Land Instability Potential for the Manti Division

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LAND INSTABILITY POTENTIAL
for the
MANTI DIVISION

Manti-LaSal National Forest
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I. INTRODUCTION

"The National Forest Management Act of 1976, the National Environmental Policy Act of 1969, and the Multiple Use - Sustained Yield Act of 1960 state that natural hazards shall be inventoried and all resource management planning shall have geologic input." Forest Service Manual 2880.1.

The purpose of this report is to identify and map the surface instability and geology on the Manti-LaSal National Forest to accomplish the following objectives:

A. To assist in the preparation of land and resource management plans;

B. To assist in the interpretation of surface and subsurface geologic conditions and processes as they relate to or affect the capability of National Forest System lands to produce resources and to support man's activities;

C. To assist in the effective management of geologic resources.

II. PROCEDURE

To determine the possible correlation between instability and geology, the geology of the Ranger Districts, D-1 Sanpete R.D., D-2 Ferron R.D., D-3 Price R.D., of the Manti Division was mapped on 7½' quadrangle topographic maps. This information was later transferred to 15' quadrangle topographic maps. Monograph series No. 3, UGMS, 1972, Central Utah Coal Fields by H.H. Doelling will be the primary source of the geology of the following 7½' quadrangles (see Bibliography):

A. D-3 - Jump Creek, Candland Mountain, Wattis, Rilda Canyon, Hiawatha, Mahogany Point, Red Point;

B. D-2 - Flagstaff Peak, Mahogany Point, Rilda Canyon, Emery West, Red Point, Ferron, Accord Lakes, Ferron Canyon, The Cap.

An unpublished report by Dwain E. McGarry and Carter Reed (Forest Service Geologists) will be the primary reference for the geology of the following 7½' quadrangles:

A. D-3 - Bird's Eye, Thistle, Mill Fork, Indianola, and C Canyon.

The remaining geology of the Districts, D-1, D-2, and D-3, was compiled from three sources; (1) the Geologic Map of Utah, 1:250,000 scale, compiled by James H. Madsen, Jr., 1961 and Lehi F. Hintze and William Lee Stokes, 1963; (2) the Materials Inventory Carbon and Emery Counties, Juab and Sanpete and Sevier Counties, Utah State Dept. of Highway Materials and Research Division Materials Inventory Section; and (3) the geologic interpretation of high level aerial photography with a scale of 1:30,000 and lower level aerial photographs with a scale of 1:15,840. The quadrangles which will be included in this method are the following:

D-3 - Huntington Reservoir, Fairview Lakes, Scofield Reservoir, Tucker, Fairview.

D-2 - Heliotrope, Ferron Reservoir, Danish Knoll, Joe's Valley Reservoir.

D-1 - Danish Knoll, Heliotrope, Huntington Reservoir, Indianola, Fairview Lakes, Wood's Lake, Black Mountain, Ephraim, Chester, Spring City, South Tent, Fairview, Indianola, - San Pitch Division, Nephi NE, Moroni NW, Nephi SE, Moroni SW, Skinner Peaks, Chriss Canyon, Wales.

Seven and one-half minute topographic and geologic maps, high level aerial photographs with a scale of 1:30,000 and lower level aerial photographs with a scale of 1:15,840 were used initially to aid in the identification of features commonly associated with land instability. The index features identified were the following: faults, bedding plane orientation, resistance to erosion, rock falls, rock slides, slumps, sag ponds, soil creep, will be verified by field reconnaissance on a continuing basis.

A map (15' or reduced 7½' quadrangle) delineating all areas with instability features as identified by the initial survey investigation form geologic and topographic maps and aerial photographs has been drafted. These areas will be noted on the map as high potential. Areas that have been verified by field reconnaissance will be noted on the map. All actively moving unstable areas will be delineated. These active areas will be identified in the field when movement is evident. The parameters to be used to identify movement will be: (1) disturbed vegetation, or (2) known movement of material relative to a man-made or natural landmark. The cause of that activity, whether it be induced by human activity or natural activity, will not be evaluated. All unstable areas that are not determined active will be classified as high potential areas since evidence of paleoinstability indicates that these geologic formations were once actively unstable in earlier environments. Similar environmental conditions could induce activity again. No effort will be made to determine the type or magnitude of the environmental conditions that would be necessary to induce instability. High potential areas will be eliminated from the map when field investigations do not verify the presence of the index instability features.

The three classifications of instability that will be noted on the map will be as follows: (1) high potential - not field investigated, (2) high potential - field investigated, and (3) active instability - field investigated.

D-3 - Huntington Reservoir, Fairview Lakes, Scofield Reservoir, Tucker, Fairview.

D-2 - Heliotrope, Ferron Reservoir, Danish Knoll, Joe's Valley Reservoir.

D-1 - Danish Knoll, Heliotrope, Huntington Reservoir, Indianola, Fairview Lakes, Wood's Lake, Black Mountain, Ephraim, Chester, Spring City, South Tent, Fairview, Indianola, - San Pitch Division, Nephi NE, Moroni NW, Nephi SE, Moroni SW, Skinner Peaks, Chriss Canyon, Wales.

Seven and one-half minute topographic and geologic maps, high level aerial photographs with a scale of 1:30,000 and lower level aerial photographs with a scale of 1:15,840 were used initially to aid in the identification of features commonly associated with land instability. The index features identified were the following: faults, bedding plane orientation, resistance to erosion, rock falls, rock slides, slumps, sag ponds, soil creep, will be verified by field reconnaissance on a continuing basis.

A map (15' or reduced 7½' quadrangle) delineating all areas with instability features as identified by the initial survey investigation form geologic and topographic maps and aerial photographs has been drafted. These areas will be noted on the map as high potential. Areas that have been verified by field reconnaissance will be noted on the map. All actively moving unstable areas will be delineated. These active areas will be identified in the field when movement is evident. The parameters to be used to identify movement will be: (1) disturbed vegetation, or (2) known movement of material relative to a man-made or natural landmark. The cause of that activity, whether it be induced by human activity or natural activity, will not be evaluated. All unstable areas that are not determined active will be classified as high potential areas since evidence of paleoinstability indicates that these geologic formations were once actively unstable in earlier environments. Similar environmental conditions could induce activity again. No effort will be made to determine the type or magnitude of the environmental conditions that would be necessary to induce instability. High potential areas will be eliminated from the map when field investigations do not verify the presence of the index instability features.

The three classifications of instability that will be noted on the map will be as follows: (1) high potential - not field investigated, (2) high potential - field investigated, and (3) active instability - field investigated.

All areas identified as zone 1 (areas actively sliding or moving) in Andrew E. Godfrey's report, A Field Reconnaissance of Mantle Instability on the Manti Division of the Manti-LaSal National Forest and Adjacent Portion of the Fishlake Forest, where geologic features are not initially identified on the aerial photographs and are not yet verified in the field, will be delineated as high potential (not field investigated), these areas will not be delineated as actively unstable until it is verified in the field.

Rockfall areas at the mouths of steep canyons in the Manti Division which occur in the Mancos Shale formation will not be delineated unless they are a direct threat to man.

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Appendix A
Land Instability of Price Ranger District

I. STRATIGRAPHY

The physical and chemical characteristics of the exposed rock strata of the Price Ranger District combined with environmental conditions, determine the stability characteristics of this area. The following is a description of the formations from the oldest to youngest which underlie this area as described in Doelling's Monographic Series No. 3, 1972, Central Utah Coal Fields:

Late Cretaceous

Mancos Shale

The oldest formation, the Late Cretaceous Mancos Shale is exposed at the base of Huntington Canyon and First and Second Water Canyons. It can range in thickness from 300 to 1,300 feet. It is yellow to gray in color and is mainly shale with interbeddings of sandstone.

Mesa Verde Group

Starpoint Sandstone

Starpoint Sandstone is the cliff forming yellow sandstone which can vary in thickness from 90 to 1,000 feet. The Starpoint Sandstone is exposed in Huntington Canyon as well as the First and Second Water Canyons.

Blackhawk Formation

The Blackhawk Formation, a slope forming sandstone interbedded with clays, can range in thickness from 700 to 1,000 feet. It is yellow to gray in color with occasional red coloration due to oxidation of iron. It is in this formation that the Hiawatha coal bed is located. The coal bed lies just above contact of the Starpoint Sandstone. The Blackhawk Formation is exposed in Huntington Canyon, Brooks Canyon, Fish Creek Ridge, and Candland Mountain Area.

Castlegate Sandstone

The Castlegate Sandstone forms prominent cliff-like ridges above the Blackhawk Formation, ranging in thickness from 150 to 500 feet. The sandstone is yellow brown in color.

Price River Formation

The Price River Formation is a sandstone interbedded with shale and thick layers of conglomerate. The Price River Formation is more conglomeritic in the northwest. The color ranges from gray to white in the south of the District to red in the north of the

District. The sandstone forms ledges while the shale and conglomerate form slopes giving the formation a step-like appearance. The Price River Formation is well exposed on Bear Ridge, Fairview Lake, Dairy Fork, Miller's Flat, Cleveland Reservoir, Lake Fork, Huntington Canyon, and high elevations throughout the Huntington Reservoir quadrangle.

Cretaceous/Tertiary

North Horn Formation

Above the Price Formation is the youngest Cretaceous formation, the North Horn Formation with a thickness of 500 to 2,500 feet. The formation consists of interbedded shales, sandstone, and fresh water limestone. The North Horn thickens to the north and forms extensive slopes due to formation thickness and instability. The North Horn Formation is exposed in Clear Creek, Dry Creek, and at high elevations in the Huntington Reservoir, C Canyon, Fairview, and Birdseye Quadrangles.

Tertiary

Flagstaff Limestone

Flagstaff Limestone is a ledge former. It is a tan, gray, white limestone with minor amounts of shale and sandstone. It often acts as a cap rock. Major outcrops of Flagstaff Limestone are exposed at high elevations in Dairy Fork Creek, Clear Creek, Johnson Ridge, and Garrett Ridge areas.

Colton Formation

The Colton Formation overlies the Flagstaff Limestone. The formation is a multicolored shale and limestone varying in thickness between 300 to 1,500 feet. Outcrops are confined to the northern most part of the Wasatch Plateau.

Green River Formation

The Green River Formation is a Tertiary limestone shale and siltstone. It is greenish in color and is only found in the northwest portion of the Forest in the Thistle and Birdseye Quadrangles.

The Cretaceous Starpoint Sandstone, Blackhawk Formation, Castlegate Sandstone, and the Price River Formation are part of the Mesa Verde Group. The Tertiary North Horn Formation and Flagstaff Formation belong to the Wasatch Group.

There is only one igneous rock formation located on this District. This formation is Early Tertiary in age, and is an andesite trachyte latite pyroclastic. This formation is located in the northern part of the District in the Clear Creek area.

II. PHYSIOGRAPHY

The physiography varies within the Price District. In Andrew Godfrey's unpublished report, A Field Reconnaissance of Mantle Instability on the Manti Division of the Manti-LaSal National Forest and Adjacent Portion of the Fishlake National Forest, Godfrey separates the Manti-LaSal National Forest into distinctive physiographic regions based on similar landscape, topography, and climate.

A. Eastern Clifflands - The steep cliffs which bound the southeastern portion of the plateau delineate this region. The topography reflects the geology where slopes coincide with the less resistent shales and cliffs coincide with the massive sandstones and limestones. This subsection has low rainfall, less than 20 inches.

B. High Plateaus - Areas above 10,000 feet belong to this physiographic region. The topography is flat due to resistent cap rock, Flagstaff Limestone. The average rainfall is 20 to 30 inches.

C. Rolling Basinlands - This rolling topography is found in lower elevations adjacent to the high plateaus at 6,000 to 9,000 feet elevation. The thick, less resistent, North Horn Formation is the major formation which forms these slopes in this physiographic subsection. The average rainfall is 20 to 30 inches.

D. Lakes - At the high elevations where glacial material has been deposited, is found the gently rolling and hummocky topography of the Lakes subsection. The Gooseberry Reservoir area of Price District belongs to this physiographic region. The average rainfall is 20 to 30 inches.

E. Ridge and Valley - This area is located in the northern portion of the Price District. The characteristic topography of this area is steep V shaped valleys and narrow ridges. The topography does not reflect the different geologic formations which underlie this area as is seen in the Eastern Clifflands. The area is structurally complex with numerous faults. The elevation varies from 6,000 to 9,000 feet with a rainfall of 20 to 25 inches.

III. GEOLOGY, PHYSIOGRAPHY, AND LAND INSTABILITY OF PRICE RANGER DISTRICT

A. Map 1 - Santaquin Peak 15 Minute Quadrangle

The major geologic formations present in this area are the Green River Formation, Flagstaff Formation, and the North Horn Formation. According to Godfrey's classification, this area belongs to the Ridge and Valley subclassification. No unstable areas have been delineated. See Appendix Map 1.

B. Map 2 - Thistle, Mill Fork, Indianola, and C Canyon Quadrangles

The major geologic formations present in this area are the Flagstaff Limestone, Green River, Price and North Horn Formations. The northern section of this map belongs to the Ridge and Valley subclassification. See map 2 in the Appendix.

This area is actively unstable both in the Green River Formation and the Price River Formation. Jackstrawed trees indicate the area is actively unstable. Landslides are evident adjacent to the Dairy Fork Creek. Two large escarpments can be seen at high elevations in the Price River Formation. According to the geologic maps, the escarpments are not due to faulting, but rather the incompetency of the formation. High potential instability is evident along Clear Creek in the North Horn Formation.

In the southern half of this map, the topography changes from Ridge and Valley to High Plateaus in physiography. The massive Flagstaff Limestone caps these high Plateaus and stabilizes the North Horn Formation which lies directly below the limestone.

C. Map 3 Soldier Summit 15 Minute Quadrangle

All the formations of this region are contained in the Ridge and Valley physiographic subsection. The North Horn Formation is unstable along the north side of Clear Creek Canyon. The Price River Formation appears to be stable in this region. Instability is evident in Little Bear Creek, Fish Creek, and French Creek in the Blackhawk Formation west of Scofield Reservoir.

D. Map 4 - Fairview, Fairview Lakes, and Huntington Reservoir Quadrangles

The major formations of this area are the Flagstaff Limestone, the North Horn Formation, and the Price River Formation. The Castlegate Formation and the Blackhawk Formation are found in the low elevations of the canyons in the northeast section of this map. See map 4 in the Appendix.

The Flagstaff Formation delineates the High Plateaus and is highly stable. Southeast of the High Plateaus is the Lakes region. The major formation which underlies this region is the North Horn Formation. The few unstable areas found in this region are slumps rather than slides.

To the west of the Lakes region is the Rolling Basinlands physiographic subsection. Most of the delineated unstable areas of map

4 are in this region. Escarpments are associated with these unstable areas and occur primarily in the North Horn Formation.

E. Map 5 - Scofield 15 Minute Quadrangle

The southeastern corner of District 3 is comprised of the Flagstaff Limestone Formation. This formation belongs to the High Plateaus physiographic subsection and is very stable.

North of this region is the Ridge and Valley physiographic subsection. The area contains the Mancos, Blackhawk, and Starpoint Formations. No major areas of instability are evident.

The Starpoint Sandstone becomes unstable in the Eastern Clifflands subsection in the Huntington Canyon where the less resistent Mancos Shale erodes beneath the sandstone causing the sandstone to fall in blocks.

The Blackhawk Formation is unstable in the northern half of the map especially in the Huntington and Price River Drainages.

In the western portion of this map, the physiographic subsection changes to the Rolling Basinlands where instability is occurring in the Blackhawk and the Price River Formations. Active sliding is occurring north of Cleveland Reservoir in the Price River Formation.

F. Map 6 - Hiawatha 15 Minute Quadrangle

In the northeast section of the Hiawatha 15 minute quadrangle, the North Horn Formation which is in the High Plateaus physiographic subsection is stable. The North Horn Formation in the west section of the District 3 is highly unstable. In the west section, the North Horn belongs to the Rolling Basinlands physiographic subsection.

West of Rilda Canyon, active sliding is taking place along the contact between the North Horn Formation and the Flagstaff Limestone. Blocks of Flagstaff Limestone are falling where the underlying, less resistent, North Horn Formation is eroding from underneath in over steepened slopes.

IV. CONCLUSIONS

Specific locations of active land instability have been delineated on the Price Ranger District, District 3 on six 15 minute maps. Areas which display paleoinstability have also been outlined as high potential instability areas. Correlations have been made relating the geology and physiography to instability in each 15 minute map.

Two shale formations appear to be the most unstable; the Green River Formation and the North Horn Formation.

The Green River Formation outcrops in the northern section of the Price Ranger District and is actively sliding adjacent to Dairy Fork Creek.

The North Horn Formation is stable in the Lakes and High Plateau physiographic subsections where the gradient of the slopes is low. A slight increase in the slope gradient, as occurs in the Rolling Basinlands physiographic subsection, causes active instability in the North Horn Formation. The North Horn Formation can also cause the stable overlying Flagstaff Limestone to be unstable. The less resistent North Horn Formation erodes beneath the Flagstaff Limestone causing falling blocks of limestone. This occurs where the Flagstaff Limestone has been over steepened due to glacial erosion.

The Price River Formation is stable except in some isolated areas where unusual environmental conditions particular to the site locations have caused instability in the formation.

No determinations have been made to the specific environmental conditions or magnitude of those conditions that presently induce or could potentially induce activity in the delineated unstable areas of this report. These determinations must be made site specifically as to provide adequate management requirements which will insure proper and safe use of the land surface in these potentially hazardous areas.

APPENDIX B

Land Instability of Ferron Ranger District

I. Stratigraphy

The physical and chemical characteristics of the exposed rock strata of the Ferron Ranger District combined with environmental conditions, determines the stability characteristics of this area. The following is a description of the formations from the oldest to youngest which underlie this area as described in Doelling's Monographic Series No. 3, Central Utah Coal Fields:

Late Cretaceous

Mancos Shale

The oldest formation, the Upper Cretaceous Mancos Shale is exposed at the foot of the east side of the Wasatch Plateau and in canyons which cut into these clifflands. Major canyons where this formation is exposed in Ferron District are as follows: North Fork of Quitchupah, Muddy Creek, Cottonwood, Straight, and Ferron.

The Mancos Shale can range in thickness from 300 to 1,300 feet. It is yellow to gray in color and is mainly shale with interbeddings of sandstone.

Mesa Verde Group

Starpoint Sandstone

Starpoint Sandstone, the cliff forming massive yellow sandstone, overlies the Mancos Shale. It can vary in thickness from 90 to 1,000 feet. The Starpoint Sandstone is exposed along the eastern escarpment of the Wasatch Plateau and in the major canyons which cut into the plateau.

Blackhawk Formation

The Blackhawk Formation, a slope forming sandstone interbedded with clays, can range in thickness from 700 to 1,000 feet. It is yellow to gray in color with occasional red coloration due to oxidation of iron. It is in this formation that the major coal beds are located. The Blackhawk Formation is exposed along the eastern escarpment of the Wasatch Plateau and in the major canyons cut into the Plateau.

Castlegate Sandstone

The Castlegate Sandstone forms prominent cliff-like ridges above the Blackhawk Formation, ranging in thickness from 150 to 500 feet. The sandstone is yellow-brown in color.

Price River Formation

The Price River Formation is a sandstone interbedded with shales and thick layers of conglomerate. The color ranges from gray to white. The sandstone forms ledges while the shale and conglomerate form slopes giving the formation a step-like appearance. The Price River Formation is well exposed in Joe's Valley, South Horn and North Horn Mountains and Wildcat Knolls.

Cretaceous/Tertiary

North Horn Formation

The Price River Formation grades into the overlying North Horn Formation. It is the youngest Cretaceous formation and its upper layers make this formation the oldest Tertiary formation. The formation consists of interbedded shales, sandstone, and fresh water limestone. The less competent shales are slope formers while the limestone layers form step-like structures. The formation is generally a slope former. The North Horn Formation is predominant on North Horn Mountain, Trail Mountain, Gentry Mountain, Joe's Valley, and areas west of the Joe's Valley Graben.

Tertiary

Flagstaff Limestone

The Flagstaff Limestone is a ledge former. It is a tan, gray, and white limestone with minor amounts of shale and sandstone. It often acts as a cap rock in the high elevation areas. Flagstaff Limestone is most noticeable in the area of The Cap East Mountain, Ferron Mountain, and many areas west of the Joe's Valley Graben i.e., Block Mountain, Heliotrope Mountain, Cove Mountain, Trail Ridge, Buck Ridge, White Mountain, Ridley Ridge, Wagon Road Ridge.

II. Physiography

The topography varies within the Ferron Ranger District. In Andrew Godfrey's unpublished report, A Field Reconnaissance of Mantle Instability on the Manti Division of the Manti-LaSal National Forest and

Adjacent Portion of the Fishlake National Forest. Godfrey separates the Manti-LaSal National Forest into distinctive physiographic regions based on similar landscapes, topography, and climate.

A. Eastern Clifflands - The steep cliffs which bound the southeastern portion of the plateau delineate this region. The topography reflects the geology where slopes coincide with the less resistent shales and cliffs coincide with the massive sandstones and limestones. This subsection has low rainfall, less than 20 inches.

B. High Plateaus - Areas above 10,000 feet belong to this physiographic region. The topography is flat due to the resistant cap rock, Flagstaff Limestone. The average rainfall is 20 to 30 inches.

C. Rolling Basin Lands - This rolling topography is found in lower elevations adjacent to the high plateaus at 6,000 to 9,000 feet elevation. The thick less resistent, North Horn Formation is the major formation which forms these slopes in this physiographic subsection. The average rainfall is 20 to 30 inches.

III. Geology, Physiography, and Land Instability of Ferron Ranger District

A. Map 8 - Spring City, South Tent, Danish Knoll, Joe's Valley Reservoir 7½ Minute Quadrangles.

The major geologic formations exposed within this area are the North Horn Formation and Flagstaff Limestone. The north-south trending graben, which is located in the eastern most section of the map has exposures of the Price River Formation, Castlegate Sandstone, and Blackhawk Formation in the outer cliff areas. The major physiographic regions present in this area are the High Plateaus to the west and the Rolling Basinlands to the east. The graben is very prominent in the Joe's Valley Reservoir area.

Paleo-landslides are evident in lower Joe's Valley. These may very well be fault related since they occur along the western edge of the graben. Active sliding is occurring along side drainages to Reeder Canyon, Seeley Creek, and two areas west of Seely Creek in the Soup Bowl area and side drainages in Bulger Canyon.

All these failures occur in the North Horn Formation on the north aspect.

B. Map 7 - Castledale, Utah 15 Minute Quadrangle.

The Mancos Shale Formation and the Mesa Verde Group are exposed along the cliffs and within the canyons of these cliffs. The Joe's

Valley fault system is the most prominent structural feature.

The North Horn and Price River Formations are major formations in the North Horn and South Horn Mountain areas.

Three physiographic subsections are represented. The Eastern Clifflands on the eastern edge of the plateau, the High Plateaus in the north which includes North Horn and South Horn Mountains and the Basinlands located in the Nelson Mountain area. Instability occurs north and south of Sage Flat and in areas north and east of The Cap. The unstable areas occur within the North Horn Formation.

C. Map 6 Hiawatha, Utah 15 Minute Map

The majority of this area is represented by the Eastern Clifflands physiographic region. The remaining area is within the High Plateaus region. The escarpments to the west are fault related and mark the eastern edge of the Joe's Valley Graben. The Mancos Shale and the Mesa Verde group are exposed along the escarpment and the canyon walls. The High Plateaus area is comprised mostly of the North Horn Formations with isolated ledges of Flagstaff Limestone.

High potential for instability is evident in the North Horn Formation and to a lesser degree in the Blackhawk Formation. Active sliding is occurring in the Blackhawk Formation in Straight Canyon and the North Horn Formation in Rilda Canyon.

D. Map 9 Ferron Reservoir, Ferron Canyon, Heliotrope and Flagstaff Peak 7½ Minute Quadrangles.

The Mancos Shale and Mesa Verde Group crop out in Muddy Creek and Ferron Canyon. The north-south trending Joe's Valley Fault Zone is prominent in the Ferron Canyon Area. The North Horn Formation and Flagstaff Limestone are the major formations exposed in this area.

Three physiographic regions are represented: High Plateaus to the west, Eastern Clifflands to the east, and the Basinlands physiographic region comprises the majority of this area.

Paleo-landslides have occurred west of North Dragon Creek. One of these areas has reactivated west of Water Terrace. Most of the present instability in this area occurs in the North Horn Formation. Other locations with high potential instability are White Slides, Windy Point and the Muddy Creek area.

E. Map 10 Accord Lakes and Emery West 7½ Minute Quadrangles.

The Price River Formation is the main formation exposed within this area. Mancos Shale, Starpoint Sandstone, Blackhawk, and Castlegate Sandstone formations crop out within Quitchupah and Muddy Creek Canyons. The higher elevation areas are within the Basinlands physiographic region bordered by the erosional escarpment of the Eastern Clifflands physiographic region.

High potential instability is evident in the northwestern portion of this map in the North Horn Formation. This area is not large in extent.

F. Map 11 Emery East 7½ Minute Quadrangle

The Mancos Shale is the major formation exposed within this quadrangle. Faulting is prominent in the western portion of this map. The area is entirely within the Eastern Clifflands physiographic region. No high potential instability areas are evident.

IV. Conclusions

Specific locations of active land instability have been delineated on the Ferron Ranger District, District 2, on six 15 minute maps. Areas which display paleoinstability have also been outlined as high potential instability areas. Correlations have been made relating the geology and physiography to instability in each 15 minute map.

Paleolandslides are evident in lower Joe's Valley. These paleolandslides could be activated as in the area west of North Dragon Creek. Active instability is also evident in the side drainages to Reeder Canyon, Seeley Creek, and Bulger Canyon. This instability all occurs in the North Horn Formation. Directly east, high potential for instability is evident in the Blackhawk Formation. Active instability is occurring in Straight Canyon.

High potential for instability occurs in the northern part of the District in the North Horn Formation in the White Slides, Windy Point, and the Muddy Creek area.

No determinations have been made to the specific environmental conditions or magnitude of those conditions that presently induce or could potentially induce activity in the delineated unstable areas of this report. These determinations must be made site specifically as to provide adequate management requirements which will insure proper and safe use of the land surface so that no adverse impacts occur in these potentially hazardous areas.

APPENDIX C

Land instability of the Manti Division of the Sanpete Ranger District

I. Stratigraphy

The physical and chemical characteristics of the exposed rock strata of the Sanpete Ranger District (Manti Division) combined with environmental conditions, determine the stability characteristic of this area. The following is a description of the formations from the oldest to youngest which underlie this area as described in Doelling's Monographic Series Number 3, 1972, Central Utah Coal Fields:

Jurassic

Jurassic Undifferentiated

The Jurassic formations are undifferentiated. They consist mainly of red shales exposed along Clear Creek in the northern part of the District.

Cretaceous

Mancos Shale

This formation is exposed in the northern part of the District in Little Clear Creek. One member of the formation predominates, the Emery Sandstone. The Emery Sandstone is buff to gray in color. Interbeddings of shale in the sandstone form step like slopes in this member.

Mesa Verde Group

Blackhawk Formation

The Blackhawk Formation, a slope forming sandstone interbedded with clays, can range in thickness from 700 to 1,000 feet. It is yellow to gray in color. The Blackhawk formation is exposed in some of the canyons associated with Birch Creek, North Creek, and Pleasant Creek.

Castlegate Sandstone

The Castlegate Sandstone forms cliff-like ridges above the Blackhawk Formation, ranging in thickness from 150 to 500 feet. The sandstone is yellow-brown in color.

Price River Formation

The Price River Formation is a sandstone interbedded with shale and thick layers of conglomerate. The color ranges from gray-white to red in color. The sandstone forms ledges while the shale and conglomerate form slopes giving the formation a step-like appearance. The Price River Formation is exposed in the Birch Creek, North Creek and Pleasant Creek Canyons.

Cretaceous Teritiary

Wasatch Group

North Horn Formation

Above the Price Formation is the youngest Cretaceous formation, the North Horn Formation, with a thickness of 500 to 2500 feet. The formation consists of interbedded shales, sandstone and fresh water limestone. The North Horn thickens to the north and forms extensive slopes due to the formation thickness and instability. The North Horn formation is the major formation forming the slopes on the east side of the Wasatch Plateau.

Tertiary

Wasatch Group

Flagstaff Limestone

The Flagstaff Limestone is a ledge former. It is a tan, gray white limestone. It often acts as a cap rock. In the southern part of the district the Flagstaff Limestone dips to the west in a monocline and is the major formation exposed along the western edge of the plateau. In the eastern part of the district the Flagstaff Limestone has a slight dip, caps the top of the plateau, and forms a ledge over the North Horn Formation.

Colton Formation

The Colton Formation overlies the Flagstaff Limestone. The formation is a multicolored shale and limestone varying in thickness between 300 to 1500 feet. This formation is similar in lithology to the North Horn Formation. Outcrops are confined to the western most edge of the Forest directly east of Sterling and northeast of Spring City.

II. Physiography

The topography varies within the Manti Division of the Sanpete District. In Andrew Godfrey's unpublished report, A Field Reconnaissance of Mantle Instability on the Manti Division of the Manti-LaSal National Forest and Adjacent Portion of the Fishlake National Forest, Godfrey separates the Manti-LaSal National Forest into distinctive physiographic regions based on similar landscapes, topography and climate.

Monocline

This area comprises two major formations; the North Horn Formation and the Flagstaff Limestone. These formations regionally dip westward in a monocline. The topography generally follows the bedding planes. Subsequently, streams and glaciers have cut into the monocline and have developed a very rugged topography between remnants of the older surface. Most of this District is classified as this subsection.

High Plateau

Areas above 10,000 feet belong to this physiographic region. The topography is flat due to the resistant cap rock, Flagstaff Limestone. The High Plateau subsection is prominentin the eastern edge of the District.

III. Geology, Physiography and Land Instability in the Manti Divsion of the Sanpete District.

A. Map 2 - Thistle, Mill Fork, Indianola, C. Canyon, 7½ Minute Maps

Active instability is occurring in Clear Creek primarily in the Undifferentiated Jurassic and the Price River formations. This instability is evident in the North Fork and South Fork of Thistle Creek. This area is in the physiographic transitional zone of the Ridge and Valley and Monocline Subsection. The Flagstaff Limestone crops out in the southern part of the map forming the High Plateaus physiographic subsection. Additional instability potential occurs west of the High Plateau subsection in the North Horn Formation.

B. Map 4 - Fairview, Fairview Lakes, Mt. Pleasant, Huntington Reservoir, 7½ Minute Maps.

The northeastern section of the district is in the High Plateaus physiographic subsection bordered to the west and south by the Monocline subsection. The major formation in the Monocline physiographic subsection is the North Horn Formation. Small canyons are cut into the North Horn exposing the Blackhawk, Castlegate and Price River Formations. High potential instability occurs in Cottonwood Canyon and the North Fork of North Creek. There is a high potential for instability in the steep canyons especially within the North Horn Formation.

C. Map 8 - Spring City, South Tent Mountain, Danish Knoll, Joe's Valley Reservoir, 7½ Minute Maps.

Two major physiographic subsections occur west of Skyline Drive; the High Plateaus and the Monocline. The Flagstaff Limestone caps both these subsections. The Monocline which is generally an unstable subsection is more stable in this area where slopes are capped by the

Flagstaff Limestone. According to Godfrey (1972), extensive slope cutting could remove the support at the base of these dipping Flagstaff Limestone beds and cause instability.

In areas where the North Horn Formation is exposed, a higher potential for instability can be expected, as in Canal and Ephraim Canyons.

Map 13 - Chester, Ephraim, 7½ Minute Maps

A large area of instability occurs in Manti Canyon. In May 1974, a slide on the south side of the canyon occurred. This slide is known as the Cottonwood Land Flow or the South Slide. The Cottonwood fault, a north-south trending fault runs almost perpendicular to Manti Canyon. Sliding could be related to active faulting glaciation of the canyon, local seismicity, annual precipatation, ground water introduced into glacial till through faults, strength of saturated materials, mineralogy and specific sliding planes (Interior Geotechnical Report - Manti Canyon North Slide Stability Studies. Caldwell, Richards and Sorensen Inc., September 1976).

The entire map area is within the Monocline subsection physiographic region. The shale beds of the North Horn which underlie the glacial till, dip 10^{o} to 20^{o} westward which form sliding planes for the mass movement of rock material.

Map 12 - Black Mountain, Woods Lake, Mayfield, Sterling, 7½ Minute Map.

Where glaciation has over steepened slopes and where the North Horn Formation is exposed high potential for instability could exist. The glacial mor aine in Six Mile Canyon may be highly susceptible to instability especially since this morraine overlies the North Horn Formation.

Most of the area is in the Monocline physiographic region. Instability is evident along Twelve Mile Creek, the Narrows South and South Fork of Manti Canyon.

IV. Conclusions

Specific locations of active land instability have been delineated on the Sanpete Ranger District, District 1, on six 15 minute maps. Areas which display paleoinstability have also been outlined as high potential instability areas. Correlations have been made relating the geology and physiography to instability in each map.

One shale formation appears to be the most unstable, the North Horn Formation, Quaternary Glacial Morraines which overlie the North Horn Formation are also highly unstable. Oversteepened canyons due to glaciation could remove the base of the dipping beds and cause instability in more stable formations such as the Flagstaff Limestone.

The monocline contains rock beds dipping 10^{o} to 20^{o} westward. Dipping clay shale beds can act like slippage planes especially since these beds dip in a down canyon direction.

No determinations have been made to the specific environment conditions or magnitude of those conditions that presently induce or could potentially induce activity in the delineated unstable areas of this report. These determinations must be made site specifically as to provide adequate management requirements which will insure proper and safe use of the land surface and to insure that other resources are not adversely impacted in these potentially hazardous areas.

APPENDIX D

Land Instability in the San Pitch Division of the Sanpete Ranger District

I. Stratigraphy

The physical and chemical characteristics of the exposed rock strata of the San Pitch Division of Sanpete Ranger District combined with environmental conditions, determine the stability characteristics of this area. The following is a description of the formations from the oldest to youngest which underlie this area as described in Doelling's Monographic Series No. 3, 1972, Central Utah Coal Fields:

Jurassic

Arapian Shale

Twelve Mile Canyon Member

The Twelvemile Canyon Member is 7000 feet in thickness. It consists of four layers. The lower layer is a dense massive dark red shale containing thick beds of rock salt. The next layer is gray shale. The overlying layer is a light gray shale. The last layer is siltstone and sandstone with local beds of commercial grade gypsum.

Twist Gulch Member

The upper member of the Arapian is the thin-bedded dark red to brown siltstone, sandstone, and shale with some massive layers of white to greenish white siltstone. It outcrops at the foot of the east side of the Gunnison Plateau in discontinuous outcrops. The maximum thickness is estimated to be 3000 feet.

Morrison Formation - This formation is missing due to Pre-Indianola Group erosion.

Cretaceous

Indianola Group

The formations included in this group cannot be differentiated in the Gunnison Plateau. The group includes conglomerates which are white, gray, buff, and red. The clastics include cobbles of pink, white, and green quartzites and dark gray limestone. No coal is contained in the undifferentiated Indianola group.

Mesa Verde Group

Blackhawk Formation - This formation is misssing due to the Pre-Price River Formation Erosion.

Price River Formation

The Price River Formation overlies unconformably on the Indianola Group. The Castlegate Sandstone which is a very pronounced cliff forming sandstone in the Wasatch Plateau below the Price River Formation is unidentifiable in the Gunnison Plateau. The Price River Formation in the Gunnison Plateau is a coarser conglomerate with sandstone lenses which weather dark brown. The clastic material of the formation contains white, pink, and red quartizite cobbles. The formation is 1000 to 2000 feet in thickness and grades into the North Horn Formation. The contact between the formations is difficult to determine.

Cretaceous/Tertiary

Wasatch Group

North Horn Formation is the youngest Cretaceous formation. The upper layer of the formation is Tertiary. The North Horn ranges in thickness from 500 to 3000 feet. It consists of inter-bedded shales, gray, blue, and red in color, buff to gray fresh water limestone and brown to buff sandstone. The upper unit of the North Horn is mostly a cliff forming massive brown sandstone. Coal is contained within this formation which comprises the Wales Field.

Teritiary

Wasatch Group

Flagstaff Limestone

The Flagstaff Limestone is dominated by fresh water limestone which ranges in color from tan, gray to white. It also contains some shale, sandstone, gypsum, volcanic ash, oil shale, bitumnous and carboniferous beds and some conglomerate. It outcrops mainly in the southern part of the San Pitch Division from Maple Canyon south. The formation caps the main frontal escarpment on the east side of the Gunnison Plateau.

Colton Formation

The Green River Formation outcrops in the very southern part of the San Pitch Division. The unit consists of two members; a lower blue gray to light blue shale, 100 to 400 feet thick, and an over-lying unit of cream to tan limestone of the same thickness.

Colton Formation

The Colton Formation consists of red and green-gray shale, gray and green sandstone and gray limestone. The thickness ranges from 800 to 1600 feet. This formation is similar in lithology to the North Horn formation.

Green River Formation

The Green River Formation outcrops in the very southern part of the San Pitch Division. The unit consists of two members; a lower blue gray to light blue shale, 100 to 200 feet thick, and an overlying unit of cream to tan limestone of the same thickness.

II. Physiography

The physiography varies within the San Pitch Division of the Sanpete Ranger District. In David Steinfeld's unpublished report, Land Systems Inventory for the Sanpete Planning Unit, Steinfeld separates the San Pitch Division into two distinct physiographic regions based on similar landscape, topography, and climate.

A. San Pitch Plateaus

This subsection consists mostly of the gently sloping uplands of the San Pitch Mountains. Geologically, this area is controlled by the relatively flat lying formations; the Flagstaff Limestone, North Horn Formation, and Indianola Group. Stream dissection is slight. Elevations range from 7,000 to 9,000 feet. Average annual precipitation ranges from 18 to 27 inches.

B. San Pitch Slopes

This area includes the steep, highly dissected slopes of the San Pitch Mountains. The most prominent formations are the North Horn Formation, Indianola Group, and Arapian Group. Elevations range from 6,000 to 9,000 feet. Rainfall increases with elevation from 14 inches on the lower slopes to 26 inches on the high ridge.

LEGEND

Igneous Rocks

Tertiary		
	Tiap	Early Tertiary Andesite-Trachyte-Latite Pyroclastics

Sedimentary Rocks

Tertiary		
	Tgu	Green River Formation
	Tc	Colton Formation
	Tf	Flagstaff Limestone
Cretaceous		
	Tknh	North Horn Formation
	Kp	Price River Formation
	Kc	Castlegate Sandstone
	Kb	Blackhawk Formation
	Ks	Starpoint Sandstone
	Km	Mancos Shale
	Ke	Emery Sandstone (Member of Mancos Shale)
Jurassic		
	Ju	Jurassic Undifferentiated

Forest Boundary

Formation Boundary

Faults (Inferred Faults)


High Potential Instability (Field Investigated)


High Potential Instability (Not Field Investigated)


Active Instability (Field Investigated)

Geologic Map Symbols

WASATCH MOUNTAINS AND VICINITY

EOCENE

Tfo — **Fowkes Formation**
Light-colored tuffaceous and limy beds with local conglomerate lenses. Stratigraphic position uncertain.

Tk — **Knight Conglomerate**
Gray and reddish conglomerate in massive beds. Chiefly fluvial.

Tch — **Crazy Hollow Formation**
Varicolored shale and sandstone.

BOOK CLIFFS AND VICINITY

EOCENE

Tc — **Colton Formation**
Fluvial red beds with channel sandstones.

Tf — **Flagstaff Limestone**
Fresh water limestone, gray and blue-gray.

TKnh — **North Horn Formation**
Chiefly fluvial sandstone and mudstone.

TKt — **Tuscher Formation**
Conglomeratic fluvial sandstone.

HERN UTAH

ts Formation
d sandy shale.

Sandstone
y massive sandstone and minor

liffs Sandstone
e sandstone; COAL BEARING.

ale
erous marine shale.

ndstone
conglomeratic sandstone.

ndstone and Cedar Mtn.
vided

ndstone and Burro Canyon
undivided

yon Formation
dstone and sandstone.

untain Formation
dstone and sandstone.

NORTHERN WASATCH

Upper Cretaceous

Kec — **Echo Canyon Conglomerate**
Sandstone, shale, and conglomerate, a few coal beds.

Kw — **Wanship Formation**
Marine sandstone and shale.

Kf — **Frontier Sandstone**
Non-marine and marine sandstone, shale and COAL.

Lower Cretaceous

Ka — **Aspen Shale**
Dark gray marine shale.

Kbr — **Bear River Formation**
Brackish-water carbonaceous shale and sandstone.

Kk — **Kelvin Conglomerate or Formation**
Continental deposits with predominant red color.

CENTRAL UTAH

Upper Cret

Kt — **Indianola Formation**
Chiefly red conglomerate sandstone and siltstone.

EAST-CENTRAL UTAH

CRETACEOUS

Upper Cretaceous

Kpr — **Price River Formation or Group**
Interbedded sandstone and mudstone. Fluvial and marine.

Castlegate Sandstone
Cliff-forming, light-colored deltaic sandstone.

Black Hawk Group
Chief COAL PRODUCER in Utah. Sandstone, mudstone, shale and coal.

Ksp — **Star Point Sandstone**
Chiefly interbedded light-colored sandstone and gray marine shale; deltaic and beach deposits.

Kms — **Mancos Shale undivided**
Light-gray, non-resistant, marine shale.

Kmm — **Masuk Shale**
Member of Mancos Shale
Gray, marine shale.

Ke — **Emery Sandstone**
Member of Mancos Shale
Light-colored, marine sandstone, probably deltaic in origin.

Kmbg — **Blue Gate Shale**
Member of Mancos Shale
Light gray, calcareous marine shale.

Kgc — **Garley Canyon**
Sandstone Member of Mancos Shale
Chiefly yellow-brown marine sandstone.

Kfe — **Ferron Sandstone**
Member of Mancos Shale
Marine and non-marine sandstone with numerous concretions and COAL BEDS in westernmost outcrops and in the subsurface.

Kmt — **Tununk Shale Member of Mancos Shace**
Gray marine siltstone and claystone.

Lower Cretaceous

Dakota Sandstone or Formation
Light colored sandstone and carbonaceous shale.

Kdcm — **Dakota Sandstone & Cedar Mountain**
Shale undivided

Kcm — **Cedar Mountain Shale**
Nodular shale with fluvial sandstone beds.

Kbc — **Burro Canyon Formation**
Chiefly continental deposits of sandstone and mudstone.

Kdbc — **Dakota Sandstone and Burro Canyon**
Formation undivided

JURASSIC — Upper Jurassic

TRIASSIC? — L. J. — M. J.

JURASSIC