

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

**af Artificial fill (uppermost Holocene)** — Fill material placed during construction of roads, railroads, and ditches. Generally consists of unsorted silt, sand, clay, and rock fragments. The average thickness of the unit is less than 10 ft (3 m).

**rd Retained and disturbed areas (uppermost Holocene)** — Unsorted silt, sand, clay, and rock fragments. This unit includes areas of excavation, construction, and quarrying operations where original deposits have been removed, replaced, or reworked.

ALLUVIAL DEPOSITS

Alluvium of the Gunnison River

The Gunnison River is associated with six terrace levels in the northern part of the quadrangle. Alluvium 3 of the Gunnison River is not in the quadrangle but its prior existence is inferred by the presence of an alluvium of the Uncompahgre River at this level indicating a confluence of the two rivers at the time of deposition of alluvium 3. Alluvium River deposits are commonly light gray to dark-brown, moderately sorted, loose to densely packed, subrounded to well rounded, weakly to strongly imbricated, clast supported pebble to cobble sized clasts in a matrix of sand, silt, and clay. They are dominantly composed of gneiss, schist, pegmatitic granites, monzonite, granodiorite, hornfels, quartzite, diatite, andesite, and basalt.

Darling and others (2009) used the location of a Lava Creek B ash deposit that at 639 Ka, on Twentyfive Mesa to calculate a local incision rate of 540 ft (165 m) / Ma (Langphre et al., 2002). The age range for Qag<sub>3</sub> and older map units provided here was determined by using this incision rate.

**Alluvium one of the Gunnison River (Holocene)** — Qag, consists of deposits in the currently active stream channel or in low stream-terrace deposits within the modern flood plain of the Gunnison River. Maximum exposed thickness of the unit locally exceeds 10 ft (3 m), but the base of the unit is not exposed in the quadrangle. Based on mapping of the equivalent unit in the Whitewater quadrangle by White and others (2014), the unit extends to a depth of approximately 30 ft (9 m) below the level of the Gunnison River. Areas mapped as Qag<sub>1</sub> may be prone to flooding, erosion, and sediment deposition.

**Alluvium two of the Gunnison River (Holocene to Upper Pleistocene)** — Qag<sub>2</sub>, consists of channel and flood plain sediments deposited prior to artificial flood control of the Gunnison River. Unit includes overbank deposits of crossbedded sand and interbedded sand and silt that locally range in thickness between 3 and 6.5 ft (1 to 2 m). Maximum exposed thickness of the unit is 16 ft (5 m), however the base is not exposed in the quadrangle. Dating of the equivalent unit in the Whitewater area indicates an approximate maximum age of 11.8 ka +/- 1 ka (White and others, 2014), correlating to the end of the Pinedale glaciation (Armour and others, 2002). Qag<sub>2</sub> is a potential source of commercial sand and gravel.

**Alluvium three of the Gunnison River (Upper to Middle Pleistocene)** — Qag<sub>3</sub>, strath levels range from 23 to 150 ft (7 to 45 m) above the level of the modern Gunnison River. Maximum exposed thickness of the unit is 16 ft (5 m). East of Roubideau Creek this unit is commonly mantled by a thick (up to 20 feet) cover of old alluvial-fan material (Qo<sub>1</sub>) emanating from Soap Creek and several unnamed drainages. Qag<sub>3</sub> mapped in the Delta quadrangle by Morgan and others (2008) corresponds to the lower 80 ft (25 m) of this unit. Estimated age for the map unit ranges from 90 ka to 320 ka. Qag<sub>3</sub> has been mined for placer deposits and has been and currently is being quarried for gravel for construction purposes; it continues to be a potential source of these resources.

**Alluvium four of the Gunnison River (Middle Pleistocene)** — Qag<sub>4</sub>, strath levels range from 155 to 200 ft (48 to 89 m) above the level of the modern Gunnison River. Maximum exposed thickness of the unit is 20 ft (6 m). The composition of the Qag<sub>4</sub> deposits in the Roubideau Creek area is virtually identical to that of the Qag<sub>3</sub> deposits and are distinguished from the Qag<sub>3</sub> deposits on the basis of terrace riser orientation and geometry. Estimated age for the map unit ranges from 330 to 580 ka. Qag<sub>4</sub> is a potential source of commercial sand and gravel.

**Alluvium five of the Gunnison River (Middle Pleistocene)** — Qag<sub>5</sub>, strath levels are approximately 305 ft (93 m) above the level of the modern Gunnison River. Maximum unit thickness is 6.5 ft (2 m); however, strath levels of Qag<sub>5</sub> deposits mapped to the east in the adjacent Delta quadrangle are at levels up to 330 ft (100 m) above the modern Gunnison River (Morgan and others, 2008). Bed-sized clasts of slabby sandstone are present in the lower part of the unit. Estimated age for the map unit is approximately 610 ka. Qag<sub>5</sub> is a potential source of commercial sand and gravel, although it is limited in extent and volume.

**Alluvium seven of the Gunnison River (Calabrian?)** — The strath level of the Qag<sub>7</sub> unit at the deposits only occurrence in the quadrangle is 435 ft (132 m) above the level of the modern Gunnison River. The maximum exposed thickness for the unit is 20 ft (6 m). The deposit can consist of 20% or more clasts of basaltic composition. The unit is capped by the Qag<sub>7</sub> gravel, with a contact that is abrupt where well exposed. Estimated age for the map unit is 840 Ka; however, this unit may be significantly younger due to knickpoint migration (Darling and others, 2009). Due to the overlying Qag<sub>7</sub> deposit, it is unlikely that Qag<sub>7</sub> could be an economically viable source of commercial sand and gravel.

Alluvium of the Uncompahgre River

The Uncompahgre River is identified as the source of three terrace levels in the map area, the lowest and youngest of which is alluvium four of the Uncompahgre River. Uncompahgre River alluvium of levels three and younger were previously mapped exclusively east of the Roubideau quadrangle (Morgan and others, 2008; White and others, 2008).

Uncompahgre River deposits are commonly light gray to light brown, moderately consolidated, pebble-to-cobble sized, rounded to subrounded, moderately sorted, clast-supported gravels in medium brown to light tan, silt-to-granule size matrix. Clast composition is dominantly volcanic, plutonic, and metamorphic rocks of the San Juan Mountains. Porphyritic andesites and dacites are common, with lesser amounts of hornfels, basalts, and quartzites typical of the Uncompahgre Group. West margins of Qau units, along the Uncompahgre Plateau deposits, contain significant percentages of cobble- to small boulder-sized sandstone and hard mudrock clasts that were deposited at confluences of tributary streams cut into Mesozoic rocks.

Darling and others (2009) used the location of a Lava Creek B ash deposit on Twentyfive Mesa in the map area to calculate a local incision rate of 540 ft (165 m) / Ma. The age range for each map unit provided here has been determined by using this incision rate.

**Alluvium four of the Uncompahgre River (Middle Pleistocene)** — Qau<sub>4</sub>, strath levels range from 165 to 280 ft (50 to 85 m) above the level of the modern Gunnison River with exposed thickness typically ranging from 23 to 26 ft (7 to 8 m). This unit is commonly overlain by old alluvial fans (Qo<sub>1</sub>) which form a gravel cap on Qau<sub>4</sub> deposits in the southeastern and northeastern portions of the map area and caps small mesas along Roubideau Creek. Estimated age for the map unit ranges from 350 ka to 560 ka. Areas along the deposit perimeters may be prone to slope failure particularly where the upper surface is or has been irrigated. Qau<sub>4</sub> is a potential source of commercial sand and gravel.

**Alluvium five of the Uncompahgre River (Middle Pleistocene)** — Qau<sub>5</sub>, deposits have strath levels ranging from 310 to 340 ft (95 to 105 m) above the level of the modern Gunnison River. Exposed thickness typically ranges from 10 to 23 ft (3 to 7 m). This unit is capped by old alluvial fans (Qo<sub>1</sub>) from the Uncompahgre Plateau at locations along Sawmill Mesa Road and near Twentyfive Mesa Road. In the Kelson Gulch and Negro Gulch areas this unit contains a high percentage (>30%) of subangular to subrounded clasts dominantly composed of sandstone with a greater amount of sand, silt, and clay matrix. A verified deposit of Lava Creek B ash, dated at 0.64 Ma, occurs at one location within Kelson Gulch at a level 15 ft (0.5 m) below the elevation of the upper surface of nearby Qau<sub>5</sub> deposits (Darling and others, 2009). Estimated age for the map unit ranges from 620 ka to 680 ka. Qau<sub>5</sub> is a potential source of commercial sand and gravel.

**Alluvium six of the Uncompahgre River (lower Middle Pleistocene)** — Straths of the Qau<sub>6</sub> unit occur between 33 and 39 ft (10 to 12 m) above the strath level of the Qau<sub>5</sub> deposit. The southern portion of the Qau<sub>6</sub> deposit south of Club Gulch are influenced by local tributaries, containing up to 50% subangular to subrounded, cobble-sized clasts of well-lithified sandstone. Maximum unit thickness occurs on Twentyfive Mesa where it is 13 ft (4 m) thick and overlain by Qo<sub>1</sub> deposits. Estimated age for the map unit is 750 ka; however, this unit may be significantly younger due to knickpoint migration (Darling and others, 2009). Qau<sub>6</sub> is a potential source of commercial sand and gravel, although it is limited in extent and volume.

Alluvium of Roubideau Creek

Four sets of deposits sourced from Roubideau Creek are recognized in the map area, the lowest two are undifferentiated on this map. Alluvium one of Roubideau Creek, the deposits of the active channel, merges with and corresponds to the Qag<sub>1</sub> Gunnison River deposits; alluvium two of Roubideau Creek corresponds to the Qag<sub>2</sub> Gunnison River deposits.

**Alluvium one and two of Roubideau Creek, undifferentiated (Holocene to Upper Pleistocene)** — The Qar<sub>1,2</sub> map unit consists of two subunits: The upper subunit, which is approximately 3 ft (1 m) thick, consists of light to dark brown, moderately to unconsolidated, moderately to poorly sorted sand and silt with frequent horizons of matrix-supported pebble- to cobble-sized clasts. The lower subunit consists of faint planar to wavy bedding with horizons of sandy organic material. The dry and hard alluvium commonly forms steep-sided walls where dissected by river erosion. The upper subunit consists of tan to dark brown, moderately consolidated to unconsolidated, moderately sorted, pebble- to boulder-sized, matrix- and clast-supported gravels; matrix consists of dark brown sand and silt. Clast composition is dominantly well-lithified sandstone with trace amounts of reworked, well-rounded Qau<sub>6</sub> clasts from adjacent deposits. Maximum exposed thickness is 6.5 ft (2 m). Areas mapped as Qar<sub>1,2</sub> may be prone to flooding, erosion, and sediment deposition.

**Alluvium three and four of Roubideau Creek (Upper to Middle Pleistocene)** — Qar<sub>3</sub> and Qar<sub>4</sub> alluvium are composed of light brown to dark brown, moderate to unconsolidated, subrounded to subangular, moderately to poorly sorted, clast- and matrix-supported pebble- to boulder-sized gravels in a matrix of dark to medium brown sand and silt. Clast composition is almost exclusively well-lithified sandstone with minor amounts of well-lithified conglomerate and mudstone. Occurrences of Qar<sub>3</sub> within Roubideau Canyon in the southern part of the quadrangle, are commonly capped by thin colluvial deposits. The Qar<sub>3</sub> deposits are at levels corresponding to the Qag<sub>3</sub> deposits, the Qar<sub>4</sub> deposits are at levels corresponding to the lowest levels of the Qau<sub>6</sub> deposits.

Alluvium of Cottonwood Creek

**Alluvium one and two of Cottonwood Creek, undifferentiated (Holocene to Upper Pleistocene)** — Alluvium one of Cottonwood Creek is composed of the deposits of the active channel, while alluvium two of Cottonwood Creek is composed of the valley-fill deposits within Cottonwood Canyon. Qacc<sub>1,2</sub> consists of two subunits: the upper 3 to 6.5 ft (1 to 2 m) is tan to light brown, moderate to unconsolidated, moderately well sorted sand and silt with horizons of matrix-supported pebble- to cobble-sized clasts. Subunit is planar to wavy laminated with zones of tangential crossbedding. Undulating horizons of up to 2 in (5 cm) thick sandy organic material are common. The subunit is not present at all locations. The lower subunit consists of tan to dark brown, moderately to poorly consolidated, moderately sorted, pebble- to cobble-sized, matrix- and clast-supported gravels in a matrix of sand and silt. Clasts are subrounded to subangular, weakly imbricated, and fine upward. Clast composition is dominantly well-lithified sandstone with a small amount (<5%) of well-lithified siltstone and conglomerate. Contact with the overlying sandstone is commonly abrupt. Maximum exposed thickness is 6.5 ft (2 m). Areas mapped as Qacc<sub>1,2</sub> may be prone to flooding, erosion, and sediment deposition.

**Alluvium three of Cottonwood Creek (Upper to Middle Pleistocene)** — The Qacc<sub>3</sub> unit is light brown to dark brown, moderately to unconsolidated, subangular to subrounded, pebble- to boulder-sized matrix-supported gravel. Matrix is composed of light to dark brown sand and silt. Maximum exposed thickness is 13 ft (4 m).

Alluvium of Buttermilk Creek

**Alluvium one of Buttermilk Creek (Holocene to Upper Pleistocene)** — The Qab<sub>1</sub> unit is a medium yellow-brown, poorly to moderately sorted, unconsolidated clay, silt, and sandy gravel in the currently active stream channel or in low stream-terrace deposits within the modern flood plain of Buttermilk Creek. The dry alluvium commonly forms steep-sided walls where dissected by river erosion. Maximum exposed thickness of the unit locally exceeds 15 ft (4.5 m). The unit merges with the Qar<sub>1,2</sub> level of Roubideau Creek. Areas mapped as Qab<sub>1</sub> may be prone to flooding, erosion, and sediment deposition.

**Alluvium two of Buttermilk Creek (Upper Pleistocene)** — The Qab<sub>2</sub> unit is composed of light gray to light brown, moderately sorted, poorly consolidated, pebble- to cobble-sized clasts in a matrix of light brown to tan sand, silt, and clay. Alluvium was derived from reworking of older alluvial deposits of the Uncompahgre River (Morgan and others, 2008). Locally, these deposits are mantled by colluvium derived from Qau<sub>6</sub> deposits. Maximum exposed thickness locally exceeds 20 ft (6 m). The unit corresponds to and merges with the lowest Qar<sub>3</sub> level of Roubideau Creek.

Alluvial Gravel Deposits

Dark gray to black, and occasionally dark red, poorly sorted, subrounded to angular, pebble- to boulder-sized gravel composed chiefly of basaltic clasts originating from Grand Mesa and deposited in confined channels that flowed southward from Grand Mesa to the ancestral Gunnison River. The lower areas are clast supported, loosely packed, with a yellow-tan to light brown sand, silt, and clay matrix. Boulder-sized clasts are most common at the base of each unit.

**Gravel deposit three (Middle Pleistocene)** — Qg<sub>3</sub> deposits have a maximum exposed thickness of 23 ft (7 m) with a strath level 125 ft (38 m) above the level of the modern Gunnison River. Qg<sub>3</sub> is prone to landslides where it caps Mancos Shale along steep slopes.

**Gravel deposit four (Middle Pleistocene)** — Qg<sub>4</sub> deposits have a maximum exposed thickness of 13 ft (4 m) with a strath level 175 ft (53 m) above the level of the modern Gunnison River. The unit is prone to landslides where it mantles Mancos Shale along steep slopes but is relatively stable where it fans out over Qg<sub>3</sub> gravels.

**Gravel deposit seven (Calabrian?)** — Qg<sub>7</sub> deposits have a maximum exposed thickness of 36 ft (11 m) with the base of the unit 450 ft (137 m) above the level of the modern Gunnison River. The unit contains a small percentage (<10%) of subrounded to well-rounded clasts of sandstone, granitic, dark gray andesite, mica schist, rhyolite, quartzite, and diorite. The deposit may be late Calabrian in age on the basis of local incision rates but may be younger due to knickpoint migration (Darling and others, 2009).

UNDIFFERENTIATED ALLUVIAL DEPOSITS

**Alluvium, undifferentiated (upper Holocene)** — Dark brown to reddish-tan, poorly to moderately sorted, unconsolidated, weakly to moderately stratified, sand, silt, and clay with pebble- to boulder-sized gravels, which are located in valley and canyon bottoms of ephemeral and perennial streams and in small basins behind dams. Deposit thickness can vary from less than 3 ft (1 m) in canyon bottoms to more than 10 ft (3 m) in basins. Areas mapped as Qm may be prone to flooding, erosion, and sediment deposition. Portions of this unit may also contain low-density and soft soil and would be susceptible to ground settlement.

**Alluvial gravels, undifferentiated (Upper to Middle Pleistocene)** — Light gray to dark brown, poorly to moderately sorted, poorly consolidated to unconsolidated, matrix- and clast-supported pebble- to boulder-sized gravels in a matrix of sand, silt, and clay. Gravel-sized clasts are commonly reworked from Qau deposits. Maximum exposed thickness is 16 ft (5 m). The unit occurs in two general areas, mantling Mancos Shale in the vicinity of Soap Creek, and south of Lochhart Road where it occurs as remnants of a drainage tributary to Cottonwood Creek.

**Old alluvial gravel of Uncompahgre Plateau origin (Middle Pleistocene)** — Dark to light brown, moderately sorted, poorly consolidated, subrounded, matrix- and clast-supported, pebble- to cobble-sized gravels. Clast composition is well-lithified sandstone, mudstone, and conglomerate. Thickness ranges from a few inches to 15 ft (0.5 m). Clast composition is consistent with lithologies of well-lithified strata of Mesozoic rocks of the Uncompahgre Plateau. The unit occurs along a gradient from Sawmill Mesa to Kelson Gulch. The Qgu deposits indicate that, during the early Middle Pleistocene, a drainage originating from the Uncompahgre Plateau flowed through present day Cactus Park and Kelso Gulch.

**Alluvial mudfill and fine valley-fill deposits (Holocene)** — Medium gray to pale gray-yellow, well to moderately sorted, poorly consolidated, silt clay to clayey silt deposited as valley fill and as coalescing alluvial fans. Planar, wavy, and thin sets of tangential cross-stratification are common. Source material is derived primarily from Mancos Shale. The unit is distinguished from the Qm map unit based on the abundance of clay and silt and the relative lack of gravel-sized clasts. Unit may be prone to hydrocompaction and contain swelling clay minerals. Exposed unit thickness may exceed 13 ft (4 m).

**Alluvial fan deposits (Holocene)** — Light tan to dark brown and gray, poorly sorted, unconsolidated, clay- to sand with scattered to abundant, pebble- to boulder-sized gravel deposited at the mouth of ephemeral streams and coalescing fans at the base of slopes. The deposits may exceed 13 ft (4 m) in thickness. The deposits may contain zones of low density and/or high porosity and may be susceptible to soil collapse and ground settlement. Areas mapped as alluvial fans may be subject to future flash floods and debris flow events.

**Old alluvial fan deposits (Upper to Middle Pleistocene)** — Tan to dark brown and reddish-brown, poorly to moderately sorted, poorly to moderately consolidated, clay- to sand with dispersed to abundant, pebble- to boulder-sized gravel. Qlo deposits west of Roubideau Creek commonly include pebble- to boulder-sized clasts composed of well-lithified sandstone, mudstone, and conglomerate that are characteristic of Mesozoic rocks of the Uncompahgre Plateau. Qlo deposits east of Roubideau Creek commonly include a high percentage of clay and silt and angular slabby sandstone clasts; these deposits may also include reworked Qau gravels. Maximum thickness exceeds 23 ft (7 m).

ALLUVIAL/COLLUVIAL AND MASS-WASTING DEPOSITS

**Colluvial deposits (Holocene)** — Light brown to light and dark gray, poorly sorted, poorly consolidated, clay- to sand-sized grains with scattered to abundant pebble- to boulder-sized gravels. The unit is typically deposited along the slopes and at the base of steep canyon walls as a result of rockfall events. Maximum unit thickness can exceed 10 ft (3 m). Colluvial deposits may be prone to settlement or mobilization and can indicate areas of slope instability.

**Alluvial and colluvial deposits, undifferentiated (Holocene)** — Dark brown to reddish-tan, poorly to moderately sorted, poorly consolidated, sand, silt and clay with pebble- to boulder-sized gravels. The unit is deposited near to or at the channel bottom in narrow canyons and near the base of slopes where hillside slithering and colluvial processes are the dominant sedimentation processes. The unit is distinguished from the Qm map unit by a lack of down channel sediment transport. Maximum exposed unit thickness is less than 10 ft (3 m).

**Old alluvial and colluvial deposits, undifferentiated (Upper to Middle Pleistocene)** — Reddish-brown to light tan, poorly to moderately sorted, mixed alluvial fan, sheetwash, and colluvium. The unit consists of non-stratified sand, silt and clay with dispersed angular pebble- to cobble-sized clasts of local origin. In the Cactus Park area, this unit forms a valley-fill deposit that likely exceeds 65 ft (20 m) in depth. Portions of this unit may contain low density and potentially collapsible soil, and could be susceptible to ground settlement.

**Landslide deposits (Holocene to Upper Pleistocene)** — Landslide deposits are found in two general locations: along the steep slopes below the edges of the gravel-capped mesas and terrace remnants, and within the plateau canyons on the canyon walls where weak mudstones of the Morrison Formation have failed. Landslide deposits along the mesa edges consist of medium gray to yellow-gray, chaotic, unsorted, unconsolidated, highly weathered and disturbed Mancos Shale fragments, derived clay, and transported and reworked terrace gravels. Landslides adjacent to mesa and terrace remnants are common where the surface is currently or was irrigated. Landslide thickness in these areas may locally exceed 20 ft (6 m). Landslide deposits within canyons consist of light gray to pale red, chaotic, unsorted, unconsolidated clay- to boulder-sized material. Sandstone blocks greater than 10 ft (3 m) in exposed diameter lie within and atop landslide deposits. In Roubideau Canyon and Cottonwood Canyon, landslide deposits also blanket and underlie a bench roughly half way down the canyon depth which becomes wider and more pronounced to the south. In some areas, erosion of old landslide deposits exposed the underlying bedrock. All landslide deposits should be considered potentially unstable and may be susceptible to reactivation. Landslide deposits within the canyons of the Uncompahgre Plateau in particular may be susceptible to reactivation and incorporation into debris flows during and after significant precipitation events.

BEDROCK GEOLOGY

**Mancos Shale (Upper Cretaceous)** — The Mancos Shale has been subdivided on the basis of regional mapping previously published by the Colorado Geological Survey (e.g. Morgan and others, 2008). All members of the Mancos Shale are prone to landsliding.

**Juana Lopez Member of the Mancos Shale** — Dark gray to orange-brown, moderately lithified, calcareous and calcareous marine shale. The unit consists of thin sets of low-angle crossbedding and planar and wavy bedding. At the base of the unit, multiple sets of distinctive orange-brown sand-rich intervals are interbedded with dark gray shale intervals. Fossils were found in exposures studied in the map area. Only the lower ~65 ft (20 m) of the unit is present in the Roubideau quadrangle.

**Blue Hill and Fairport Members of the Mancos Shale, undivided** — Olive-green to dark to light gray, fissile, glauconitic, poorly indurated, moderately to noncalcareous, silty, marine shale. Oblate septarian concretions and very fine-grained, calcareous sandstone lenses consistently occur in the upper 23 ft (7 m) of this unit in multiple horizons. The middle part of the unit is olive-green, fissile shale with distinct bedding planar. The lower part of the unit is distinctly lighter gray in color due to a decrease in glauconitic. Fossils are rare. The unit is 110 to 125 ft (33 to 38 m) thick.

**Graneros and Bridge Creek Limestone Members of the Mancos Shale, undivided** — Soft, dark gray to black to olive-green, slightly calcareous, moderately lithified marine shale. The upper 26 to 33 ft (8 to 10 m) of the unit consists of discontinuous calcareous shale and marlstone of the Bridge Creek Limestone Member. Nolluk fossiliferous limestone is occasionally located at the base of the Bridge Creek Limestone. Discontinuous beds of fine-grained, calcareous sandstone from 2 to 6 in (5 to 15 cm) thick are found in the lower 33 ft (10 m) of the unit. Contact with the underlying Dakota Formation is gradational. Unit thickness is 90 to 165 ft (28 to 52 m).

**Dakota Formation (Upper to Lower?) (Cretaceous)** — Dark brown to orange-brown sandstone, dark to light gray and green-gray shale, minor coal, and dominantly matrix-supported conglomerate. Moderately to well indurated, and moderately to well sorted except for conglomerate intervals, which are poorly sorted. Upper conformable contact with Graneros Member of the Mancos Shale was mapped 10 to 16 ft above the highest ~3-ft thick sandstone bed in the Dakota Formation. The upper portion of the unit consists of alternating sandstone and shale intervals with sandstones becoming more dominant at the base. Sandstone intervals are planar to wavy bedded and tangentially crossbedded. Ripple-marked sandstones and bioturbated zones are common. Shale intervals are commonly dark gray, organic rich, and are planar to wavy bedded. The lower portion of the unit consists of alternating intervals of sandstones and organic-rich shales with minor coal beds. Sandstone intervals are well lithified, erosional resistant composed of medium- to coarse-grained sand, and are planar, wavy, and tangentially crossbedded. Asymmetrical ripple-marked sandstone is common. The base of the Dakota Formation is dominantly marked by a sandstone and chert pebble and mud rip-up conglomerate bed ranging from less than 3 ft to over 16 ft (1 m to over 5 m) thick. The basal contact with the underlying Burro Canyon Formation is often undulating, abrupt, and is unconformable. The thickness of the Dakota Formation ranges from 110 to 125 ft (33 to 38 m).

**Burno Canyon Formation (Lower Cretaceous)** — The Burno Canyon Formation consists of an upper unit which is a light green to yellow-green, moderately consolidated, slightly calcareous to non-calcareous mudrock with minor sandstone beds. Planar and wavy bedding is common with frequent trace fossils. Sandstone beds in this upper unit are most commonly less than 8 in (20 cm) thick but can be over 3 ft (1 m) thick, laterally discontinuous, well consolidated, non-calcareous, and are planar to wavy bedded. The upper contact with the overlying Dakota Formation is undulating, abrupt, and unconformable, occasionally marked by calcareous. The basal portion of the upper unit is often composed of a distinctive dark red to reddish-brown, weakly to moderately consolidated, non-calcareous siltstone to medium-grained sandstone. The upper unit ranges from less than 6.5 ft (2 m) to approximately 55 ft (17 m) thick. The lower unit of the Burno Canyon Formation consists of a tan to dark brown, poorly to moderately well sorted, well-consolidated, fine- to coarse-grained, laterally continuous sandstone and conglomerate. Sandstone is tangential and trough crossbedded as well as wavy and planar bedded. The base of the subunit is commonly conglomeratic with clasts of lithic and chert pebbles up to 1.5 ft (4 m) in diameter with occasional mud-rippled clasts. Subunit ranges from less than 10 ft to over 130 ft (3m to over 40 m) thick. The lower subunit base was mapped at the lowest, resistant conglomeratic sandstone (following Scott and Phoenix, 1948). However, some or all of the basal sandstone herein mapped as Burno Canyon Formation may, in places, be amalgamated-channel sandstone beds of the underlying Morrison Formation (Aubrey, 1998).

**Morrison Formation (Upper Jurassic)** — The Morrison Formation is divided into three members, from the top down: the Brushy Basin Member, the Salt Wash Member, and the Tidwell Member. The base of the Morrison Formation is not exposed in the map area; based on well log data the formation is approximately 675 ft (205 m) thick (Colorado Oil and Gas Conservation Commission, 2015).

**Brushy Basin Member of the Morrison Formation** — Light gray to dark red and purple, moderately consolidated, slope-forming mudstone with channel-forming sandstone beds which are more common in the upper portion of the member. Mudrock intervals contain bentonitic claystone and siltstone, and are planar and wavy bedded. Plant fossils, including rhizomes, are common. Sandstones are commonly composed of dark brown to reddish-brown, moderately to well indurated, fine- to coarse-grained sand with tangential and trough crossbedding. Typically moderately to well sorted but can contain matrix-supported chert pebbles. These sandstones are commonly 3 to 6.5 ft (1 to 2 m) thick and may extend laterally 300 ft (90 m) or more. These sandstones are consistent with channel sandstones in the upper Morrison described by Aubrey (1998). The Brushy Basin Member is prone to mass wasting including significant landsliding. Landslide complexes are common along the base of this unit in the deep canyons composed of Roubideau Canyon, Cottonwood Canyon, and along the Gunnison River. Steep slopes composed of the Brushy Basin Member should be considered unstable and a potential hazard. The Brushy Basin Member ranges from 295 ft to 360 ft (90 m to 110 m) thick.

**Salt Wash Member of the Morrison Formation** — Buff to dark brown, moderately well sorted, moderately to moderately well indurated, medium- to coarse-grained sandstone interspersed with moderately to poorly consolidated, light gray to green and dark red mudrocks, shales, and sandy shales. Sandstones are trough and tabular tangential crossbedded, commonly silica cemented, and occasionally include basal matrix-supported pebble conglomerates. Sandstone beds range from less than 3 ft to over 30 ft (1 m to over 10 m) thick. Mudrock intervals are tabular-planar and wavy bedded and are typically friable and fissile; they range from less than 3 ft to more than 16 ft (1 m to more than 5 m) thick. Both sediment deformation structures such as load casts, dewatering structures, and bioturbation are common. The contact with the overlying Brushy Basin Member is disconformable (Steiner, 1998). For mapping purposes, this contact was located at the top of the highest, continuous, significant (>10 ft (3 m) thick) sandstone bed. Unit thickness ranges from 150 to over 215 ft (54 m to over 66 m).

**Tidwell Member of the Morrison Formation** — Medium gray to dark red, moderately to moderately well indurated, slope-forming mudrock, shale, siltstone, and limestone. Thin (<2 ft (0.6 m)) reddish-brown, planar-bedded, medium- to fine-grained sandstone beds are interspersed with the mudrocks. Limestone is micritic, weakly fossiliferous, and occurs in beds up to 4 to 10 cm thick. The contact with the overlying Salt Wash Member is gradational but for mapping purposes the top of the Tidwell Member was located at the top of the uppermost large limestone bed (Scott and others, 2002). Maximum exposed thickness in the map area is 90 ft (28 m); however, the base of the unit is not exposed in the map area. Based on well log data the total unit thickness is approximately 150 ft (46 m) (Colorado Oil and Gas Conservation Commission, 2015).

**Wanakah Formation (Middle Jurassic) and Extrada Sandstone (Middle Jurassic) undivided** — Shown on cross section only.

**Chinle Formation (Upper Triassic)** — Shown on cross section only.

**Precambrian Rocks** — Shown on cross section only.

MAP SYMBOLS

**Contact**

**Fault** — Dashed where inferred, dotted where concealed, U on upthrown side, D on downthrown side.

**Syncline** — Line denotes axis of syncline.

**Monocline** — Line denotes location of axis of monocline, arrow shows direction of dip; dotted where concealed.

**Landslide scarp** — Line denotes top of landscape scarp, hachure in downslope direction.

**Terrace Tread Riser** — Line denotes approximate lateral extent of terrace scarp, hachure is in upslope direction.

**Strike and dip of inclined bedding** — Showing direction and angle of dip.

**Lava Creek B ash** — Volcanic ash of Yellowstone Caldera origin, 0.64 Ma.

**Mine adit**

**Alignment of cross section**

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This map is dedicated to the memory of Felicie Williams.