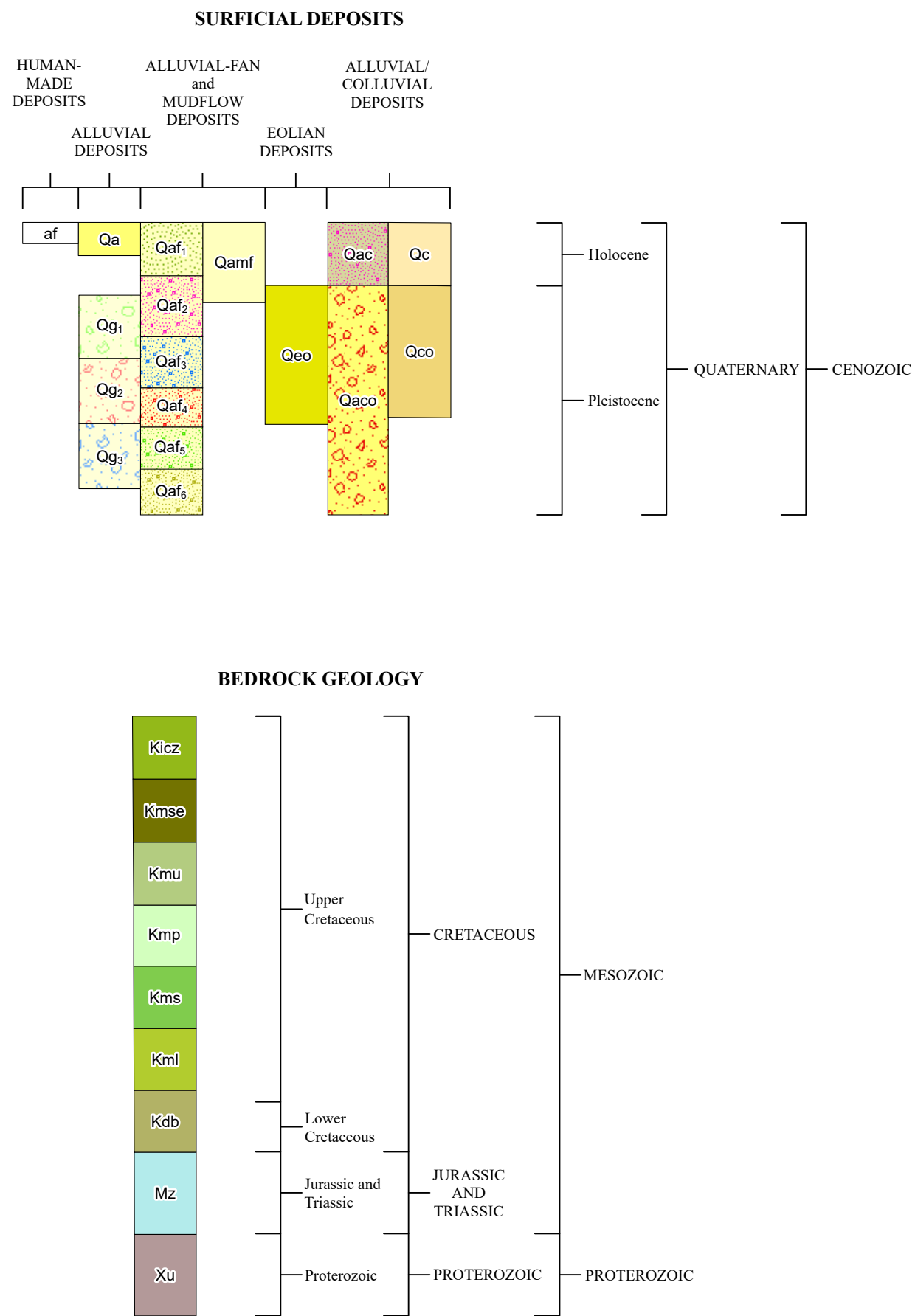
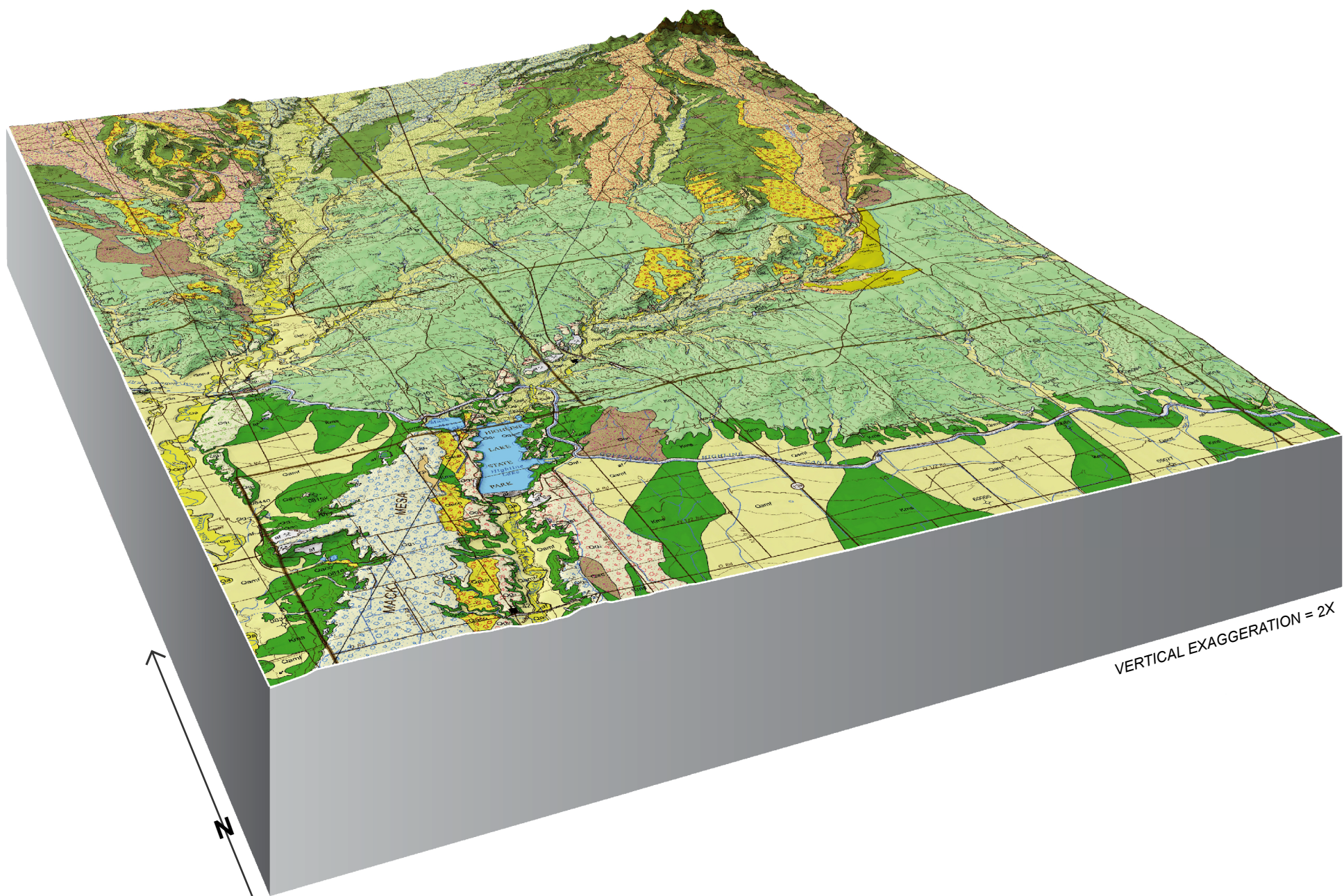


## CORRELATION OF MAP UNITS



## 3-D OBLIQUE



## PHYSIOGRAPHIC SETTING

The Highline Lake quadrangle is 20 km northwest of the town of Fruita and 15 km east of the Utah border in Mesa and Garfield Counties, Colorado. The quadrangle is located at the northwestern edge of the Grand Valley where agricultural lands are irrigated by the Government Highline Canal. The Grand Valley is a topographically low area of subdued hills and badlands that lie between the Uncompaghe Plateau and the Book Cliffs. Access to the quadrangle map area is best from U.S. Highway 6&50 to State Highway (SH) 139 that continues to head north through the Book Cliffs to Douglas Pass. The Colorado Highline Lake State Park lies wholly within the map area. This reservoir is fed by water from the nearby Highline Canal. The topography in the map area is wide and subdued flats, low hills, and low (<45-m high) mesas capped with Pleistocene alluvial-fan and fluvial terrace gravel that are now topographically inverted. In the map area, the Highline Canal approximates the stratigraphic contact of the Smoky Hill (Kms) and Prairie Canyon (Kmp) members in the Mancos Shale. Canal builders took advantage of the stratigraphic transition from flat lands underlain by the Kms unit (now irrigated agricultural lands) to the overlying Kmp where the shale becomes sandier, more resistant to weathering, and develops landforms of low hills and ridgelines that rise from 70 to 90 m above the irrigated lands. These hills are typically eroded in a shallow dendritic drainage pattern. The major drainage creeks in the map area are either intermittent or ephemeral, including East Salt Creek, Mack Wash, and Coyote Wash. The confluence of East Salt and West Salt creeks occurs 1.7 km beyond the southwestern map boundary where the Salt Creek thalweg extends an additional 5 km to its confluence with the Colorado River in Ruby Canyon. The highest elevation within the Highline Lake quadrangle is 1,848.3 m above mean sea level (AMSL) at the northeastern map boundary within the mid-elevation escarpment of the Book Cliffs. The lowest is 1,382.3 m AMSL at the southwestern map boundary where the present East Salt Creek channel last passes through the map area. The climate is arid and vegetation outside of irrigated areas is sparse. The landscape is adobe-type badlands that are common in west-central Colorado where surface exposures of the underlying Mancos Shale bedrock occur in arid climates, which include the wide valleys of Grand Valley (Colorado River) and the Gunnison and Uncompaghe rivers. The annual precipitation (National Centers for Environmental Information) ranges from 20 to 30 cm in the map area.

## GEOLOGIC SETTING

The geologic setting of Highland Lake quadrangle is similar to the adjacent Badger Wash quadrangle (White and Perman, 2024). The basal bedrock unit exposed in the map area is the Late Cretaceous Mancos Shale, specifically the upper stratigraphic members. The marine shale was deposited during the transgression of the Cretaceous Western Interior Seaway (CWIS) (Franczyk and others, 1992). Regressive and transgressive sequences of the western shoreline of the CWIS deposited overlying terrestrial and near-shore sediments that formed the thick package of sandstone, shale, and coal of the Iles and Williams Fork Formations. These rocks, more resistant to weathering, formed the Book Cliffs escarpment that is exposed in the northeast corner of the map area. Off map to the south, faulting and monocliminal folding of the northeast front of the Uncompaghe Uplift exposes earlier Mesozoic rocks and Proterozoic basement rocks of the Uncompaghe Plateau in the Colorado National Monument (Scott and others, 2001) and the McInnis Canyons National Conservation Area south of the Colorado River (White and others, 2015). The exposed package of Triassic and Jurassic sedimentary rocks includes the basal Triassic Chinle Formation, which lies nonconformably on the Proterozoic basement rocks (Xu). This type of unconformity reflects a loss of a stratigraphic rock interval during an earlier Pennsylvanian-Permian orogeny that uplifted the Ancestral Uncompaghe Mountains. The earlier Paleozoic sedimentary rocks were exposed in the ancestral uplift and subsequently eroded away over millions of years. The Triassic Period ground surface in the Mesozoic Era was beveled to a peneplain eroded in crystalline Proterozoic basement rocks prior to the deposition of terrestrial and later marine and near-shore Mesozoic sedimentary rocks. It was these rocks that were later uplifted during the Late Cretaceous-Paleogene Laramide Orogeny when the faulting and folding of the present Uncompaghe uplift occurred. During this orogeny, another syndepositional package of terrestrial Paleogene and Neogene rocks were also deposited nearby, which included volcanic flows in some areas. Subsequently, erosion in the Grand Valley area formed the present Uncompaghe Plateau to the south, the Book Cliffs and Roan Cliffs to the north, and Grand Mesa (capped by Neogene basalt of the Grand Mesa Volcanic Field). The broad Grand Valley was formed by differential, late Neogene through Quaternary erosion that caused long-term ground lowering by the incision of the Colorado River and its tributaries where the easily erodible Mancos shale is(was) exposed at the surface (Aslan and others, 2019).

The structural geology of the Highline Lake quadrangle reflects the regional faulting along the general northwest to southeast trend of the Uncompaghe Uplift. The general dip of the strata is to the north to northeast towards the Unita and Piceance basins. Structural data was difficult to obtain because of the weathering of the exposed shale bedrock. However, useful attitudes of the bedrock were gained from exposures of sandstone beds of the lower Book Cliffs, tabular sandy dolomite concretionary beds, very thin beds of bentonite, and where thinly interbedded sandstone beds of the Prairie Canyon Member were exposed. The major structural feature in the map area is the Garmesha fold (Krey, 1962), a paired anticlinal and synclinal fold within the upper Mancos Shale near the Book Cliffs escarpment. Other minor synclinal and anticlinal structures in Krey (1962) such as the Highline Canal anticline could not be identified in the field. The fault trends mapped at the adjacent Badger Wash quadrangle (White and Perman, 2024) do not occur in this quadrangle. Only minor faulting and structural bending of strike were noted where dolomitic concretionary bedding was offset, or strike of beds markedly changed from 271° to 316° azimuth.

## WATER RESOURCES

Water resources of the Highline Lake quadrangle are minimal. The underlying Mancos Shale members are not water bearing and the water quality of older Mesozoic rocks at depth is poor. The stream channels only flow intermittently during high precipitation events. Homeowners on private lands along 16 and S roads must haul potable water to their properties. The cobble aquifer of lower Colorado River terrace gravels of the Grand Valley is not present in the map area. This buried water-bearing cobble deposit ends where the Colorado River has incised into Horseshief Canyon between Fruita and Mack (Butler and others, 1996).

## MINERAL RESOURCES

Oil and gas resources lie in the Highline Lake quadrangle. The Garmesha gas field occurs within the map area (Colorado Energy and Carbon Management Commission (ECMC)). This field was developed in the structural terrain mapped and described by Krey (1962). For most of the oil and gas wells, the total depth was in the Entrada Sandstone and production predominantly occurred from the Dakota Sandstone (Naturita Formation) and Burro Canyon Formation (Kdb) and the Entrada Sandstone (Je). These units are not exposed in the map area but are shown in the cross section. Within the Mancos Shale, the Niobrara Member may have oil and gas potential using horizontal well drilling and hydraulic-fracturing (fracking) completion techniques. There are small gravel pits and quarries in some mesa surfaces underlain by old (Qg) gravels, but the quality is poor, being composed of only less-durable sandstone clasts eroded from the Mesaverde Group rocks exposed in the Book Cliffs.

## GEOLOGIC HAZARDS

Potential geologic hazards in the map area are primarily the risks of mud flows and debris flows. The channel floors of the intermittent streams, especially near the base of the Book Cliffs escarpment, show evidence of flooding, scour, and bouldery gravel debris deposition. The Mancos Shale contains bentonite and other expansive clay minerals. Clayey surficial deposits (soils) derived from the shale may be expansive (swelling soils). Some silty to clayey sand deposits may also be low density and may be collapsible and settle upon wetting (hydrocompactive soils). Unimproved dirt road and 4WD tracks in the adobe badlands become impassable when they are wet and the clay soils become increasingly slick, greasy, and clump to tires and shoes. The marine shale may also be high in sulfates and possibly corrosive to unprotected concrete and steel. High selenium levels and other dissolved solids have been reported in irrigation return waters in the Mancos Shale (Butler and others, 1996). Site-specific geotechnical investigations, including bore holes and soil testing, should be conducted for structures planned in the Mancos Shale or in clayey soils derived from it.

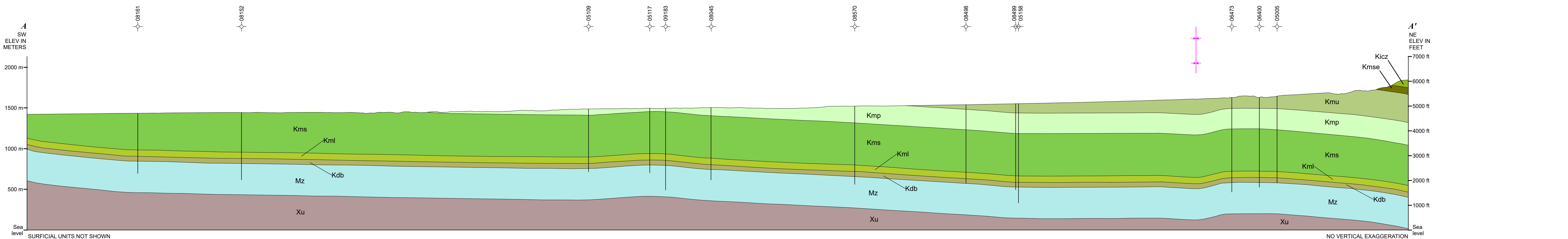
## PREVIOUS GEOLOGIC MAPPING

The preparation of this map was aided by the review of previous geologic mapping conducted in the area. The geology of the Highline Lake quadrangle was previously mapped at limited, small-scale extents at 1:100,000 scale by Ellis and Gabaldo (1989) and at the 1:250,000 scale (1° by 2°) by Cashion (1973). Krey (1962) included a small-scale structural map of the area. On adjacent 1:24,000-scale quadrangles, the geology of the Mack quadrangle to the south was mapped by White and others (2015), the Fruita quadrangle to the southeast by Livaccari and Hodge (2009) and to the west, the Badger Wash quadrangle by White and Perman (2024). Highline Lake quadrangle and the adjacent 1:24,000-scale quadrangles cited above are part of a multi-year geologic mapping program of the Grand Valley by the Colorado Geological Survey. The 1:24,000-scale quadrangle locations are shown on the Plate 1 index map.

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## CROSS SECTION A-A'



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## GEOLOGIC MAP OF THE HIGHLINE LAKE QUADRANGLE, MESA AND GARFIELD COUNTIES, COLORADO CORRELATION OF MAP UNITS, 3-D OBLIQUE, GEOLOGIC SETTING, AND CROSS SECTION

By Jonathan L. White and Andrew P. Schmidt  
2025