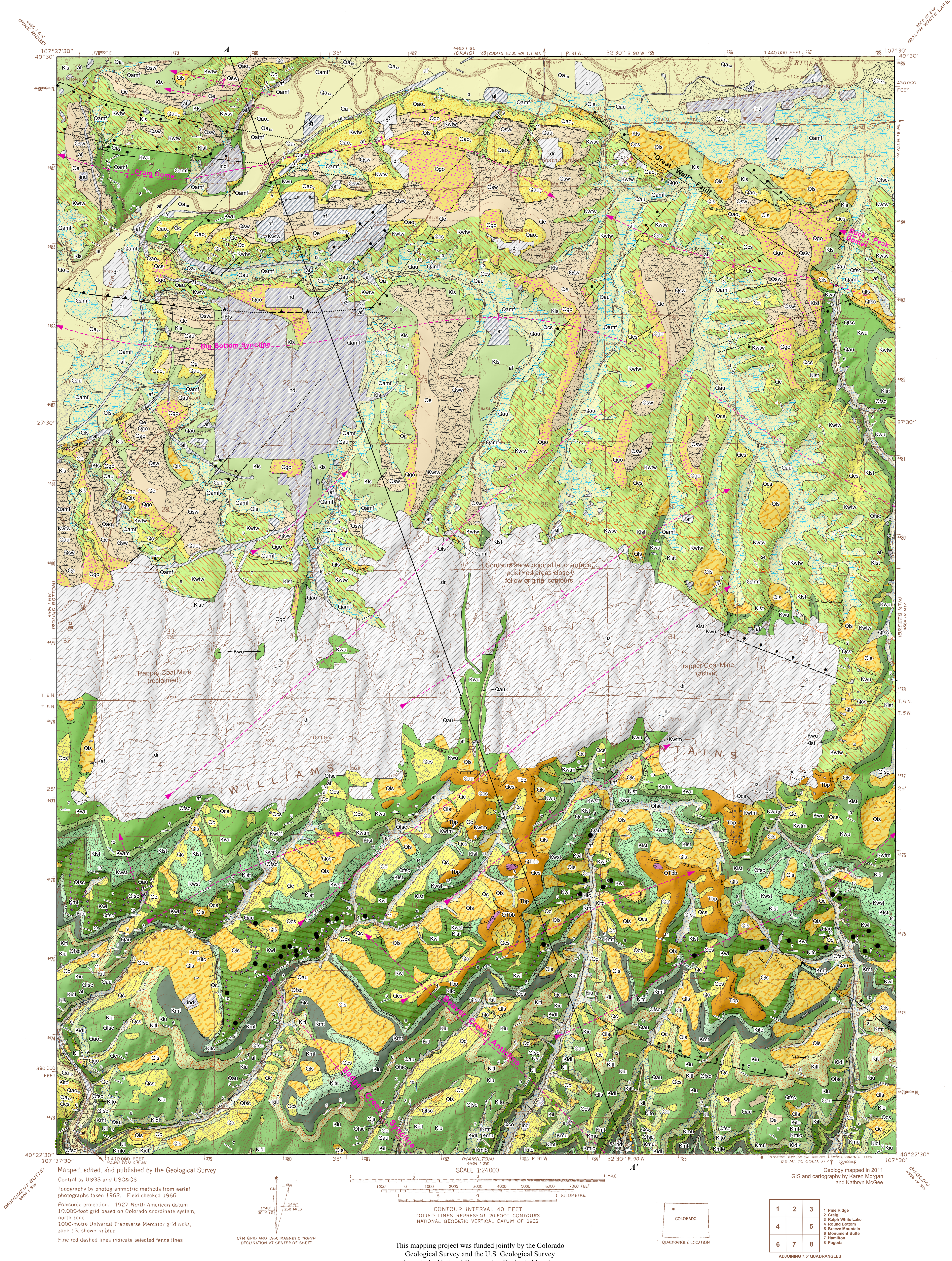

This mapping project was funded jointly by the Colorado Geological Survey and the U.S. Geological Survey through the National Cooperative Geologic Mapping Program under STATEMAP agreement number G13AC00213

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af — **Artificial fill (latest Holocene)** — Riprap, fill, and refuse placed during construction of roads, railroads, buildings, dams, and landfills. Generally consists of unsorted silt, sand, clay, and rock fragments. The average thickness of the unit is typically less than 20 feet, although high embankments can be more. Artificial fill may be subject to settlement, slumping, and erosion if not adequately compacted or designed for drainage control.

dr — **Disturbed and/or reclaimed ground (latest Holocene)** — Deposits in areas where the land has been disturbed as a result of mining, quarrying, or oil and gas production. Natural landform has been modified and surface is covered by either disturbed locally derived material or imported material. Material can be highly variable from sand, silt, and clay; to gravel and boulders and may include refuse of many types including household and industrial sources. Some locations have been contoured and revegetated to match original contours. Other areas have been adapted to other uses or have been left vacant.

ind — **Industrial area (latest Holocene)** — Riprap; fill; pavement; earth material and waste product storage; and buildings or industrial facilities covering large areas of ground.

ALLUVIAL DEPOSITS

Qau — **Alluvial deposits, undifferentiated (Holocene to late Pleistocene)** — Brown to tan to gray, poorly to moderately sorted, poorly consolidated, locally derived sand, gravel, and silt. It occurs primarily in valley heads and in tributary streams where differentiation of specific alluvial units is not possible due to poor exposure. Unit is connected to modern perennial and intermittent stream courses. Thickness is estimated to be up to 15 feet.

Qa_1, Qa_{1a}, Qa_{1b} — **Alluvium one of Yampa River and Williams Fork (Holocene to late Pleistocene)** — Tan to medium-brown, poorly to moderately sorted, poorly to moderately consolidated, sand, gravel, silt, and minor clay and sparse boulders. Deposits in the currently active stream channels, or in low stream-terrace deposits less than 5 feet higher than the current stream channel, that are flooded during most spring run-off seasons are designated Qa_{1a}. Those between 5 and 12 feet higher than the active channel that are flooded only in very high run-off seasons are designated Qa_{1b}. Where Qa_{1a} and Qa_{1b} are not differentiated they are mapped as Qa_1. Clasts are subrounded to well rounded and the dominant sediment is sand with a sandy silt matrix. Deposits associated with the Yampa River consist of up to 7 feet of sand and silt over a medium pebble and cobble gravel of granite, granitic gneiss, hornblende gneiss, vein quartz, occasional red sandstone, and rare vesicular basalt. Maximum exposed thickness of the unit locally exceeds 10 feet. The unit is connected to modern perennial and intermittent stream courses and is subject to frequent flooding. It is a source of sand and gravel.

Qao_y — **Older gravel deposits of Yampa River (Pleistocene)** — Medium gray to grayish brown, poorly sorted, fine to coarse sand interbedded with pebble and cobble gravel. Fines are dominant at the top of the unit and may include, and be indistinguishable from, overlapping colluvium, mud fan, and sheetwash deposits. Clasts are subrounded to well rounded with sizes generally less than eight inches, although rare clasts can reach 2.5 feet in diameter. Matrix consists predominantly of quartz, feldspar, and lithic fragments derived from multiple sources. Clasts consist of granite; gray diorite; pink, white, and black gneiss; quartz; red sandstone; brown and gray chert; and rare vesicular basalt. Clasts of red sandstone and chert imply the presence of Paleozoic strata in the watershed. Generally unconsolidated, but occasionally may be cemented with $CaCO^3$. The deposits form terraces between 10 and 200 feet above the modern floodplain and thickness can locally exceed 20 feet. In many areas the unit has been quarried for sand and gravel. The deposit forms a stable building surface.

Qao_w — **Older gravel deposits of Williams Fork (Pleistocene)** — Gray to tan-brown, moderately sorted, fine to coarse sand interbedded with pebble and cobble gravel. Fines are dominant at the top of the unit and may include, and be indistinguishable from, overlapping colluvium and sheetwash deposits. Clasts are subrounded to well rounded with sizes generally less than 8 inches. Matrix consists predominantly of quartz, feldspar, and lithic fragments derived from multiple sources. Clasts consist of vesicular and massive basalt; quartz; feldspar; granite; gneiss; quartzite; dark white and gray chert; and sandstone. Sources are exposures of Mesaverde Group, Browns Park Formation, as well as transport of volcanic clasts from the Dunkley Flat Tops. The deposits form terraces between 10 and 120 feet above the modern floodplain. The unit locally exceeds 10 feet in thickness. The deposit forms a stable building surface and is a potential source of sand and gravel.

Qsw — **Sheetwash alluvial deposits (Holocene to late Pleistocene)** — Tan to grayish-brown, poorly sorted, poorly to moderately consolidated sand, silty and clayey sand, with minor amounts of gravel. Unit consists chiefly of local materials transported on moderate slopes (~10 percent grade) by sheetflow, but also includes some sediment delivered by runoff in rills and minor gullies. The unit is prone to hydrocompaction. Maximum exposed thickness is 15 feet.

ALLUVIAL-FAN DEPOSITS

Qfsc — **Alluvial fan, sheetwash, and colluvial deposits, undifferentiated (Holocene to late Pleistocene)** — Stream-channel and flood plain deposits along valley floors of ephemeral, intermittent, and small perennial streams, small coalescing alluvial fans, sheetwash on slopes, and colluvium along valley sides. Alluvial deposits are typically composed of poorly- to well-sorted, stratified, interbedded, pebbly sand, sandy silt, and sandy gravel derived from local sources. Sheetwash deposits are similar to alluvial deposits, but may contain more fine-grained material and are not found in distinct channels. Colluvium may range from unsorted, clast-supported, pebble to boulder gravel in a sandy matrix to matrix-supported, gravelly, clayey sand. Maximum thickness of the unit is approximately 15 feet.

Qamf — **Alluvial, mud flow and mud fan deposits (Holocene to late Pleistocene)** — Well- to occasionally poorly sorted, poorly consolidated, clayey to sandy silt deposited in valley-head and valley-side alluvial fans, tributary stream valleys, and coalescing fans in local basins. The deposits comprise a complex system of deposits that may extend for miles along tributary stream reaches. The basin- and valley-fill sediments were deposited primarily by muddy debris flows with occasional input from sheetwash, hyperconcentrated flows, and water-flood flows. The deposits consist of poorly defined silt layers, typically less than an inch to a few inches thick, which record individual mudflow depositional events. Some layers show incipient soil development that was curtailed by burial during subsequent events. Areas mapped as Qamf may be subject to future flash floods and debris flow events, especially in non-incised valley-head and valley-side areas and within the deeply dissected modern arroyo channels. The deposits may be prone to significant collapse from dispersion, hydrocompaction, or slope failure when wetted or loaded. Qamf deposits may exceed 5 feet in thickness in valley-head and valley-side areas and may exceed 15 feet in thickness along the valley reaches and in the basins. Many of the tributary-stream mudflow deposits and coalescing fans have been deeply dissected by stream erosion during the late Holocene, resulting in narrow, steep-walled arroyos that are 5 to 20 feet deep along the valley bottoms in most areas.

Qgo — **Older gravel deposits (Pleistocene)** — Gray to grayish brown, poorly sorted, fine to coarse sand interbedded with pebble, cobble and boulder gravel. Clasts are subrounded to well rounded from multiple sources and occupy paleo-stream valleys that are no longer in depositional contact with modern drainages. Deposits of paleo-drainages sourced off of the Williams Fork Range can contain large boulders of basalt up to 4 feet in diameter. The paleo-valleys are now inverted, positive features in the landscape and may display remnant morphology of the original channels or fans. The unit locally exceeds 10 feet in thickness. It can form a stable building surface and is a potential source of sand and gravel.

MASS-WASTING DEPOSITS

Qc — **Colluvial deposits (Holocene to late Pleistocene)** — Unsorted and unstratified to stratified, reddish-brown to pale brown, pebble to boulder size rock fragments in a sandy silt and clay matrix on slopes up to 30 percent grade. Unit contains locally derived angular to subangular clasts that can be either clast-support, or matrix-support, and often form wedge-shaped deposits below ledge-forming bedrock. May include rockfall debris. The unit can be transitional with landslide deposits and is differentiated by the lack of a well-defined scarp.

Qcs — **Colluvial and sheetwash deposits (Holocene to late Pleistocene)** — Deposits of colluvium transitional with deposits of sheetwash consisting of local materials transported on moderate to steep slopes. Also includes some sediment delivered by runoff in rills and minor gullies. Deposits locally exceed 15 feet in thickness. Areas mapped as colluvial and sheetwash are susceptible to future rockfall events and flood events.

Qco — **Older colluvial deposits (Pleistocene)** — Colluvial deposits on features above modern drainages where coarse material armors the underlying material from erosion.

Qls — **Landslide deposits (Holocene to middle Pleistocene)** — Heterogeneous deposits consisting of unsorted and unstratified clay, silt, and sand, and cobble- and boulder-size rock fragments. Unit includes rotational and translational slides and complex earthflow mass movements. In most places, landslides show obvious geomorphic expression that disrupts the profile of the slopes. Generally, head scarps (near-vertical detachment scars exposed at the top of and sides of the landslides) are readily recognizable; however, some scarps may be eroded or covered and not pronounced. Other common diagnostic features include hummocky topography, closed depressions, sag ponds, fissures, terracettes, tension cracks, and pressure ridges at the toe of the mobilized mass. Landslide areas are subject to future movement during episodes of heavy rain or snowfall or may be reactivated by human-made disturbances such as cutting of slopes for roads, quarries, grading for housing developments, and irrigation and septic systems. Landslide deposits are prone to settlement when loaded or wetted. The deposits may contain expansive soils where derived from shale and mudstone formations. Thickness of landslide deposits locally exceeds 10 feet.

QTbb — **Basalt boulder deposits (early Pleistocene to Pliocene? or Miocene?)** — Assemblages of large basalt boulders ranging in size from less than 6 inches to over 5 feet. Consists of both massive and vesicular basalt, with occasional surfaces retaining original flow textures. Angular to sub-angular boulders are clast supported, with a matrix of smaller cobbles and boulders along with brown to dark brown organic-rich silt and clay. Fines may be wind-derived soil. Deposits form small isolated knobs and linear ridges. Boulders show little evidence of long-range transport and may be old talus deposits with no remaining local cap-rock sources. The unit has potential for rockfall. Ar/Ar analysis by the New Mexico Geochronology Laboratory of a sample of non-vesicular basalt yielded a date of 23.11 ± 0.013 million years (Ma) (M. Heizler, personal communication 2013).

EOLIAN DEPOSITS

Qe — **Eolian deposits (Holocene to late Pleistocene)** — Yellowish-brown to reddish-brown, fine- to medium-grained sand and silt deposited primarily by wind. Grains are subangular to subrounded. The deposits form blankets, or occasionally drifts, that are thickest on northeast-facing slopes. Dune forms are not present in the mapped area. Dryland farming is common is areas underlain by these deposits especially where silt dominates. These eolian deposits are moderately compacted and easily excavated; however, they can hold surface water. Unit may reach 15 feet in thickness.

BEDROCK UNITS

Tbp — **Browns Park Formation (Pliocene to Oligocene)** — Cream-colored, white to grey to tan, occasionally mottled rusty brown, fluvial sandstone interbedded with eolian sandstone, mudstone, and gravel. Generally recessive unit forms slopes and ledges. Fluvial sandstone is fine to coarse-grained, poorly to moderately sorted, moderately cemented, and occurs in lenticular beds up to ten feet thick that exhibit trough cross-beds and horizontal planar beds; multiple channel deposits can be stacked on top of each other. Where cross-bedding is well exposed, foreset orientation indicates a generally northwest-to-north current direction. Eolian sandstone is medium- to fine-grained, moderately well-sorted, friable, with poor internal structure or large scale trough cross-bedding. In places, white color and blocky texture suggests high ash content. Exposures are rare in elevated terrain, where presence of the unit is often indicated only by occurrence of abundant pebbles and cobbles of a basal conglomerate scattered on the surface. Basal conglomerate is shown as a dashed line on the map where observed. Clasts in the basal conglomerate are well-rounded and range from pebble size up to 6-inches, and consist of granite, quartz, quartzite, white and black gneiss, epidote-rich gneiss, and limestone. A cream white volcanic ash bed near the base in Section 5, T.5N., R.90W. yielded an Ar/Ar age date of 29.84 +/- 0.03 Ma and an isolated ash in Section 17, T.6N., R.90W. yielded an age of 27.57 +/- 0.10 Ma (Daniel Miggens, Oregon State University 40Ar/39Ar Geochronology Laboratory, personal communication, 2015). The unit is prone to landsliding. Unit thickness is variable, up to 120 feet in this quadrangle.

Lewis Shale (Upper Cretaceous)

Kls — **Lewis Shale, main body** — Gray to brownish-gray thin-bedded, fissile, marine mudstone containing thin beds of silt and fine- to very fine- grained sandstone. It is light gray where silt content is high and weathers to pale to moderate yellowish brown. The unit is recessive, resulting in a gentle rolling landscape, with natural exposures of undisturbed bedding limited primarily to deeply eroded gullies and landslide scarps. High bentonite content gives this shale a high swell/shrink capacity and the unit is prone to landsliding. Only the lower several hundred feet of Lewis Shale are exposed in this quadrangle, primarily within the Big Bottom Syncline and on the downthrown side of the Great Wall Fault.

Klst — **Tongues of Lewis Shale** — Tongues of the Lewis Shale underlie and are upwardly transitional with the Three white sandstones member (Kwtw), Twentymile Sandstone Member (Kwtm), and Sub-twentymile sandstone member (Kwst) of the Williams Fork Formation, forming distinctive low-sloping benches beneath the ledge-forming sandstones. Tongues are similar in composition and bedding as the main body of the Lewis Shale. The unit is prone to landsliding. Thickness varies from less than 20 feet to almost 200 feet. The tongues tend to thin and become dominated by thin

Williams Fork Formation (Upper Cretaceous)

Kwtw — **Three white sandstones member** — White to tan, moderately to well- indurated sandstone, interbedded with marine and non-marine shale with minor coal beds. Well indurated, forming cliffs, distinct ledges, and "hoodoos". Three distinct, upward-coarsening, very fine to medium grained sandstone intervals can be present, and are usually only seen together in steep valley wall exposures. Ledge-forming sandstones are shown as dashed lines on the map. Beds of grey marine shale 20 to 40 feet thick separate the sandstone beds and are mapped as Lewis Shale (Kls) in this area. Sandstone consists of moderately well-sorted grains of quartz, feldspar, and grains of black chert or hornblende, with a $CaCO_3$ cement. Bedding grades from horizontally laminated thin beds of sand, silt and shale; to sandstone beds up to 100 feet thick, displaying large-scale, trough cross-bedding, local hummocky cross-bedding, and massive-bioturbated intervals. Toward the top, bedding becomes sub-horizontal and the surface is typically planar and often pock-marked or bioturbated. Carbonaceous shale with occasional thin beds of coal may cap the sandstone intervals. Oyster shells can be abundant in the shale above the sandstone bodies. Bivalve hash may also be present in thin tabular sandstone beds. Locally, resistant knobs of brown very fine- to fine-grained irregularly bedded to ripple-bedded sandstone rise above more easily eroded friable sandstone. These irregular knobs of more resistant sandstone appear to be cemented by iron-rich calcite and are more common in the lower-most sandstone interval, giving it a distinctive appearance. Total unit thickness of the Three white sandstones member is 200 to 300 feet. The unit is prone to rockfall. Regionally, the unit becomes more marine to the east as the sandstone intervals thin, become finer-grained, and non-marine shale and coal beds pinch out. The unit may be equivalent to the Almond Formation as recognized in the subsurface to the north in the Sand Wash and Washakie Basins (Roehler, 1987).

Kwu — **Williams Fork Formation, upper part** — Interbedded sandstone, non-marine shale, and coal that form ledges and slopes. Brown, rusty brown, and tan to grey lenticular to tabular sandstone beds consist of fine to medium grained quartz and feldspar with black grains of chert or hornblend. Beds range from less than one foot to over 20 feet in thickness, and exhibit ripple cross-bedding, horizontal bedding, trough cross-bedding, local convoluted bedding, and local non-organized bioturbated intervals. Shale beds are grey to pale grey and can be lignitic. Coal beds as thick as ten feet comprise the Upper Coal Group of the Yampa Coal Field and have been commercially mined in the area. In many exposures the coals have naturally burned, baking and fusing adjacent beds of shale to a distinctive brittle red "klinker". Total unit thickness is 300 to 400 feet.

Kwtm — **Twentymile Sandstone Member** — Cream-white to pale-orange, well indurated sandstone that forms a band of distinctive cliffs and ledges. The sandstone coarsens upward from the gradational contact with the underlying slope-forming tongue of the Lewis Shale (Klst), to fine- to medium-grained sand at the top. In places the unit consists of a single cliff-forming sandstone body as thick as 120 feet and in other locations, where it is more recessive, it consists of multiple sandstone beds up to 15 feet thick separated by thin shale stringers. Sand grains consist of quartz, feldspar, and grains of black chert or hornblende, cemented by $CaCO_3$. Bedding grades from horizontally laminated thin beds of sand, silt and shale; upward to massive sandstone that can often be structureless and bioturbated; or may display large trough cross-bedding up to 6 feet high, planar bedding, or local hummocky cross beds. The top is typically capped by tabular beds of horizontally bedded sandstone less than three feet thick displaying a rough bioturbated surface. Locally, the top can be incised by distinct brown, resistant, channel-shaped bodies of trough cross-bedded very fine- to fine- grained sandstone up to 10 feet thick. The unit is prone to rockfall. Total thickness of the member ranges from 100 to 150 feet.

Kwst — **Sub-twentymile sandstone member** — Tan to light brown indurated sandstone, interbedded with shale, overlain and underlain by tongues of Lewis Shale (Klst), forming ledges and slopes. Sandstone beds 20 to 80 feet thick consist of fine- to medium-grained quartz, feldspar, and black grains of chert and hornblende. They exhibit trough cross-bedding, hummocky cross-bedding, horizontal bedding, and can appear structureless and bioturbated. Trace fossils include *Ophiomorpha* and rare worm burrows. Beds of grey shale up to 5 feet thick separate the individual sandstone beds. The unit is prone to rockfall. Total unit thickness is variable ranging from 120 feet to over 200 feet.

Kwl — **Williams Fork Formation, lower part** — Interbedded sandstone, non-marine shale, and coal that form ledges and slopes less resistant than the overlying Sub-twentymile sandstone member (Kwst). Brown, rusty brown, and tan to grey, lenticular to tabular sandstone beds consist of fine- to medium-grained quartz and feldspar with black grains of chert or hornblende. Beds range from less than 1 to over 20 feet in thickness. They exhibit ripple cross-bedding, horizontal bedding, trough cross-bedding, local convoluted bedding, and local bioturbated intervals. Shale beds are grey to pale grey and can be lignitic. Coal beds as thick as 10 feet comprise the Middle Coal Group of the Yampa Coal Field and have been commercially mined in the area. In many exposures the coals have naturally burned, baking and fusing adjacent beds of shale to distinctive brittle red "klinker". Total unit thickness is 250 to 300 feet.

Kwah — **Hamilton ash bed** — Cream- to rose-colored tonstein below the Sub-twentymile member (Kwst). The bed has often been baked by naturally burning coals into a brittle porcelanite and forms distinctive cream- or rose-colored bands on slopes. The bed is up to 5 feet thick and can contain casts of woody material and leaves.

Kway — **Yampa ash bed** — Cream- to rose-colored tonstein in the lower part of the Williams Fork Formation. The bed has often been baked by naturally burning coals into a distinctive brittle porcelanite. Can be massive and fresh appearing with small crystals of biotite. It locally contains casts of gastropods, bivalves or plant material. The bed is up to 10 feet thick and forms distinctive cream or rose-colored bands on slopes. Where the bed is thick it can form unstable scree slopes. It is difficult to distinguish from light grey shale beds where the burning coal has not baked the bed to porcelanite. A field scintillometer indicates gamma-ray radiation can be elevated above background in this area (up to 62 mr/min as compared to 30 to 35 mr/min). A sample of the ash bed near the base in Section 8, T.5N., R.90W. yielded an Ar/Ar age date of 72.57 +/- 0.34 Ma (Daniel Miggens, Oregon State University 40Ar/39Ar Geochronology Laboratory, personal communication, 2015).The bed is described in detail by Brownfield and Johnson (2008).

ILES FORMATION (CRETACEOUS)

Kitc — **Trout Creek Sandstone Member** — Cream-, white-, to tan-colored, well indurated sandstone that forms a conspicuous band of cliffs below the Williams Fork Formation. It typically appears as a single interval of sandstone, but in places it may consist of up to three, distinct ledge-forming beds separated by thin layers of shale. It consists of sand containing quartz, feldspar, and grains of black chert or hornblende, cemented by $CaCO^3$, that coarsens upward from very fine- to fine-grained. Rare rip-up clasts of shale can be present in the sandstone. The base is gradational with the slope-forming tongue of the Mancos Shale (Kmt) beneath. Bedding grades upward from horizontally laminated, thin beds of sand, silt and shale, to a thick bed of sandstone up to 120 feet thick, displaying trough cross-bedding, local hummocky cross-bedding, local convoluted bedding, and intervals that are structureless and bioturbated. The top may be capped by tabular beds of sandstone less than 3 feet thick, displaying a rough pock-marked, bioturbated surface. *Ophiomorpha* burrows may be present. The unit is prone to rockfall. Total thickness ranges from 100 to 150 feet. The unit is genetically tied to the overlying Williams Fork Formation, representing eastward shoreline progradation above the Mancos Shale tongue (Kmt) and transition from a marine through delta/shoreline to non-marine coastal plain setting. However, it has historically been mapped as the upper member of the Iles Formation (Bass and others, 1955), as shown herein.

Kiu — **Iles Formation, upper part** — Interbedded well-indurated sandstone, siltstone, carbonaceous shale, and marine shale, and coal, forming slopes and ledges that tend to be more recessive than the lower part of the Iles Formation (Kil). Tan to brown, whitish to grey, and pale orange beds of sandstone up to 25 feet thick can be lenticular to tabular and laterally continuous, and consist of very fine to fine grained quartz, feldspar, and grains of black chert or hornblende, cemented by $CaCO^3$. Sandstone beds can have ripple cross-bedding, trough cross-bedding, sub-horizontal planar bedding, contorted bedding, and structureless, bioturbated intervals. Sandstone occasionally has liesegang iron oxide banding. Rip-up clasts of mudstone can be present. Where planar cross-bed forests are well exposed, the orientation indicates a generally south-to-southeast current direction. Shale beds are light to medium grey to tan. Palm frond imprints and gastropod and bivalve shell fragments may be present in the sandstone. Fragments of light brown to tan petrified wood can also be present. Total unit thickness is between 600 and 700 feet.

Kitl — **Triple ledge sandstone member** — Cream-white-, to tan-colored, well indurated sandstone, interbedded with gray shale that forms a series of ledges and small cliffs near the top of the Iles Formation. Typically, three to four distinct ledges can be present, starting approximately 20 to 40 feet below the distinct Mancos Shale tongue (Kmt) beneath. Sandstone contains quartz, minor feldspar, and black grains of chert or hornblende, cemented with $CaCO^3$. It tends to be upward-coarsening very fine to fine grained and exhibits sub-horizontal planar bedding, trough cross-bedding, structureless-bioturbated intervals, ripple cross-bedding, and convoluted bedding. Rip-up clasts of shale can be present. Local trough cross-bedding indicates bi-directional, tidal, current direction. The tops of each ledge-forming sandstone interval can be planar and pock-marked or bioturbated. Some pock marks may be crude dinosaur tracks. Unit thickness ranges from 200 to 350 feet and is a source for large-clast alluvial fan deposits and rock-fall debris in canyon floors.

Kidl — **Double ledge sandstone member** — The uppermost distinctive, laterally continuous interval of well-indurated sandstone in the lower part of the Iles Formation. Forms a series of ledges and cliffs that rim the steep canyons of the Williams Fork Mountains. The sandstone is tan to pale grayish-orange and consists of one to three, thick, tabular sandstone bodies separated by shale and thin-bedded sandstone stringers. In places, the lower-most interval is up to 80 feet thick. Sandstone intervals consists of upward-coarsening, very fine- to fine-grained sand containing quartz, feldspar, and grains of black chert or hornblende cemented by $CaCO^3$. Bedding can be large-scale trough cross-bedding to sub-horizontal planar bedding to massive and bioturbated. Mud drapes and mud rip-up clasts can be present. The tops of each ledge are typically planar and pock-marked. Some pock marks may be crude dinosaur tracks. Total unit thickness is 40 to 80 feet. The unit is source for large-clast alluvial fan deposits and rockfall debris in canyon floors.

Kil — **Iles Formation, lower part** — Interbedded sandstone, siltstone, carbonaceous shale, marine shale, and minor coal that forms slopes, small cliffs, and ledges. A number of laterally continuous, ledge-forming intervals of sandstone, that Crabaugh (2001) describes as shoreline tongues within the Iles clastic wedge, make the lower part of the Iles Formation more resistive to erosion, producing rougher topographic relief than the upper part. Light-brown, to whitish, to very-pale orange beds of sandstone up to 40 feet thick can be lenticular to tabular, and laterally continuous. They consist of very fine to fine grained quartz, feldspar, and grains of black chert or hornblende. Sandstone beds can have ripple cross-bedding, trough cross-bedding, sub-horizontal planar bedding, hummocky cross-bedding, contorted bedding, and structureless-bioturbated intervals. Shale beds are light to medium grey to tan. The coal beds comprise the Lower Coal Group of the Yampa Coal Field and have been commercially mined in the area. Locally, the coals have naturally burned, baking and fusing adjacent beds of shale to distinctive brittle red "klinker". Total unit thickness is between 300 and 400 feet. The unit is a source for large-clast alluvial fan deposits and rockfall debris in the canyon floors.

Kito — **Tow Creek Sandstone Member** — The lowermost distinctive, cliff-forming, well indurated sandstone interval of the lower part of the Iles Formation. It consists of tan- to cream-colored to pale orange, upward-coarsening, very fine to fine-grained sandstone in gradational contact with the underlying tongue of the Mancos Shale (Kmt). It consists of multi-storied bodies of sandstone displaying sub-horizontal bedding, hummocky cross-bedding, large-scale trough cross-bedding, channel scours, and thin tabular beds with ripple cross-bedding. Mud-draped surfaces can be present. *Ophiomorpha* burrows and bivalve fossils can be present. The unit is prone to rockfall. Total unit thickness is 60 to 100 feet.

MANCOS SHALE

Kmu — **Mancos Shale, upper part of main body** — Olive-gray to pale yellowish-brown, non-calcareous, silty to sandy, marine mudstone that forms recessive slopes below the Iles Formation. Thin, sheet-like, hummocky cross-bedded sandstone beds near the top form small ledges that step up to the base of the steeper, cliff forming Iles Formation. Overall thickness is 1,250 to 1,450 feet but only the uppermost 200 to 300 feet are found in the quadrangle.

Kmt — **Tongue of the Mancos Shale** — A tongue of the Mancos Shale underlies, and is upwardly transitional with, the Trout Creek Sandstone member (Kitc). It forms a distinctive gently-sloping bench beneath the ledge-forming sandstone. It is similar in composition and bedding form as the main body. Thickness ranges between 40 and 120 feet. It is highly prone to landsliding, and the benches above the Iles Formation are often sites of conspicuous earth flows.

Kmlo — **Loyd Sandstone Member** — A ledge-forming, moderately to well indurated sandstone, forming low cliffs and ledges below the Tow Creek Sandstone (Kito), that has a distinctive light olive-brown color. It consists of upward-coarsening sandstone with large-scale trough cross-bedding and occasional, conspicuous bioturbation. *Ophiomorpha* burrows and *Inoceramus* casts can be present. Total unit thickness is 80 to 120 feet.

MAP SYMBOLS

Kwtw — **Three white sandstones member ledge—** Three dots per dash indicate upper sandstone ledge; two dots per dash indicate middle ledge; one dot per dash indicates lower ledge.

Kiss — **Iles Formation sandstone ledges—** Four dots per dash indicate sandstone number 4; two dots per dash indicate sandstone number 2 counted from the Loyd Sandstone Member up.

Kmss — **Mancos Formation—** sandstone ledge in upper part on the unit, may be equivalent to the Berry Gulch sandstone.

Contact—Approximately located

Fault—Long dash where approximate; Short dash where inferred; Dotted where concealed; ball and bar on downthrown side.

Reverse Fault—Long dash where approximate; Dotted where concealed; teeth on overthrust side.

Anticline—Approximately located, axial arrow in direction of plunge.

Syncline—Approximately located, axial arrow in direction of plunge.

Monocline—Steepest part, approximately located, axial arrow in direction of plunge.

Landslide scarp above a landslide deposit (Qls) where source material is highly deformed. Hachure in slope direction.

Incipient landslide scarp— A scarp above an intact block of bedrock that appears to have moved slightly yet the area below remains organized with original bedrock characteristics still recognizable. Movement may have lateral as well as rotational components. The area below scarp has the potential to move if disturbed by erosion or excavation. Hachures are on downslope side. Yellow where certain, red where inferred.

Edges of Pleistocene terraces Hachures are on sede where alluvial deposit is present.

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

Ash beds—Outcrop exposures.

A — A′ **Alignment of cross section**

GEOLOGIC MAP OF THE CASTOR GULCH QUADRANGLE, MOFFAT COUNTY, COLORADO

By Peter E. Barkmann, William Curtiss, Christopher J. Carroll, Daniel R. Hosler, Nathan T. Rogers, Zachary D. Logan, and Michael J. Zawaski

2015

COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES