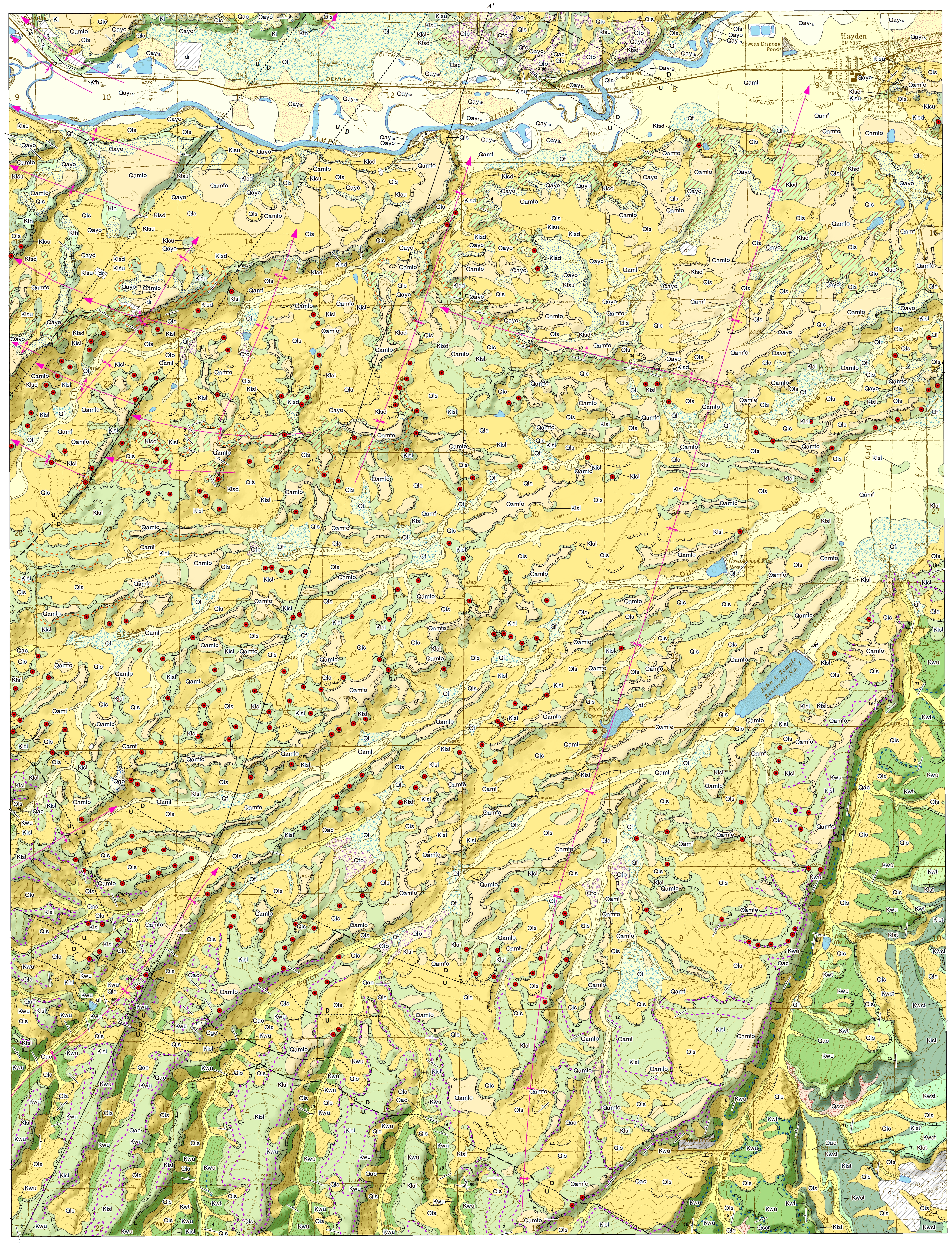

Base from U.S. Geological Survey, 1971
Lambert Conformal Conic Projection, 1927 North American Datum
10,000-foot grid based on Colorado coordinate system, north zone
1,000-meter Universal Transverse Mercator grid ticks, zone 13

Geology mapped in 2011
GIS and cartography by Pangaea Geospatial, LLC

GN MN 1° 30' 27 MILS 14 1/2° 258 MILS

UTM GRID AND 1971 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET
DIAGRAM IS APPROXIMATE

SCALE 1:24,000

0 0.225 0.45 0.9 1.35 1.8 Miles

0 485 970 1,940 2,910 3,880 4,850 5,820 6,790 Feet

0 0.5 1 2 Kilometers

CONTOUR INTERVAL 40 FEET
DOTTED LINES REPRESENT 20-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

COLORADO

QUADRANGLE LOCATION

1	2	3
4		5
6	7	8

1 Ralph White Lake
2 Rock Spring Gulch
3 Hooker Mountain
4 Breeze Mountain
5 Mount Harris
6 Pagoda
7 Hayden Gulch
8 Dunckley

ADJOINING 7.5' QUADRANGLES

GEOLOGIC MAP OF THE HAYDEN QUADRANGLE, ROUTT COUNTY, COLORADO

By David C. Noe, Peter E. Barkmann, Kevin J. McCall, Michael J. Zawaski, Zachary D. Logan, and Daniel R. Hosler

2015

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

HUMAN-MADE DEPOSITS

af — **Artificial fill (late Holocene)** — Riprap, engineered fill, and refuse placed during construction of dams and other embankments. Generally consists of unsorted silt, sand, clay, and rock fragments. Artificial fill may be subject to settlement, slumping, and erosion if not adequately compacted or designed for drainage control. Thickness is typically less than 20 feet, although high embankments can be more.

dr — **Disturbed and/or reclaimed ground (late Holocene)** — Deposits in areas where land is disturbed as a result of mining. Target resource may be gravel, sand, or coal. Natural landform has been modified and surface is covered by disturbed, locally derived or imported material. Material can be highly variable, from fine sand, silt, and clay to gravel and boulders, and may include household or industrial refuse. Some locations have been regraded, revegetated, and reclaimed. Thickness is typically less than 20 feet.

ALLUVIAL DEPOSITS

Qay_{1a} — **Alluvium one-a of the Yampa River (late to middle Holocene)** — Tan to medium-brown, poorly to moderately sorted, poorly to moderately consolidated, sand, gravel, silt, and minor clay and sparse boulders in the currently active stream channels or in low stream-terrace deposits less than 5 feet higher than the modern Yampa River. Gravel clasts are subrounded to well rounded. Consists of up to 7 feet of sand and silt over a medium pebble and cobble gravel with clasts of granite, granitic gneiss, hornblende gneiss, vein quartz, occasional red quartzitic sandstone, and rare vesicular basalt, in a matrix of fine, silty sand. The unit is associated with the modern active river channel and is subject to frequent flooding and high ground water levels. It is a source of sand and gravel. Maximum exposed thickness locally exceeds 10 feet.

Qay_{1b} — **Alluvium one-b of the Yampa River (early Holocene to late Pleistocene)** — Light- to dark-brown to gray, poorly to moderately sorted, moderately to well consolidated, silt, sand, gravel, and minor clay and boulders in stream terrace deposits approximately 5 to 15 feet higher than the modern Yampa River. Clasts are subrounded to well rounded. Consists of cobble and pebble gravel with clasts of granite, granitic gneiss, hornblende gneiss, vein quartz, occasional red quartzitic sandstone, and rare vesicular basalt, in a matrix of fine to medium sand. The unit flanks, and probably underlies, the modern flood plain (Qay_{1a}). Its surficial exposures may subject to infrequent flooding during large floods. It is a source of sand and gravel. Maximum exposed thickness exceeds 15 feet.

Qac — **Alluvial and colluvial deposits, undifferentiated (Holocene to late Pleistocene)** — Stream-channel and flood plain deposits along valley floors of ephemeral, intermittent, and perennial tributary streams, and associated colluvium along valley sides. The alluvium is typically composed of poorly- to well-sorted, stratified, interbedded, pebbly sand, sandy silt, and sandy gravel derived from local sources. The colluvium may range from unsorted, clast-supported, pebble to boulder gravel in a sandy matrix to matrix-supported, gravelly, clayey sand. Maximum thickness is approximately 15 feet.

Qayo — **Older alluvial deposits of the Yampa River (late to middle Pleistocene)** — Light- to dark-brown to gray, poorly to moderately sorted, well consolidated gravel, sand, silt, and minor clay and boulders in stream terrace deposits approximately 20 to 600 feet higher than the modern Yampa River. There are at least nine levels of relict river terraces, with older deposits occurring at progressively higher terrace elevations. The composition and fabric are similar to that of Qay1b. May be overlain by older mud fan deposits (Qamfo) or by thin veneers of eolian or over-bank sand and silt. The deposits form stable building surfaces, and are potential sources of sand and gravel. Average thickness of the deposits within each terrace level varies from 15 to 25 feet.

MUD FLOW, DEBRIS FLOW, AND ALLUVIAL FAN DEPOSITS

Qamf — **Alluvial, mud flow, and mud fan deposits (Holocene to late Pleistocene)** — Light-gray to pale-orange, 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. Terminal, low-gradient mud fans at the mouths of Smuin Gulch and Dry Creek grade to and over-run the modern Yampa River flood plain. Qamf 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 mud flow depositional events. Some layers show incipient soil development. Occasional lenses of muddy gravel are present, especially near the base of the unit. The gravel consists of subrounded to angular sandstone fragments or basalt clasts. Areas mapped as Qamf may be subject to future flash floods and mud flow events, especially in non-incised 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. Thickness may exceed 5 feet in thickness in valley-head and valley-side areas and may exceed 15 feet along the valley reaches and in the basins. Some of the deposits have been deeply dissected by stream erosion during the late Holocene, resulting in narrow, steep-walled arroyos that are 5 to 10 feet deep along the valley bottoms.

Qamfo — **Older alluvial, mud flow, and mud fan deposits (late to middle Pleistocene)** — Composition and mode of deposition is similar to Qamf. The unit forms a series of poorly formed terrace deposits on the tops or flanks of low hills throughout the quadrangle. The deposits increase in age at progressively higher terrace elevations. We interpret that they are remnants of former mud fans and valley fills that have been mostly eroded away. The deposits occupied paleo-stream valleys and basins that are no longer in depositional contact with modern drainages. They are now inverted, positive features in the landscape. Older mud fan deposits grade to and overlie older Yampa River gravel terraces (Qayo) in the northern part of the quadrangle. Some of the deposits contain concentrations of basal gravel, consisting of sandstone fragments or basalt gravel. In particular, Qamfo deposits capping the ridge to the west of Dry Creek have basal deposits that include basalt boulders up to 5 feet in length. Eolian silt and sand may be present at the top of some of the Qamfo bodies, but we could not distinguish between these different types of fine-grained sediments in the field. Thickness is variable, but in general ranges from 5 to more than 15 feet.

Qf — **Alluvial fan deposits (late Holocene)** — Reddish-brown to light-brown, well sorted to locally poorly sorted, poorly consolidated, sandy silt to sandy gravel deposited in alluvial fans at the mouths of arroyos and small, ephemeral streams, and as fan aprons along the base of gravel-capped hills. The deposits typically have a fan-shaped morphology. Sediments are locally derived and deposited primarily as sheetwash with occasional input from muddy debris flows and hyperconcentrated flows. The deposits consist of well- to poorly defined sand, silt, and gravel layers, typically several inches thick, which record individual depositional events. Stringers and lenses of locally reworked gravel may be present. Depending on source material, cobbles and boulders can be abundant. Areas mapped as alluvial fans are subject to future flash floods and debris flow events. The deposits may be prone to significant collapse from dispersion, hydrocompaction, or slope failure when wetted or loaded. Thickness may locally exceed 10 feet.

Qfo — **Older alluvial fan deposits (middle Holocene to late Pleistocene)** — Composition and mode of deposition is similar to Qf. The Qfo deposits occupy a slightly higher position on the landscape and are typically not in depositional contact with the modern stream valleys. Thickness may locally exceed 10 feet.

Qgo — **Older gravel deposits (middle Pleistocene)** — Dark-gray to black, poorly sorted, sub-angular to angular, basalt-boulder gravel with minor sandstone blocks and fragments. Matrix is a mixture of clay, sand, and silt. Limited to an isolated hilltop to the west of Temple Gulch. It may be the remnant of a debris flow or debris avalanche deposit. Thickness is 40 feet.

Surficial gravel lag deposits (late to middle Pleistocene) — Remnant deposits of sandstone, basalt, or Yampa River gravels that are too small in extent to map as polygons. The deposits may mark the courses of former streams, or they may be eroded from other, older gravel deposits and redeposited. Thickness is typically 5 feet or less.

MASS WASTING DEPOSITS

Qls — **Landslide deposits (Holocene to middle Pleistocene)** — Heterogeneous deposits consisting of unsorted and unstratified to stratified clay, silt, and sand, and cobble- and boulder-sized rock fragments. Landslide deposits are abundant and widespread throughout the quadrangle. The unit includes rotational slides, earthflows, and translational slides. In most places, the landslides show obvious geomorphic expression that disrupts the profile of the slopes. Head scarps and internal scarps (the near-vertical detachment scars exposed at the top of and internally within the landslides) are often readily recognizable, and are shown on the map. 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 rainfall or snowfall. They 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 may be prone to settlement when loaded or wetted. The deposits may contain expansive soils where derived from shale formations. Thickness is highly variable, and typically ranges from 10 to more than 20 feet.

Qscr — **Sheetwash, colluvial, and rockfall deposits, undifferentiated (Holocene)** — Unsorted and unstratified to stratified clay, silt, sand, and pebble- to room-sized rock fragments and blocks. The rock fragments and blocks are subangular to angular as a result of close proximity to the source outcrops. Qscr deposits form wedge-like sediment aprons along the base of sandstone-rimrock-capped slopes. They occur locally along hogbacks to the east of Dry Creek, in the southwestern part of the quadrangle. Sheetwash, colluvial, and rockfall processes all contribute to the deposition of the sediment bodies. Areas mapped as Qscr are susceptible to future rockfall events, and may be prone to settlement when loaded or wetted. Thickness locally exceeds 15 feet.

BEDROCK UNITS

Note: formal units are capitalized, informal units are listed in lowercase

Kl — **Lance Formation (Upper Cretaceous)** — Gray and yellow-brown, very fine-grained to medium-grained sandstone interbedded with gray-green and gray carbonaceous shale, and thin seams of coal. The unit is moderately recessive and forms slopes and ledges. Sandstone occurs in beds ranging in thickness from less than one foot to over 20 feet. The sandstone bodies are tabular or lenticular. They exhibit massive, bioturbated texture, trough cross-bedding, ripple cross-bedding, and occasional convoluted bedding. Where cross-bedding is well exposed, forest orientation indicates a generally northward direction. Trace fossils are common and include worm tracks. The sand is arkosic, with grains of chert giving a salt and pepper appearance. Thin beds of coal are interbedded with sandstone and shale near the base. The full thickness of the unit is approximately 900 to 1100 feet. Only the basal 100 feet of the unit is exposed in the northwestern corner of the quadrangle.

Kfh — **Fox Hills Sandstone (Upper Cretaceous)** — Tan to cream-colored, poorly to well-indurated sandstone that forms subdued sandstone bluffs and rimrock in the northwestern corner of the quadrangle. The unit consists of very fine- to medium-grained sand that contains quartz, lesser feldspar, and rare black grains of chert, cemented with calcium carbonate. The well-indurated sandstone beds display trough cross-beds and rippled, horizontal, or hummock cross-stratified bedding. Trace fossils are common and include Ophiomorpha burrows. Total unit thickness is 160 to 170 feet.

Lewis Shale (Upper Cretaceous)

Klsu — **Lewis Shale, upper part** — 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. Natural exposures of undisturbed bedding are rare, and limited primarily to deeply eroded gullies and landslide scarps. High bentonite content gives this shale a high swell/shrink capacity. Hill slopes in the shale are highly susceptible to landsliding. There are two main shale-bearing intervals within the Lewis Shale (mapped as the upper and lower parts). The upper part is 300 feet thick.

Klsd — **Dad sandstone member** — Distinctive, tan to yellowish-brown, ledge-forming, marine sandstone bodies in the middle part of the Lewis Shale, separating the upper and lower shale-bearing intervals. Individual bodies grade upward from thin-bedded silty shale to fine-grained sand consisting of quartz, minor feldspar and black chert, with local rip-up clasts of mudstone, and are cemented by calcium carbonate. Tabular sandstone beds exhibit planar horizontal bedding, convoluted bedding, hummocky bedding, and low-angle cross-bedding. Total thickness of individual beds ranges from approximately 10 feet to over 40 feet. The outcrops of some prominent sandstone beds are shown on the geologic map. Most of the unit consists of poorly exposed, sandy shale beds that separate the sandstone bodies. Regionally, the unit appears to be highly variable in terms of overall thickness and in the internal distribution and lateral continuity of the sandstone bodies. Thickness of the unit, from an oil-and-gas well just to the south of the quadrangle, is 200 feet.

Klsl — **Lewis Shale, lower part** — This shale-bearing interval is similar in composition and character to the upper part of the Lewis Shale. The outcrops of a few sandstone zones, which are generally less than 10 feet thick, are shown on the geologic map. The lower part is 2250 feet thick, which includes the basal 200 feet where sandstone-rich zones associated with the three white sandstone members occur.

Sandstone-rich zones within the Dad Sandstone member and lower part of Lewis Shale

Williams Fork Formation of the Mesaverde Group (Upper Cretaceous)

Three white sandstones member — Pale- to medium-orange, well-indurated, marine sandstone, mapped as three to four individual zones within the basal, lower part of the Lewis Shale. Each zone consists of one or more beds of very-fine- to fine-grained sandstone, interbedded with and bounded by marine shale. The sandstone beds are tabular, 1 to 6 feet thick, and contain hummocky and low-angle cross-bedding. To the west of the quadrangle, the zones thicken and amalgamate into an interval of interbedded sandstone, marine and non-marine shale, and minor coal at the top of the Williams Fork Formation. 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, 1989).

Kwu — **Williams Fork Formation, upper part** — Interbedded sandstone, non-marine shale, and coal that form ledges and slopes. The sandstone bodies are brown, rusty brown, or tan to grey. They are lenticular to tabular, and consist of fine- to medium-grained quartz and feldspar with black grains of chert or hornblende. The sandstone 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 bioturbated intervals. The shale beds are grey to pale grey and can be lignitic. Coal beds within the unit are as thick as 10 feet, and comprise the Upper Coal Group of the Yampa Coal Field. In many exposures, the coals have naturally burned, baking and fusing adjacent beds of shale and sandstone to form a distinctive, brittle, red “klinker.” Total unit thickness is 350 to 400 feet.

Big white sandstone member — Pale- to medium-orange, well-indurated, marine sandstone, mapped as an individual zone within the upper part of the Williams Fork Formation. The unit consists of one or more, amalgamated sandstone bodies that are laterally continuous in some places and highly lenticular in other places. The sandstone beds contain hummocky and low-angle cross-bedding near the base and trough cross-bedding, hummocky cross bedding, and horizontal planar bedding near the top. The unit is underlain gradationally by a thin, unmapped tongue of the Lewis Shale. The Big White Sandstone Member ranges from zero to 80 feet in thickness.

Kwt — **Twentymile sandstone member** — Cream-white to pale-orange, well- to moderately 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 sandstone at the top. In places, the unit consists of a single cliff-forming sandstone body as thick as 120 feet, while in other locations, where it is more recessive, it consists of multiple sandstone beds up to 15 feet thick, separated by thin shale stringers. The sand grains consist of quartz, feldspar, and black grains (chert or hornblende), cemented by calcium carbonate. 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 3 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 ten feet thick. Some of the channels contain lags of oyster shells and rippled cross-bedding surfaces. Trace fossils include Ophiomorpha and rare worm burrows. Total thickness of the unit ranges from 140 to 180 feet.

Klst — **Tongues of Lewis Shale** — Tongues of the Lewis Shale underlie and are upwardly transitional with the Twentymile Sandstone (Kwt), and Sub-twentymile (Kwst) Members of the Williams Fork Formation. The shale tongues form distinctive, gently sloping benches beneath those cliff-forming sandstones. They are similar to the previously described upper part of the Lewis Shale in composition and character. The tongues thin and become dominated by thin sandstone beds to the west of the quadrangle. Total thickness of the two Klst tongues and the intervening Kwst unit is 450 feet.

Kwst — **Sub-twentymile sandstone member** — Tan to light-brown, indurated sandstone interbedded with minor shale overlain and underlain by tongues of Lewis Shale (Klst). The unit forms ledges and cliffs. The sandstone beds are 5 to 60 feet thick. They consist of fine- to medium-grained quartz, feldspar, and black grains of chert and hornblende. They exhibit trough cross-bedding, hummocky cross-bedding, horizontal planar bedding, or can appear structureless and bioturbated. Trace fossils include Ophiomorpha and rare worm burrows. Beds of grey, sandy shale up to 2 feet thick separate the individual sandstone beds. Total unit thickness is 80 to 120 feet.

Kwl — **Williams Fork Formation, lower part** — Shown on cross section only. No outcrops occur within the Hayden quadrangle. This unit is similar in lithology with the upper unit, as described above. Thickness is 500 feet.

Ki — **Iles Formation of the Mesaverde Group, undivided (Upper Cretaceous)** — Shown on cross section only. No outcrops occur within the Hayden quadrangle. Includes Trout Creek Sandstone Member, main body of the formation, Tow Creek Sandstone Member, and tongues of Mancos Shale. Thickness is 1150 feet.

Km — **Mancos Shale, undivided (Upper Cretaceous)** — Thickness is greater than 5000 feet. No outcrops occur within the Hayden quadrangle.

Contact—Dashed where approximately located

Fault— Dashed where approximately located; dotted where concealed; upthrown (U) and downthrown (D) sides marked where evident

Monocline— Axial line marks center of the dipping limb. End arrow indicates direction of plunge

Anticline—End arrow indicates direction of plunge

Syncline—End arrow indicates direction of plunge

Landslide scarp

6 **Strike and dip of inclined bedding or contacts**—showing direction and angle of dip

7 **Strike and dip of inclined joints or fractures**—showing direction and angle of dip

A —— A′ **Alignment of cross section**

A note about map shading: The map has a shaded relief underlay that generally enhances the appearance of the topography, but can make the geologic unit colors darker or lighter in areas of steep topography.

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 G11AC20250.

COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES