses. It is unclear how many springs and flowing wells are located within the project area. The SEO records identify two named springs among the 1,081 groundwater rights within 1 mile of the project area (SEO 2011). The SEO records indicate that 118 of the 1,081 groundwater rights are flowing wells (SEO 2011). Of the 1,081 groundwater rights, 325 lack the information to determine if the groundwater permit is for a spring or flowing well.

According to previous studies, springs in the area intercept the ground surface in three geologic units. South of I-80, springs occur in the Green River Formation. North of I-80, springs occur in the Wasatch and Battle Springs formations (Mason and Miller 2005; Bartos *et al.* 2006).

Historic water-quality data were located for 16 water samples collected from springs or flowing wells (WRDS 2007, USGS 2012b). Water quality for these samples is variable because these samples represent different formations and a wide range of depth. Conductance levels range from 769 to 16,215 µmhos/cm. TDS levels ranged from 479 to 12,755 mg/L. Detailed information related to springs and flowing wells can be found in **Appendix F**. Based on a February 2011 search of SEO water rights information, none of the 16 springs evaluated for water quality are covered by valid water rights.

#### 3.4.3.7 The Safe Drinking Water Act as it Relates to Groundwater

The Safe Drinking Water Act (SDWA) is the main federal law that regulates drinking water quality, including drinking water from groundwater sources. Under the SDWA, the EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. Two aspects of the SDWA that are relevant to an assessment of the groundwater quality related to the CD-C project are the underground injection control (UIC) program and the sole source aquifer (SSA) protection program. The UIC program ensures that injection wells meet appropriate performance criteria for protecting underground sources of drinking water (USDW). As defined in 40 CFR 144.3, a USDW aquifer supplies any public water system or contains a sufficient quantity of groundwater to supply a public water system; currently supplies drinking water for human consumption or contains fewer than 10,000 mg/l TDS; and is not an exempted aquifer (i.e. exempt from SDWA regulation). The EPA defines an SSA as an aquifer that supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer. While there are no EPA designated SSAs associated with the CD-C project area, there are aquifers in the area that qualify as an USDW. One EPA-permitted public water supply system is within the project area, associated with six groundwater wells for the town of Wamsutter.

Quaternary-age aquifers within the CD-C project area may qualify as USDWs based on suitability of water quality; however, there are currently no wells designated for municipal use and supply for a public water system from Quaternary-age aquifers. Further, the yields from these aquifers are not likely sufficient to sustain a public water system. Tertiary age aquifers within the CD-C project area do qualify as USDWs based on the presence of Wamsutter municipal wells and on the suitability of the groundwater quality. The Wamsutter municipal wells are completed in the Tertiary-age Green River Formation (WSGS 2014).

There are no wells that are designated for municipal use or supply a public water system completed in Upper Cretaceous aquifers within the project area. Wyoming State Engineer records indicate that one domestic well is completed in the Upper Cretaceous Lance Formation aquifer within the project area. Upper Cretaceous age aquifers within the CD-C project area qualify as USDWs based on suitability of water quality, on the presence of a sufficient quantity of groundwater to supply a public water system, and the one domestic well completed in the Lance Formation aquifer. Due to the depth of the Upper Cretaceous aquifers in the CD-C area (2,000 to 12,000 feet depending on location [Mason and Miller 2005]) and the low population density of the area, these aquifers are not likely to be the target for large numbers of domestic or public water system wells.

Lower Cretaceous and Jurassic age aquifers within the CD-C project area could qualify as USDW based on suitability of water quality and based on the presence of a sufficient quantity of groundwater to supply a public water system. Lower Cretaceous and Jurassic age aquifers in the CD-C area occur at depths of

2,000 to 12,000 feet depending on location (Mason and Miller 2005); therefore, these aquifers are not likely to be the target for domestic or public water system wells. Pennsylvanian age and older aquifers within the CD-C project area could qualify as USDW based on the presence of a sufficient quantity of groundwater to supply a public water system, but due to several factors including high TDS concentrations generally present within these aquifers, the depths of these aquifers in the CD-C area (4,800 to 18,000 feet depending on location [Mason and Miller 2005]), and the low population density of the area, they are not likely to be the target for domestic or public water system wells.

#### 3.4.3.8 Groundwater (Aquifer) Sensitivity

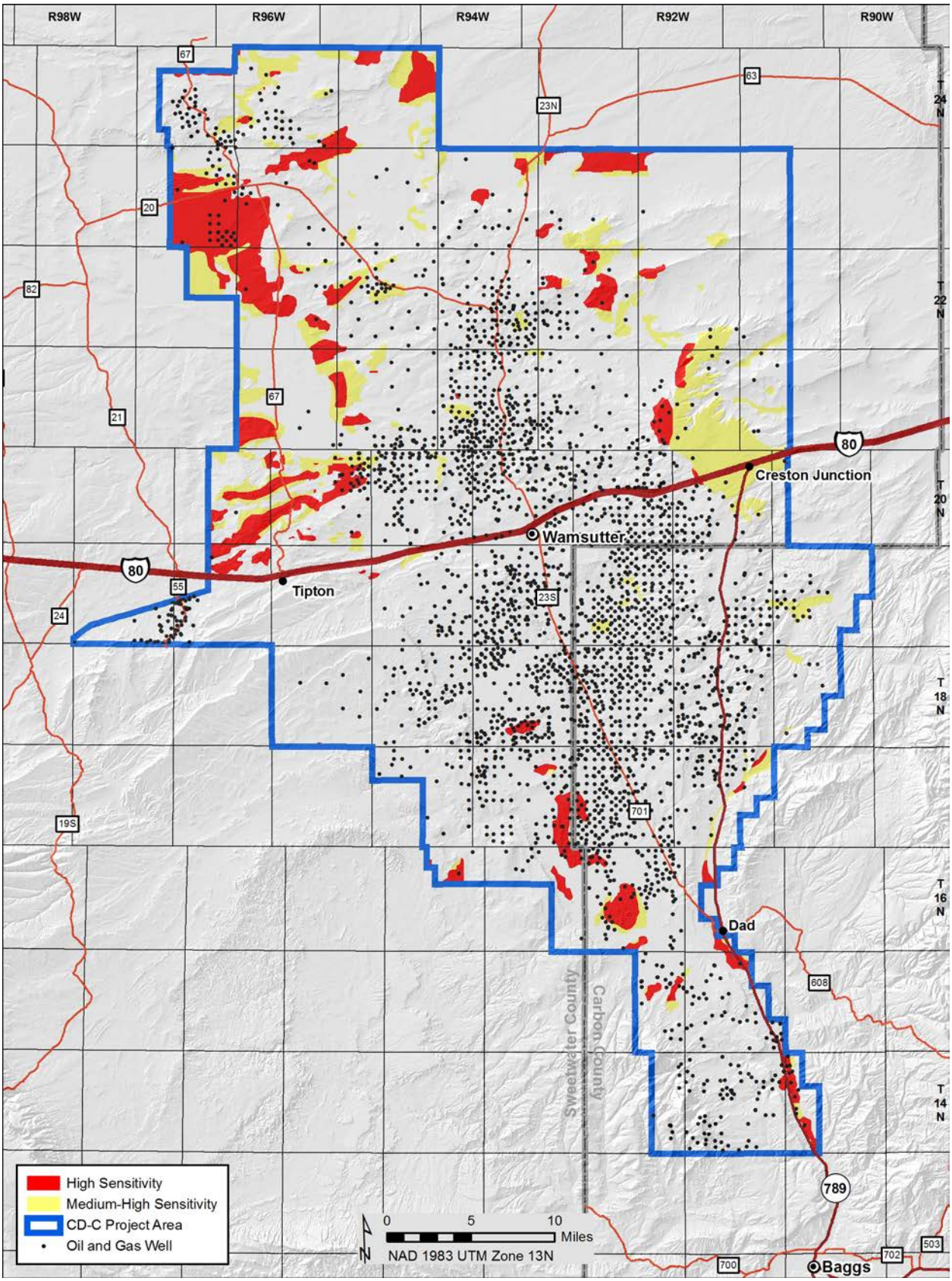
Aquifer sensitivity is defined as the relative ease with which contaminants can move from the surface through various substrates to pollute groundwater (Hamerlinck and Arneson 1998).

The Wyoming Ground Water Vulnerability Mapping Project was initiated in 1992 to provide the public groundwater management agencies with a better understanding of the state's groundwater resources and the vulnerability of important aquifers to contamination, particularly pesticides. Fundamental to such efforts is the concept of assessing the relative sensitivity of groundwater to pollution and to isolate areas needing the most attention to prevent contamination. County mapping that resulted from the project was used to assess aquifer sensitivity within and near the project area (Hamerlinck and Arneson 1998). The aquifer sensitivity portion of Hamerlinck and Arneson's report (1998) was applied to the CD-C project area because aquifer sensitivity is not dependent on land use and contaminant characteristics. The parameters used in the sensitivity model included depth to water, geohydrologic setting, soils, recharge, slope, and vadose (unsaturated) zone. The resulting mapping grouped aquifer sensitivity into five classes: low, medium-low, medium, medium-high, and high. Hamerlinck and Arneson (1998) associated the high sensitivity class with lands located primarily in alluvial deposits adjacent to rivers, streams, and lakes or in highly fractured mountainous belts that bound these basins. Low sensitivity class areas were described as areas with ever-increasing depth-to-water, diminished vadose zone hydraulic conductivities, and stable geologic environments such as those found within the interior of the Green River Basin. **Map 3.4-3** illustrates the high and medium-high aquifer sensitivity areas within the project area. The mapping indicates that approximately 14 percent of the project area has a medium-high to high aquifer sensitivity.

### 3.4.4 Injection Wells

As discussed above, subsurface water-disposal methods are administered by the EPA under the UIC program (40 CFR 144). The UIC program ensures that injection wells meet appropriate performance criteria for protecting USDWs. There are six classes of injection wells permitted under the UIC program based on similarity in the fluids injected, activities, construction, injection depth, design, and operating techniques. Class II and Class V injection wells would likely be used to dispose of produced water resulting from the CD-C project. Class II injection well permits are issued by the WOGCC for injection of fluids associated with oil and natural gas production (EPA 2011a), and are issued by the WOGCC under a 1989 Memorandum of Agreement (MOA) between the EPA and the WOGCC. Class V injection wells are permitted through WDEQ–WQD and cover wells not included in Classes I-IV. Most Class V wells (facilities) inject non-hazardous fluids into or above USDWs and are typically shallow, onsite disposal systems (stormwater drainage wells, cesspools, and septic tanks) but also include more complex wells that are deeper and often used for commercial or industrial facilities (EPA 2011a). Class VI injection wells are related to the injection of carbon dioxide for long-term storage and are not relevant to the CD-C project.

According to WOGCC information there are 14 permitted Class II injection wells within the CD-C project area that are capable of operation (WOGCC 2015). The target injection formations for these wells are Big Red (1), Big George (1), Fort Union (1), Fox Hills (2), Mesaverde/Lewis (1), Almond (2), Mesaverde (1), and Lance (5). According to WDEQ, there are no permitted Class V injection wells within the project area but there are seven Class V wells adjacent to the project area (WDEQ–WQD 2015). All seven wells are the deeper injection type and target the Haystack Mountain (1), Deep Creek (3), and Mesaverde Coal (3) formations.




**Map 3.4-3. Aquifer Sensitivity Areas, CD-C project area**

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

## 3.5 AIR QUALITY

Regional air quality is influenced by a combination of factors including climate, meteorology, the magnitude and spatial distribution of local and regional air pollution sources, and the chemical properties of emitted pollutants. Within the lower atmosphere, regional and local scale air masses interact with regional topography to influence atmospheric dispersion and transport of pollutants. The following sections summarize the climatic conditions and existing air quality within the project area and surrounding region.

### 3.5.1 Regional Climate

The CD-C project area is located in a semiarid (dry and cold), mid-continental climate regime. The area is typified by dry, windy conditions with limited rainfall and long, cold winters. The nearest precipitation and temperature measurements were collected at Wamsutter, Wyoming (1897–2012), located near the center of the project area at an elevation of 6,800 feet above mean sea level (WRCC [Western Regional Climate Center] 2014).

The annual average total precipitation at Wamsutter is 7.1 inches, with annual totals for the period of record ranging from 3.8 inches (1979) to 13.6 inches (1983). Precipitation is greatest from spring to summer, tapering off during the fall and winter months. An average of 27.3 inches of snow falls during the year (annual high 78.0 inches in 2010), with the majority of the snow distributed evenly between November and April.

The region has cool temperatures, with an average monthly range (in degrees Fahrenheit [˚F]) between 7.2˚F and 28.7˚F in January to between 48.9˚F and 84.6˚F in July. Extreme daily temperatures have ranged from -40˚F (02/02/2011) to 105˚F (07/28/1897). The frost-free period generally occurs from May to September. **Table 3.5-1** shows the mean monthly temperature ranges and total precipitation amounts.

**Table 3.5-1. Mean monthly temperature ranges and total precipitation amounts**

| Month | Average Temperature Range (˚F) | Total Precipitation (inches) |
|---|---|---|
| January | 7.2 – 28.7 | 0.27 |
| February | 10.6 – 33.1 | 0.30 |
| April | 18.4 – 41.9 | 0.40 |
| April | 26.5 – 54.3 | 0.75 |
| May | 34.6 – 65.1 | 1.06 |
| June | 42.4 – 76.6 | 0.80 |
| July | 48.9 – 84.6 | 0.76 |
| August | 46.8 – 82.1 | 0.81 |
| September | 38.5 – 72.5 | 0.73 |
| October | 28.5 – 59.0 | 0.58 |
| November | 17.2 – 41.9 | 0.36 |
| December | 8.5 – 29.9 | 0.28 |
| ANNUAL | 41.6 (mean) | 7.09 (mean) |

*Source: WRCC 2014*

The CD-C project area is subject to strong and gusty winds, often accompanied by snow during the winter months, producing blizzard conditions and drifting snow. The closest comprehensive wind measurements were collected in the project area at the Wyoming Department of Environmental Quality (WDEQ) – Air Quality Division (AQD) meteorological monitoring station located approximately 2 miles northwest of Wamsutter. To describe the wind flow pattern for the region, a wind rose for the Wamsutter site for years 2008 through 2010 is presented in **Figure 3.5-1**.

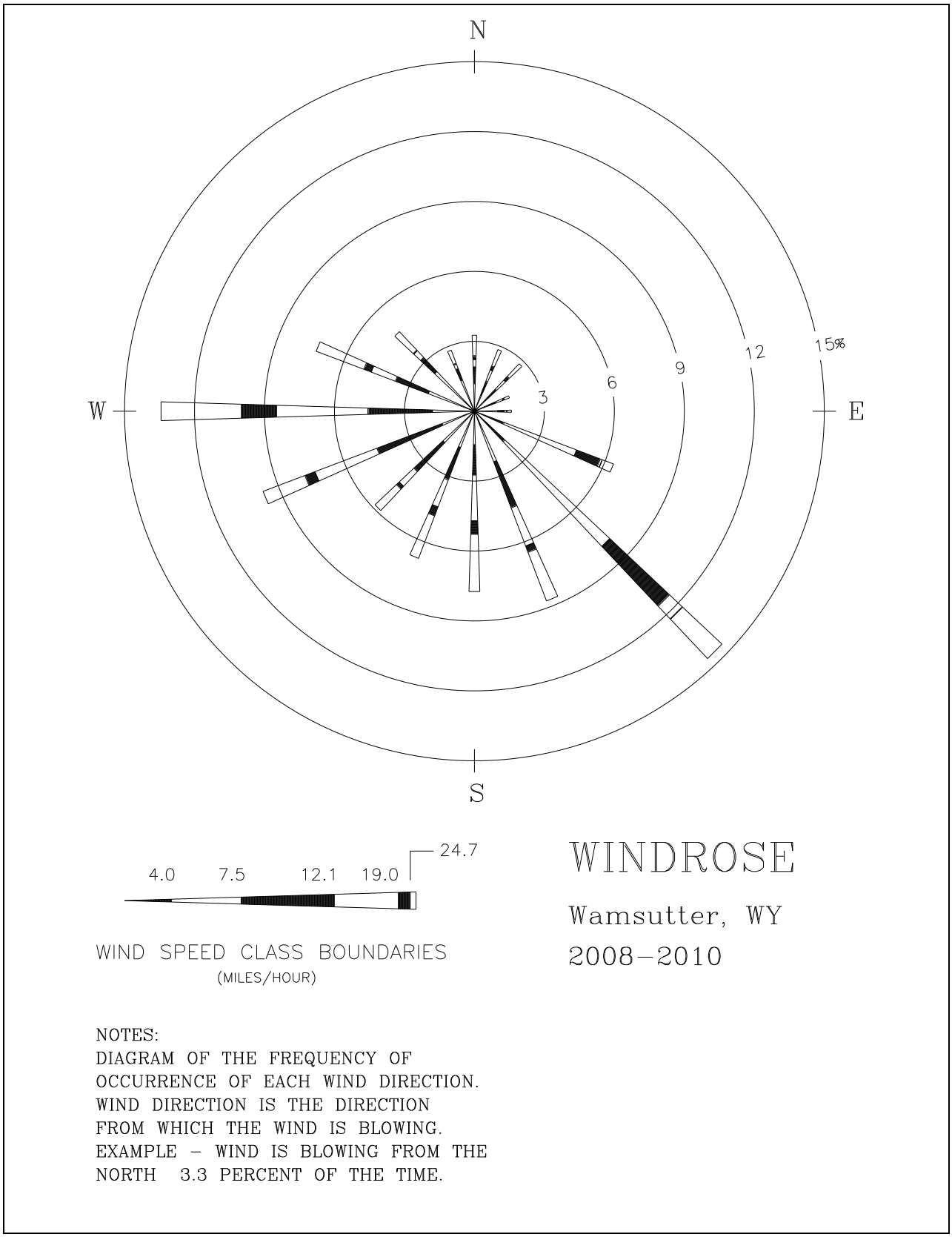



**Figure 3.5-1. Wamsutter, WY meteorological data wind rose**

**Tables 3.5-2 and 3.5-3** provide the wind speed and wind direction distributions in tabular format. From this information, it is evident that the winds originate from the west to southwest nearly 36 percent of the time and from the south to southeast over 37 percent of the time. The frequency and strength of winds greatly affect the transport and dispersion of air pollutants. The annual mean wind speed is 11.4 miles per hour (mph), and the relatively high average wind speed indicates good dispersion and mixing of any potential pollutant emissions.

**Table 3.5-2. Wind speed distribution, Wamsutter, Wyoming, 2008–2010[1]**

| Wind Speed (mph) | Frequency (%) |
|---|---|
| 0 – 4.0 | 8.3 |
| 4.0 – 7.5 | 25.0 |
| 7.5 – 12.1 | 22.6 |
| 12.1 – 19.0 | 16.9 |
| 19.0 – 24.7 | 4.5 |
| Greater than 24.7 | 2.3 |

[1]*Source: WDEQ-AQD 2012.*

**Table 3.5-3. Wind direction frequency distribution, Wamsutter, Wyoming, 2008–2010**

| Wind Direction | Frequency (%) |
|---|---|
| N | 3.3 |
| NNE | 2.8 |
| NE | 2.8 |
| ENE | 1.6 |
| E | 1.6 |
| ESE | 6.4 |
| SE | 14.6 |
| SSE | 8.7 |
| S | 7.7 |
| SSW | 6.8 |
| SW | 5.9 |
| WSW | 9.7 |
| W | 13.4 |
| WNW | 7.3 |
| NW | 4.7 |
| NNW | 2.8 |

*Source: WDEQ-AQD 2012*

### 3.5.2 Overview of Regulatory Environment

The WDEQ–AQD is the primary air quality regulatory agency responsible for estimating impacts once detailed industrial development plans have been made. Those development plans are subject to applicable air quality laws, regulations, standards, control measures, and management practices. Unlike the conceptual 'reasonable, but conservative' engineering designs used in NEPA analyses, any WDEQ–AQD air quality preconstruction permitting demonstrations required would be based on very site-specific, detailed engineering values, which would be assessed in the permit application review. Any proposed facility which meets the requirements set forth under Wyoming Air Quality Standards and Regulations (WAQSR) Chapter 6 (WDEQ–AQD 2015) is subject to the WDEQ–AQD permitting and compliance processes.

Federal air quality regulations adopted and enforced by WDEQ–AQD limit incremental emission increases to specific levels defined by the classification of air quality in an area. The Prevention of Significant Deterioration (PSD) Program is designed to limit the incremental increase of specific air pollutant concentrations above a legally defined baseline level. Incremental increases in PSD Class I areas are strictly limited, while increases allowed in Class II areas are less strict. Under the PSD program, Class I areas are protected by Federal Land Managers through management of air quality related values (AQRVs) such as visibility, aquatic ecosystems, flora, fauna, and others.

The 1977 Clean Air Act amendments established visibility as an AQRV for Federal Land Managers to consider. The 1990 Clean Air Act amendments contain a goal of improving visibility within PSD Class I areas. The Regional Haze Rule, finalized in 1999, requires states, in coordination with federal agencies and other interested parties, to develop and implement air quality protection plans to reduce the pollution that causes visibility impairment.

Regulations and standards which limit permissible levels of air pollutant concentrations and air emissions and which are relevant to the CD-C project air impact analysis include:

- National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50), Wyoming Ambient Air Quality Standards (WAAQS) (WAQSR Chapter 2), and Colorado Ambient Air Quality Standards (CAAQS) (5 CCR 1001-14);
- Prevention of Significant Deterioration (PSD) (40 CFR Part 51.166);
- New Source Performance Standards (NSPS) (40 CFR Part 60);
- Non-Road Engine Tier Standards (40 CFR Part 89);
- Wyoming 2013 Oil and Gas Permitting Guidance (supplement to WAQSR Chapter 6, Section 2); and
- National Emission Standards for Hazardous Air Pollutants (40 CFR Part 63)

Each of these regulations is further described in the following sections.

#### 3.5.2.1 Ambient Air Quality Standards

The Clean Air Act requires the EPA to set NAAQS for pollutants considered to endanger public health and the environment. The NAAQS prescribe limits on ambient levels of these pollutants in order to protect public health, including the health of sensitive groups. The EPA has developed NAAQS for six criteria pollutants: nitrogen dioxide, carbon monoxide, sulfur dioxide, particulate matter, ozone, and lead. Lead emissions from CD-C project sources are negligible and therefore the lead NAAQS is not addressed in this analysis. States typically adopt the NAAQS but may also develop state-specific ambient air quality standards for certain pollutants. The NAAQS and the state ambient air quality standards for Wyoming (WAAQS) and Colorado (CAAQS) are summarized in **Table 3.5-4.** The CAAQS are included in this table due to the proximity of the CD-C project area to Colorado (**Map 3.5-1, Section 3.5.2.6**). The ambient air quality standards are shown in units of parts per million (ppm), parts per billion (ppb), and micrograms per cubic meter ($\mu g/m^3$) for purposes of providing the standards as written in the corresponding regulation, and for comparison with the pollutant concentration units as provided by the air quality models used for impact analysis (**Section 4.5**).

**Table 3.5-4. Ambient air quality standards**

| Pollutant | Averaging Time | NAAQS | | | CAAQS | | | WAAQS | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | (ppm) | (ppb) | (μg/m$^3$) | (ppm) | (ppb) | (μg/m$^3$) | (ppm) | (ppb) | (μg/m$^3$) |
| Carbon monoxide | 1-hour[1] | **35** | 35,000 | 40,000 | **35** | 35,000 | 40,000 | 35 | 35,000 | **40 (mg/m$^3$)** |
| | 8-hour[1] | **9** | 9,000 | 10,000 | **9** | 9,000 | 10,000 | 9 | 9,000 | **10 (mg/m$^3$)** |
| Nitrogen dioxide | 1-hour[2] | 0.1 | **100** | 188 | 0.1 | **100** | 188 | 0.1 | **100** | 188 |
| | Annual[3] | 0.053 | **53** | 100 | 0.053 | **53** | 100 | 0.053 | 53 | **100** |
| Ozone | 8-hour[4] | **0.070**[5] | 70 | 137 | **0.070** | 70 | 137 | **0.075** | 75 | 147 |
| $PM_{10}$ | 24-hour[1] | NA | NA | **150** | NA | NA | **150** | NA | NA | **150** |
| | Annual[3] | NA | NA | --[6] | NA | NA | -- | NA | NA | **50** |
| $PM_{2.5}$ | 24-hour[7] | NA | NA | **35** | NA | NA | **35** | NA | NA | **35** |
| | Annual[3] | NA | NA | **12** | NA | NA | **12** | NA | NA | **12** |
| Sulfur dioxide | 1-hour[8] | 0.075 | **75** | 196 | 0.075 | **75** | 196 | 0.075 | **75** | 196 |
| | 3-hour[1] | **0.5** | 500 | 1,300 | 0.267 | 267 | **700** | **0.5** | 500 | 1,300 |

*Note: **Bold** indicates the standard as written in the corresponding regulation. Other values are conversions.*

[1] *Not to be exceeded more than once per year.*

[2] *An area is in compliance with the standard if the 98th percentile of daily maximum 1-hour nitrogen dioxide concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

[3] *Annual arithmetic mean.*

[4] *An area is in compliance with the standard if the fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

[5] *On October 1, 2015 the EPA revised the NAAQS for 8-hour ozone concentrations from 75 ppb to 70 ppb. The effective date of the revised NAAQS is December 28, 2015 (EPA 2015a),.*

[6] *The NAAQS for this averaging time for this pollutant has been revoked by EPA.*

[7] *An area is in compliance with the standard if the highest 24-hour $PM_{2.5}$ concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

[8] *An area is in compliance with the standard if the 99th percentile of daily maximum 1-hour sulfur dioxide concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

An area that is shown to exceed the NAAQS for a given pollutant may be designated as a non-attainment area for that pollutant. In May 2012, Sublette County and parts of Lincoln and Sweetwater counties were designated by the EPA as "marginal" non-attainment areas under the 2008 ozone standard given there were monitored ozone concentrations above the 75 ppb ozone NAAQS. The effective date of the non-attainment designation was July 20, 2012 http://deq.wyoming.gov/aqd/winter-ozone/resources/nonattainment-info/. EPA has recently proposed to determine that these areas attained the 2008 NAAQS by the applicable attainment date of July 20, 2015, based on complete, quality-assured and certified ozone monitoring data for 2012–2014 (EPA 2015b). The CD-C project area is located in eastern Sweetwater and western Carbon counties, outside of this non-attainment area (**Map 3.5-1, Section 3.5.2.6**).

On October 1, 2015, the EPA lowered the primary ozone NAAQS from 75 ppb to a more stringent value of 70 ppb. The EPA expects to issue detailed guidance on the designation process in early 2016, but has indicated that attainment designations for the 2015 NAAQS will be based on 2014-2016 data. State recommendations for designations of attainment and nonattainment areas are due to EPA by October 1, 2016 and EPA will finalize designations by October 1, 2017. Therefore, at the time of writing of this document, the attainment status of the project area and all Wyoming counties under the 2015 NAAQS is not yet known and the designations under the 2008 NAAQS remain in place.

### 3.5.2.2 Hazardous Air Pollutants

Toxic air pollutants, also known as hazardous air pollutants (HAPs), are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. No ambient air quality standards exist for HAPs; instead, emissions of

these pollutants are controlled by a variety of regulations that target the specific source class and industrial sectors for stationary, mobile, and product use/formulations. Sources of HAPs from CD-C operations include well-site production emissions (benzene, toluene, ethyl benzene, xylene, n-hexane, and formaldehyde), and compressor station and gas plant combustion emissions (formaldehyde).

For the CD-C analysis, short-term (1-hour) HAP concentrations are compared to acute Reference Exposure Levels (RELs) (EPA 2011c) shown in **Table 3.5-5**. RELs are defined as concentrations at or below which no adverse health effects are expected. No RELs are available for ethyl benzene and n-hexane; instead, the available "Immediately Dangerous to Life or Health" (IDLH) values divided by 10 (IDLH/10) are used. These IDLH values were determined by the National Institute for Occupational Safety and Health and were obtained from EPA's Air Toxics Database (EPA 2011c). These values are approximately comparable to mild effects levels for 1-hour exposures.

Long-term exposure to HAPs is compared to Reference Concentrations for Chronic Inhalation (RfCs). An RfC is defined by the EPA as the daily inhalation concentration at which no long-term adverse health effects are expected. RfCs exist for both non-carcinogenic and carcinogenic effects on human health (EPA 2010). Annual modeled HAP concentrations for all HAPs emitted were compared directly to the non-carcinogenic RfCs shown in **Table 3.5-6**.

Long-term exposures to emissions of suspected carcinogens (benzene, ethyl benzene and formaldehyde) are also evaluated based on estimates of the increased latent cancer risk over a 70-year lifetime.

**Table 3.5-5. Acute RELs (1-hour exposure)**

| HAP | REL (µg/m$^3$) |
|---|---|
| Benzene | 1,300[1] |
| Toluene | 37,000[1] |
| Ethyl Benzene | 350,000[2] |
| Xylene | 22,000[1] |
| n-Hexane | 390,000[2] |
| Formaldehyde | 55[1] |

[1] *EPA Air Toxics Database, Table 2 (EPA 2014a).*

[2] *No REL available for these HAPs. Values shown are IDLH (IDLH/10), EPA Air Toxics Database, Table 2 (EPA 2014a).*

**Table 3.5-6. Non-Carcinogenic HAP RfCs (annual average)[1]**

| HAP | Non-CarcinogenicRfC[1] (µg/m$^3$) |
|---|---|
| Benzene | 30 |
| Toluene | 5000 |
| Ethyl Benzene | 1,000 |
| Xylenes | 100 |
| n-Hexane | 700 |
| Formaldehyde | 9.8 |

[1] *EPA Air Toxics Database, Table 1 (EPA 2014b).*

### 3.5.2.3 Prevention of Significant Deterioration

The PSD Program is designed to limit the incremental increase of specific air pollutant concentrations above a legally defined baseline level. All areas of the country are assigned a classification which describes the degree of degradation to the existing air quality that is allowed to occur within the area under the PSD permitting rules. PSD Class I areas are areas of special national or regional natural, scenic, recreational, or historic value, and very little degradation in air quality is allowed by strictly limiting industrial growth. PSD Class II areas allow for reasonable industrial/economic expansion. Certain

national parks and wilderness areas are designated as PSD Class I, and air quality in these areas is protected by allowing only slight incremental increases in pollutant concentrations. Seven PSD Class I areas are located within the CD-C study area as shown on **Map 3.5-2, Section 3.5.3**: the Bridger, Fitzpatrick, Eagles Nest, Flat Tops, Mount Zirkel and Rawah Wilderness Areas, and Rocky Mountain National Park. In addition the Savage Run Wilderness Area, located in the study area, is a federal PSD Class II area given Class I protection by the WDEQ. In a PSD increment analysis, impacts from proposed emissions sources are compared with the allowable limits on increases in pollutant concentrations, which are called Class I PSD increments; these increments are shown in **Table 3.5-7**. Dinosaur National Monument is a federal PSD Class II area given Class I protection for sulfur dioxide by the Colorado Department of Public Health and Environment (CDPHE). The remainder of the impact study area is classified as PSD Class II, where less stringent limits on increases in pollutant concentrations apply. The Gros Ventre and Popo Agie Wilderness Areas and the Wind River Roadless Area are considered sensitive areas and are subject to the PSD Class II Increments shown in Table 3.5-7.

**Table 3.5-7. PSD increments (µg/m$^3$)**

| Pollutant | Averaging Time | PSD Class Increment | PSD Class II Increment |
|---|---|---|---|
| Nitrogen dioxide | 1-hour | None | None |
| | Annual | 2.5 | 25 |
| $PM_{10}$ | 24-hour | 8 | 30 |
| | Annual | 4 | 17 |
| $PM_{2.5}$ | 24-hour | 2 | 9 |
| | Annual | 1 | 4 |
| Sulfur dioxide | 1-hour | None | None |
| | 3-hour | 25 | 512 |
| | 24-hour | 5 | 91 |
| | Annual | 2 | 20 |

*Note: The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.*

Comparisons of CD-C project impacts to the PSD Class I and II increments are for informational purposes only and are intended to evaluate a threshold of concern. They do not represent a regulatory PSD Increment Consumption Analysis, which would be completed as necessary during the New Source Review (NSR) permitting process by the State of Wyoming.

In addition to the PSD increments, Class I areas are protected by FLMs through management of AQRVs such as visibility, aquatic ecosystems, flora, and fauna. Evaluations of impacts to AQRVs would also be performed during the NSR permitting process under the direction of the WDEQ–AQD in consultation with the FLMs.

AQRVs that were identified as a concern for the CD-C project included visibility, atmospheric deposition, and potential sensitive lake acid neutralizing capacity. A discussion of the analysis thresholds and applicable background data is provided below.

### Visibility Thresholds

Change in atmospheric light extinction relative to background conditions is used to measure regional haze. Analysis thresholds for atmospheric light extinction are set forth in The Federal Land Managers' Air Quality Related Values Work Group (FLAG) Report (FLAG 2010), with the results reported in percent change in light extinction and change in deciviews (dv). A 5-percent change in light extinction (approximately equal to 0.5 dv) is the threshold recommended in FLAG (2010) and is considered to contribute to regional haze visibility impairment. A 10-percent change in light extinction (approximately equal to 1.0 dv) is considered to represent a noticeable change in visibility when compared to background conditions.

Estimated visibility degradation at the Class I areas and sensitive Class II areas of concern are presented in terms of the number of days that exceed a threshold percent change in extinction, or dv relative to background conditions. Although procedures and thresholds have not been established for sensitive Class II areas, the BLM is including these areas in its visibility analysis.

### Atmospheric Deposition and Lake Chemistry Thresholds

The effects of atmospheric deposition of nitrogen and sulfur compounds on terrestrial and aquatic ecosystems are well-documented and have shown to cause leaching of nutrients from soils, acidification of surface waters, injury to high-elevation vegetation, and changes in nutrient cycling and species composition. FLAG (2010) recommends that applicable sources assess impacts of nitrogen and sulfur deposition in Class I areas.

This guidance recognizes the importance of establishing critical deposition loading values ("critical loads") for each specific Class I area as these critical loads are completely dependent on local atmospheric, aquatic, and terrestrial conditions and chemistry. Critical load thresholds are essentially a level of atmospheric pollutant deposition below which negative ecosystem effects are not likely to occur. FLAG 2010 does not include any critical load levels for specific Class I areas and refers to site-specific critical load information on FLM websites for each area of concern. This guidance does, however, recommend the use of deposition analysis thresholds (DATs) developed by the National Park Service (NPS) and the U.S. Fish and Wildlife Service (USFWS). The DATs represent screening level values for nitrogen and sulfur deposition from project-alone emission sources below which estimated impacts are considered negligible. The DAT established for both nitrogen and sulfur in western Class I areas is 0.005 kilograms per hectare per year (kg/ha/yr).

In addition to the project-specific analysis, results from cumulative emission sources are compared to critical load thresholds established for the Rocky Mountain region to assess total deposition impacts. The NPS has provided recent information on nitrogen critical load values applicable for Wyoming and Colorado Class I and sensitive Class II areas (NPS 2014). For Class I and sensitive Class II areas in Wyoming, a critical load value of 2.2 kg/ha/yr for nitrogen deposition (estimated from a wet deposition critical load value of 1.4 kg N/ha/yr) is applicable, based on research conducted by Saros et. al.(2010) in the eastern Sierra Nevada and Greater Yellowstone ecosystems. This is a critical load value that is protective of high elevation surface waters. For Colorado Class I and sensitive Class II areas (with the exception of Dinosaur National Monument), a critical load value of 2.3 kg N/ha/yr is applicable, based on research conducted by Jill Baron (Baron 2006) that estimated 1.5 kg/ha/yr as a critical loading value for wet nitrogen deposition for high-elevation lakes in Rocky Mountain National Park, Colorado. For Dinosaur National Monument, which is an arid region, a nitrogen deposition critical load value of 3 kg/ha/yr is used. This value is based on research conducted by Pardo et al. (2011) which concluded that the cumulative critical load necessary to protect shrublands and lichen communities in Dinosaur National Monument is 3 kg N/ha/year total deposition.

For sulfur deposition, the critical load threshold published by Fox et al. (Fox 1989) for total sulfur of 5 kg/ha/yr, for the Bob Marshall Wilderness Area in Montana and Bridger Wilderness Area in Wyoming, is used as critical load threshold from cumulative sources for each of the Class I and sensitive Class II areas.

Analyses to assess the change in water chemistry associated with atmospheric deposition are performed following the procedures developed by the USFS Rocky Mountain Region (USDA 2000). The analysis assesses the change in the acid neutralizing capacity (ANC) of the 19 sensitive lakes (**Table 3.5-6**) within the CD-C study area (**Map 3.5-2, Section 3.5.3**). Predicted changes in ANC are compared with the applicable threshold for each identified lake: 10 percent change in ANC for lakes with background ANC values greater than 25 microequivalents per liter [μeq/L], and less than a 1μeq/L change in ANC for lakes with background ANC values equal to or less than 25 μeq/L.

#### 3.5.2.4 New Source Performance Standards

Under Section 111 of the Clean Air Act, the EPA has promulgated technology-based emissions standards which apply to specific categories of stationary sources. These standards are referred to as New Source Performance Standards (NSPS; 40 CFR Part 60). The NSPS potentially applicable to the CD-C project include the following subparts of 40 CFR Part 60:

- Subpart A – General Provisions;
- Subpart Kb – Standards of Performance for Volatile Organic Storage Vessels;
- Subpart JJJJ – Standards of Performance for Stationary Spark-Ignition Internal Combustion Engines;
- Subpart KKKK – Standards of Performance for Stationary Combustion Turbines;
- Subpart OOOO – Standards for Crude Oil and Natural Gas Production Sources; and
- Proposed Subpart OOOOa – Standards for Crude Oil and Natural Gas Production Sources.

**Subpart A – General Provisions**

Provisions of Subpart A apply to the owner or operator of any stationary source which contains an affected facility. The provisions apply to facilities that commenced construction or modification after the date of publication of any proposed standard. Provisions of Subpart A apply to proposed CD-C sources that are affected by NSPS.

**Subpart Kb – Volatile Organic Liquid Storage Vessels**

Subpart Kb applies to storage vessels with a capacity greater than or equal to 75 cubic meters ($m^3$) that are used to store volatile organic liquids for which construction, reconstruction, or modification is commenced after July 23, 1984. This subpart is applicable to storage tanks for natural gas liquids.

**Subpart JJJJ – Spark-Ignition Internal Combustion Engines**

Subpart JJJJ establishes emission standards and compliance schedules for the control of emissions from spark ignition (SI) internal combustion engines (ICE). The rule requires new engines of various horsepower classes to meet increasingly stringent nitrogen oxides and VOC emission standards over the phase-in period of the regulation. Owners and operators of stationary SI ICE that commenced construction, modification, or reconstruction after June 12, 2006 are subject to this rule; standards will depend on the engine horsepower and manufacture date. This regulation applies to central compressor engines, wellhead and lateral compressor engines, and artificial lift engines as well as any other miscellaneous engines that are stationary, spark-ignited natural gas-powered engines. Therefore, provisions of Subpart JJJJ apply to proposed SI ICE sources in the CD-C project area.

**Subpart KKKK – Stationary Combustion Turbines**

Subpart KKKK establishes emission standards and compliance schedules for the control of emissions from stationary combustion turbines that commenced construction, modification, or reconstruction after February 18, 2005. Stationary combustion turbines with a heat input at peak load equal to or greater than 10.7 gigajoules (10 MMBtu) per hour are subject to this rule. Based on the engine characteristics, stationary combustion turbines in the CD-C project area are affected by Subpart KKKK.

**Subpart OOOO – Crude Oil and Natural Gas Production Sources**

Effective October 15, 2012 with related amendments through July 31, 2015, the NSPS Subpart OOOO regulates volatile organic compound (VOC) emissions from common sources in oil and gas upstream and midstream facilities that include well sites and natural gas processing plants. It also regulates sulfur dioxide emissions from sweetening units at onshore natural gas processing plants. The emission sources

affected by Subpart OOOO include well completions, pneumatic controllers, equipment leaks from natural gas processing plants, sweetening units at natural gas processing plants, reciprocating compressors, centrifugal compressors and storage vessels at facilities which are constructed, modified or reconstructed after August 23, 2011. Well completions subject to Subpart OOOO are limited to hydraulic fracturing or re-fracturing completion operations at natural gas wells.

#### Proposed Subpart OOOOa – Crude Oil and Natural Gas Production Sources

Proposed NSPS Subpart OOOOa (EPA 2015c) would regulate VOC and methane emissions from oil and gas upstream and midstream facilities constructed, modified, or reconstructed after the date of publication of the final rule in the Federal Register. Newly regulated emission sources would include 1) fugitive emissions from well sites and compressor stations, 2) hydraulically fractured or re-fractured oil well completions, 3) pneumatic pumps, and 4) compressors and pneumatic controllers at natural gas transmission compressor stations and gas storage facilities.

### 3.5.2.5 Non-Road Engine Tier Standards

The EPA sets emissions standards for non-road diesel engines for hydrocarbons, nitrogen dioxide, carbon monoxide, and particulate matter. The emissions standards are implemented in tiers by year, with different standards and start years for various engine power ratings. The new standards do not apply to existing non-road equipment. Only equipment built after the start date for an engine category (1999-2006, depending on the category) is affected by the rule. Over the life of the CD-C project, the fleet of non-road equipment would turn over and higher-emitting engines would be replaced with lower-emitting engines. This fleet turnover is accounted for in the CD-C project emissions inventory.

### 3.5.2.6 Wyoming Oil and Gas Permitting Guidance

The CD-C project area lies entirely within eastern Sweetwater County and western Carbon County in Wyoming; this area is part of the State of Wyoming's Concentrated Development Area (CDA; **Map 3.5-1**), and is therefore subject to CDA restrictions on emissions set forth in the WDEQ–AQD's Oil and Gas Production Facilities Chapter 6, Section 2 Permitting Guidance (Guidance), with revisions through September 2013 (WDEQ-AQD 2013). The Guidance states, "….all new or modified sources or facilities which may generate regulated air emissions shall be permitted prior to start-up or modification and Best Available Control Technology (BACT) shall be applied to reduce or eliminate emissions." The Guidance establishes presumptive BACT requirements for emissions from the following source categories for new facilities:

- Tank Flashing[1] (see **Glossary**). Pad facilities: 98-percent control upon startup; single-well facilities: 98-percent control of all new/modified tank emissions ≥ 8 tons per year VOC within 60 days of startup/modification.
- Dehydration Units. Operators of existing and new dehydration units must follow presumptive BACT requirements under either Scenario 1 or Scenario 2 of the Guidance. In general, dehydration units must achieve a VOC control efficiency of at least 98 percent. Under certain conditions and with approval, combustion units used to achieve the 98-percent control may be removed after 1 year. Specific BACT requirements for each scenario are detailed on Pages 13 and 14 of the Guidance.

[1] Flashing losses occur when a liquid with entrained gases goes from a higher pressure to a lower pressure. As the pressure on the liquid drops, some of the compounds dissolved in the liquid are released, or "flashed" as gas.

- Pneumatic Pumps. Pad facilities: Upon FDOP or date of modification, VOC and HAP emissions associated with the discharge streams of all natural gas-operated pneumatic pumps must be controlled by at least 98 percent or the pump discharge streams must be routed into a closed-loop system such as sales line, collection line, fuel supply. Single-well facilities: upon FDOP or date of modification, those with combustion units installed for the control of flash or dehydration unit emissions: VOC and HAP emissions associated with the discharge streams from natural gas-operated pneumatic pumps must be controlled by at least 98 percent by routing the pump discharge streams into the combustion unit or the discharge streams routed into a closed loop system.
- Pneumatic Controllers. Upon FDOP or date of modification, install low- or no-bleed controllers at all new facilities or discharge streams routed into a closed-loop system; the same requirement applies to existing controllers within 60 days of modification.
- Well Completions. Operators must submit applications to perform well completions using Best Management Practices. One permit will be issued to each company that drills and completes wells within the CDA. The permits will be modeled after those issued to companies completing wells in the Jonah and Pinedale Anticline Development Area (**Map 3.5-1**).
- Produced-Water Tanks. Pad facilities: Upon FDOP, 98-percent control of all produced-water tank VOC and HAP emissions must be achieved. No water may be produced into open-top tanks except for emergency or upset condition use. Single-well facilities: Within 60 days of FDOP, 98 percent of all produced-water tank emissions must be controlled at sites where flashing emissions occur. Existing open-top active produced water tanks must be removed from service, and all active produced water tanks must have a closed top and be controlled by at least 98 percent. Produced-water tank emissions control removal may be allowed upon approval.
- Blow-down/Venting. BMPs and information-gathering requirements incorporated into permits for new and modified facilities.
- Other sources. For uncontrolled sources emitting ≥8 tpy VOC or ≥5 tpy total HAPs that do not have presumptive BACT requirements, a BACT analysis must be filed with the permit application for the associated facility.

#### 3.5.2.7 National Emission Standards for Hazardous Air Pollutants

Under Section 112 of the Clean Air Act, the EPA has promulgated emissions standards for HAPs which apply to specific source categories. These standards are referred to as National Emission Standards for Hazardous Air Pollutants (NESHAPS) and are codified in 40 CFR 63. Applicable to the CD-C project is 40 CFR 63 Subpart HH, National Emission Standards for Hazardous Air Pollutants from Oil and Natural Gas Production Facilities. Subpart HH sets standards for benzene, ethylbenzene, toluene, and xylene (BTEX) at gas well facilities and natural gas processing plants. Sources regulated include existing and new small and large glycol dehydrators at major and area sources, certain storage vessels at major sources, and compressors and ancillary equipment in VOC/HAP service at major sources.