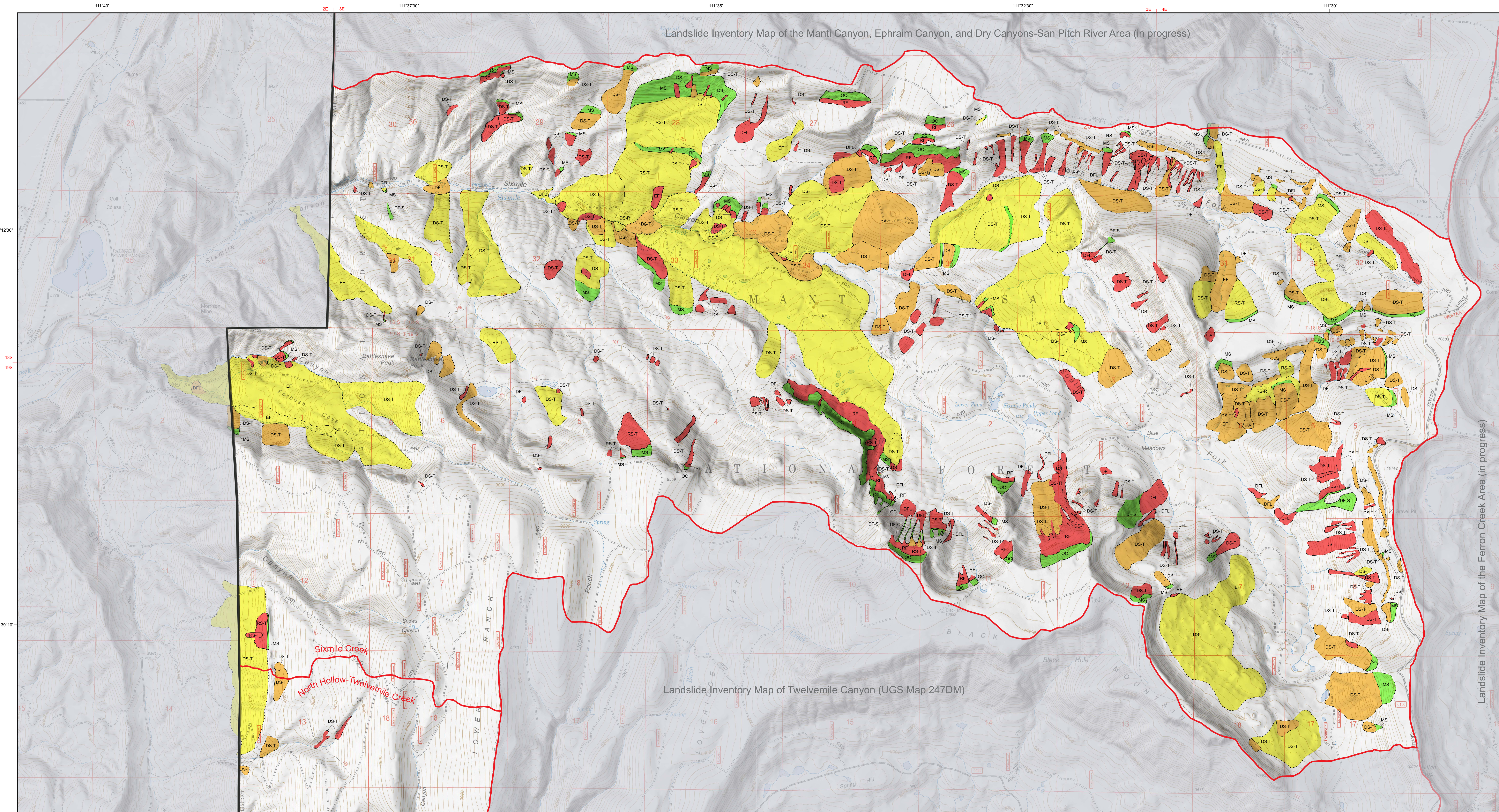
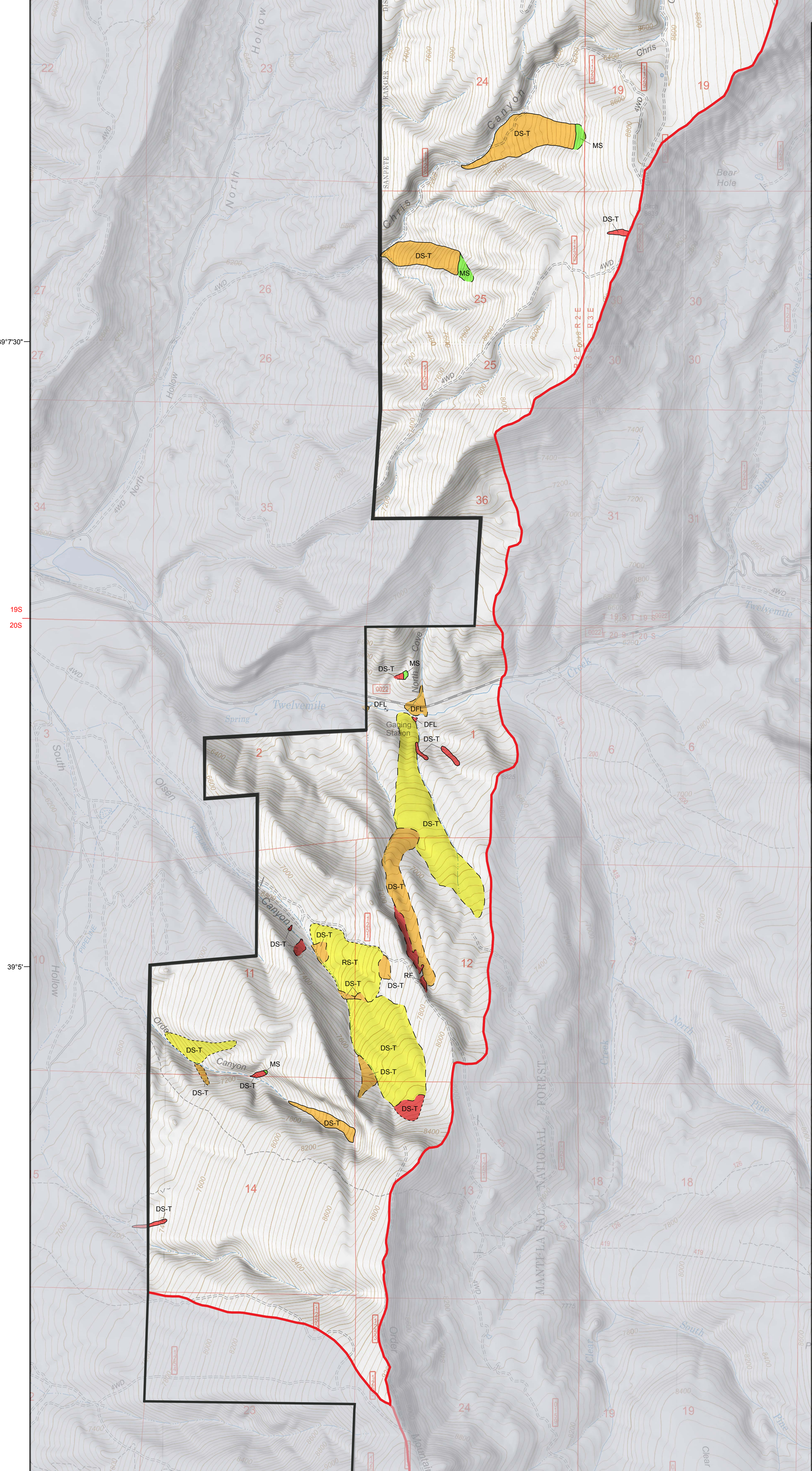
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
in cooperation with the
United States Forest Service





EXPLANATION

This map presents a landslide inventory of part of the Sixmile Canyon and North Hollow area, Sanpete County, Utah, at a scale of 1:24,000. The purpose of the map and accompanying geodatabase is to show and characterize prehistoric and historical landslides larger than about 120 feet across their shortest dimension, and to provide information useful for managing landslide problems. The map and accompanying geodatabase were prepared by the Utah Geological Survey (UGS) as a cooperative project with the Manti-La Sal National Forest. The map covers 42 square miles on the west side of the Wasatch Plateau, and includes parts of two hydrologic units: 33 square miles in the Sixmile Creek Hydrologic Unit (hydrologic unit code no. 160300040502) and 9 square miles in the northern part of the North Hollow-Twelvemile Creek Hydrologic Unit (hydrologic unit code no. 160300040404) (hydrologic unit boundaries from Utah Automated Geographic Reference Center, 2012). We used geographic information system (GIS) software to capture, store, and display the data for each mapped landslide.

Manti-La Sal National Forest boundary

Hydrologic unit boundary

We prepared the landslide inventory by analyzing and interpreting 12 different sets of stereo and orthophoto aerial photography acquired periodically from 1940 through 2011, which provide a 72-year history of landsliding in the area. We cite photography dates and scale in our aerial photographs reference list. We recorded spatial and tabular data for each mapped landslide. Spatial data pertain to landslide deposit and landslide geomorphic source type; source types include slide and flow main scarps, rockfall cliff bands and outcrops, and debris-flow source areas and channels. Tabular data describe landslide characteristics in text or numeric form. The spatial and tabular data are stored in the geodatabase and linked to the inventory map. Landslide information stored in the geodatabase includes area, material type, movement type, landslide deposit name, landslide source name, movement activity, thickness, movement direction, approximate movement dates, geologic unit(s) associated with the landslide, confidence in mapped boundaries, mapper name, peer reviewer name, and comments.

Landslide Classification

The characteristics used to classify landslides were observed on aerial photography of various dates, on topographic quadrangle maps, in Manti-La Sal National Forest reports, and in the field. Our landslide classification methodology is similar to that used by the California Geological Survey (Irvine and others, 2007) and the Oregon Department of Geology and Mineral Industries (Burns and Madin, 2009). Landslide classification is based primarily on terminology and mapping criteria of Varnes (1978), Wieczorek (1984), Cruden and Varnes (1996), Keaton and DeGraff (1996), and Haskins and others (1998). Landslide deposits are classified based on type of geologic material and type of movement. Where a landslide source could be identified and mapped, the source was classified based on the geomorphic source type. Both the landslide deposit and source were further classified based on landslide movement activity and boundary-mapping confidence. The geodatabase includes additional landslide information not shown on the map.

Landslide Deposit Materials and Movement

Each landslide deposit is assigned a two-part name based on dominant material type and movement type after Cruden and Varnes (1996). The material is classified as rock or soil, and soil is further subdivided as debris (mostly coarser than sand-sized particles) or earth (mostly sand-sized or finer particles). The observed movement types in the Sixmile Canyon and North Hollow area consist of falls, flows, and slides (rotational and translational). We used the following landslide names in our mapping:

RF rockfall
RS-R rock slide, rotational
RS-T rock slide, translational
DS-R debris slide, rotational
DS-T debris slide, translational
DFL debris flow
EFL earth flow

Landslide Source Type

Landslide source areas are classified based on geomorphic source type. Cliff bands and outcrops are typically the source areas for rockfall deposits. Main scarps are typically the source area for slide and flow deposits. A debris-flow source is an eroded area above the deposit. A debris-flow/channel is the scoured path the debris flow has taken from its source to the deposit. We identified the following landslide source types in our mapping:

CB cliff band
OC outcrop
MS main scarp
DF-S debris-flow source
DF-C debris-flow/channel

Landslide Movement Activity

We classified landslide deposits based on landslide features observed on aerial photographs and/or in the field.

Active or historical: The landslide has documented movement or landslide features observed on aerial photography and/or in the field indicative of historical movement.

Dormant or very-slow moving: Landslide-deposit landforms are fresh or uneroded, but there is no evidence of historical movement. Landslide movement is suspended or at a slow rate preventing development of sharp recognizable features associated with active movement and allowing erosion to smooth existing features.

Dormant-eroded: Landslide-deposit landforms are smoothed, subdued, and incised by erosion.

Landslide Mapping Confidence

The confidence of landslide mapping is based on the visual clarity of boundaries around source and landslide deposits. Erosion or vegetation may obscure boundaries, making them difficult to map accurately.

High: The landslide boundary is clearly evident and discernable. The landslide generally shows features indicative of recent movement.

Moderate: Some, but not all, parts of the boundary are clearly evident, other parts are approximate or gradational. Diagnostic landforms are generally present.

Low: The boundary is difficult to determine and is approximately located, and few diagnostic landforms may be present.

Geology and Landslides in the Sixmile Canyon and North Hollow Area

The Sixmile Canyon and North Hollow area lies on the western side of the Wasatch Plateau. Previous geologic mapping of the area includes the 1:24,000-scale geologic map of the Sterling 7.5' quadrangle (Weiss, 1994) and the 1:100,000-scale geologic map of the Manti 30' x 60' quadrangle (Witkind and others, 1987). The geologic units exposed within the area consist of, from oldest to youngest, Cretaceous Price River Formation, Tertiary-Cretaceous North Horn Formation, Tertiary Flagstaff Limestone, Tertiary Colton Formation, and Quaternary moraine (Witkind and others, 1987). The Price River Formation contains sandstone and shale. The North Horn Formation is primarily shale with lesser amounts of sandstone. Shale in the North Horn Formation commonly weathers to clay and typically produces more landslides than the other rock units on the Wasatch Plateau (McDonald and Giraud, 2011). The Flagstaff Limestone contains shale and limestone. The Colton Formation commonly contains claystone and mudstone. Quaternary glacial moraine deposits are composed chiefly of eroded Flagstaff, and lesser North Horn material, and are found in the upper part of Sixmile Canyon. Rock units in the eastern part of the map area are generally flat lying and are cut by north-south-trending, high-angle, small-displacement normal faults. In the western part of the North Hollow area, and the lower part of Sixmile Canyon, these units dip moderately to the west as part of the Wasatch monocline.

Weak geologic units within the Sixmile Canyon and North Hollow area show evidence of widespread landsliding. The upper part of Sixmile Canyon was glaciated most recently during the Pleistocene (Wilson, 1949; Larson, 1996) and post-glacial landslides have commonly displaced moraines. Weathered shale of the North Horn Formation commonly produces the largest landslides. Limestone of the Flagstaff Formation forms a plateau cap rock that is a common source of rockfall along cliff bands. Our mapping shows that most of the active landslides are reactivations of pre-existing landslides. Pre-existing landslides are prone to reactivation due to their weak strength characteristics. Some of these landslides have moved very slowly, inches or less per year, while others have moved rapidly and traveled miles.

The map area has a long history of damaging landslides. Landsliding and exceptionally high stream flows in 1983 caused extensive damage to the main Sixmile Canyon Road (USFS Road 50047) (U.S. Forest Service, 1983) and two of three springs that provided the town of Sterling with its culinary water supply. Landslides in the map area have also caused damage to developed areas below the mouth of Sixmile Creek. During one of these landslide events, Sixmile Creek changed course several hundred yards before it passed beneath U.S. Highway 89 just north of Sterling. The resulting backup of debris filled the ravine east of the highway, caused flooding of nearby fields, and deposited layers of silt and sand in low-lying areas.

ACKNOWLEDGMENTS

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DISCLAIMER

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AERIAL PHOTOGRAPHS

Aerial photographs listed here, with the exception of ESRI World Imagery, and the National Agriculture Imagery Program and Google orthophotos, are available online via the UGS Aerial Imagery Collection at https://geodata.geology.utah.gov/imagery/.

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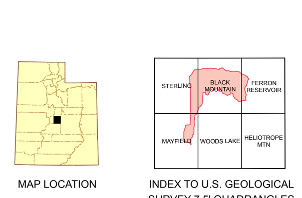
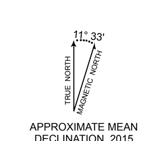
SCALE 1:24,000

2 1 0 2 Miles

2 1 0 2 Kilometers

CONTOUR INTERVAL 40 FEET





APPROXIMATE MEAN DECLINATION, 2015

Base from USFS Black Mountain, Ferron Reservoir, Sterling, Mayfield and Woods Lake 7.5' Quadrangles 2012
Projection: UTM Zone 12
Datum: NAD 1983
Spheroid: Clarke 1866

Program Manager: Steve D. Bowman
Project Manager: Richard E. Giraud
GIS and Cartography: Jay C. Hill and Gordon E. Douglass

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LANDSLIDE INVENTORY MAP OF THE SIXMILE CANYON AND NORTH HOLLOW AREA, SANPETE COUNTY, UTAH

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2015