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United States Department of Agriculture | Forest Service | Manti-LaSal N.F.

Reply to: 1590 Defense and Emergency Operations
2880 Geologic Services

Date: June 24, 1983

Subject: Twin Lakes North and South Landslide

To: William H. Boley, Forest Engineer WHB
Attention: Ted Fitzgerald TCF

Attached is the Twelve Mile Canyon, Twin Lakes North and South slide geologic report written by Maureen McBrien. Also attached are photographs (slides) of the land failure area.

Maureen J McBrien

MAUREEN MCBRIEN
Geologist

Enclosure

cc: D-1
D-2
Maureen McBrien

Twelve Mile Canyon

Geologic Assessment
of the
Twin Lakes North and
South Landslide

by
Maureen McBrien, Geologist
Manti-LaSal National Forest

June 23, 1983

TWELVE MILE CANYON

Twin Lakes North and South Slide

Summary of Events

On June 6, 1983, concern was identified for two slides occurring on the north and south sides of Twelve Mile Canyon Creek, west of Pinchot Campground. Both slides are directly across from each other. The North Slide is located in the W½, Sec. 32, T19S, R3E. The South Slide is located in the S½S½, SE¼, Sec. 31, T19S, R3E and NW¼NW¼, Sec. 5, T20S, R3E. The slides were moving at approximately 4 - 6 feet per day. The creek at maximum flow was approximately 900 cubic feet per second. Potential for the damming of water in the creek exists. A corresponding breaching of the natural dam could increase water flow in the creek which could be catastrophic to the town of Mayfield.

On June 7, 1983, another concern developed. Tension and shear fractures were developing progressively north and were within ¼ mile from Twin Lakes Reservoir. On June 8, 1983, a fracture which may or may not be related to the presently active North Slide was identified 1/8 of a mile from Twin Lakes.

A decision was made to breach half the water, 80 acre feet, from Twin Lakes. An uncontrolled breaching of Twin Lakes if water was to be released in 30 minutes, would produce a flow of 4,000 cubic feet per second. This type of flow would also be catastrophic to the small town of Mayfield, 3 miles down canyon from the slide area.

In the controlled breaching of Twin Lakes, a flow of 30-35 cubic feet per second for a period of 13 hrs. was maintained. A debris flow could have resulted if water was to flow on the slide. The resulting volume of debris material which would flow down canyon would be 5 times that of the volume of water released, if a debris flow were to develop. To prevent a debris flow from occurring, a channel was dug to divert the water off the slide into the old natural drainage.

Geologic Assessment

General

Two formations crop out in the Twelve Mile Canyon Area. The Late Cretaceous - Early Tertiary North Horn Formation and the Tertiary Flagstaff Limestone. Thick deposits of glacial moraine cover the valley floors as well as fluvial deposits.

The North Horn Formation consists of interbedded shales, sandstones, and fresh water limestone. The beds dip 10^o to 20^o to the northwest. Because no accurate dip measurements were measured nor was there an outcrop of the Price River Formation, no accurate determination could be made of the bed thickness. Much of the North Horn Formation is covered with Quartернary Glacial Moraine within the valley floor. According to the September 1976 Geotechnical Report, Caldwell, Richards, and Sorensen, Inc., Manti Canyon North Slide Stability Studies, the North Horn Formation is 300 - 400 feet thick in Manti Canyon. The glacial moraine is more than 500 feet thick. Similar conditions seem to occur in Twelve Mile Canyon south of Manti Canyon. Drilling would be required to accurately determine the thickness of the North Horn Formation and the glacial moraine. The North Horn Formation is highly unstable and many of the recent massive landslides in Utah ie. Manti, Thistle, have occurred in this formation.

The Flagstaff Limestone caps the North Horn Formation and forms a near vertical outcrop. The formation is a fresh water limestone and lies conformably on the North Horn Formation. The Flagstaff Limestone is a stable formation except where the North Horn Formation may be undercut causing rock fall.

Twelve Mile Canyon is in the western margin of the Wasatch Plateau. This area, known as the Wasatch Monocline, dips west to Sanpete Valley. The monocline has been dissected by glacial action forming steep canyons during the Ice Age and stream action up to present times. Thick glacial moraine deposits (500 feet) occur in the valley bottom. Fluvial deposits also occur.

Twelve Mile Canyon is within the Musinia Fault Zone which is a series of normal, near vertical faults which strike generally north-south.

The two active slides appear to be within two multiple rotational paleolandslide features as evidenced by the hummocky slope/bench topography of the area.

The north paleolandslide is bounded to the west and east by a fault. The south slide is bounded by a fault on its east side. The active slides are smaller in extent than the topography indicates for the paleolandslides. New fissures are developing daily which indicate that the active land slide area is enlargening.

The North Slide (Twin Lakes)

The present North Slide (Twin Lakes) is within an older paleo-landslide. The paleo-landslide is bounded by two faults. The western and eastern fault strike at approximately N 10° E.

A well defined shear at the western flank of the active slide also strikes at approximately N 10° E. The shear fracture extends northeast 3000 feet from the toe of the slide. The shear is well developed except at the Northern most 100 feet where the shear is evidenced only by enechelon tension cracks. The tension cracks strike N 55° E. The western flank of the slide is also defined by a shear, however it is not fully developed. It too trends at approximately N 10° E but is only well developed 1400 feet northeast of the toe. Other cracks with an orientation which match compression features of the active slide, striking N 30° W, were found 600 feet east of the eastern most shear.

On June 5, 1983, Station 1 (See map 1) was set up near the toe and western flank shear of the slide to determine the approximate movement rate of the slide. Measurements were made until June 8, 1983. At Station 1 the landslide material was rotating downstream and compression features had destroyed the siting station. On June 6, 1983, a second station (Station 2, See map 1) was set up 3/8 of a mile north of the toe of the slide on the western flank shear during the construction of the diversion channel for the breaching of Twin Lakes. The second station was lost at 3:00 p.m., June 10, 1983.

A well defined shear fracture bounded the western flank of the slide. Two stakes were set up in line in the stable western side of the shear. A third stake was set up on the east side of the shear in line with the two other stakes on the west side of the shear. The next day movement could be determined by measuring the distance between the stake of the previous day on the east side of the shear to the stake which was newly in line with the two stakes on the west side of the shear (See figure 1). The following data was collected from the two stations:

Station 1

DATE	TIME	DISTANCE	RATE	
6/5/83	7:25 p. m.	-	-	- -
6/6/83	3:42 p. m.	38 inches	.16ft./hr	3.75 ft./24 hrs
6/683	5:05 p. m.	6 inches	.4 ft./hr	9.6 ft./24 hrs
6/7/83	10:00 a. m.	18 inches	.24ft./hr	5.7 ft./24 hrs
6/8/83	Station lost	-		

Station 2

DATE	TIME	DISTANCE	RATE	
6/7/83	11:22 a.m.	-	-	-
6/8/83	10:13 a.m.	70 inches	.21 ft/hr	5.23 ft/24 hr
6/9/83	9:45 a.m.	72 inches	.26 ft/hr	6.13 ft/24 hr
6/10/83	10:38 a.m.	64 inches	.22 ft/hr	5.18 ft/24 hr
6/10/83	3:00 p.m.	Station lost		

The slide appeared to be moving 4 to 6 feet per 24 hours. The movement of material could be observed. Extensive tension cracks and compression features were observed on the slide up to 3000 feet north of the toe of the slide.

The slide appears to be retrogressive since the shear and associated tension fractures of the western flank have progressed opposite to the direction of movement of the slide. The slide appears to be spreading laterally eastward as evidenced by compression features east of the shear zone.

The slide is striking in the same orientation as the boundary fault east and west of the slide. Because the slide does not follow the dip and because the flank shears follow a definite strike regardless of the topography, I assume the slide is a deep rotational slide. The tension fractures first appear on the slope areas below the benches. The slopes are most likely the boundaries of the paleolandslide rotational slump blocks. It appears the movement may be structurally controlled along the faults and shear planes at the base of the rotational blocks. (See Figure 2)

Reactivation of the paleolandslide is most probably related to the excessive water the area has received in the past two years. Water is probably acting as a lubricant along the fault and the basal paleo-shear planes. The fault also acts as a conduit for water, entering the eastern fault, being intercepted along the paleo-shear planes under the rotation block and being intercepted by permeable beds dipping northwestward.

The increased flow in Twelve Mile Creek has eroded the lower reaches of the paleolandslide area which has either cut the toe of the paleolandslide or has oversteepened the slope at the creek edge, causing land instability.

South Slide (Twin Lakes)

The presently active South Slide (Twin Lakes) is within an older paleolandslide, a fault, with a strike of N 20^{o} W marks the eastern boundary.

The shear zone is most evident at the eastern boundary of the slide. Activity is greatest in this area. The zone consists of three parallel shear cracks. The eastern most shear is not as well developed as the other two. Vertical displacement is small and the shear crack is represented by enechelon tension cracks in the southern most extension (See Map 1). The other cracks are well developed striking N 20° W and have vertical displacement as great as 20 to 25 feet. Two thousand two hundred feet to the west of the eastern most shear is the development of a shear directly across from Birch Creek. This shear also strikes N 20° W and consists mostly of enchelon tension cracks. There is a zone of inactivity. No cracks are evident in an area one thousand feet east of the shear. This shear could be the western flank of the active slide or it is the eastern most flank of a second slide developing across from Birch Creek.

The active shear zone extends 1300 feet south from the toe. The meadow area south of the southern most extension of the shear zone had no evidence of cracking. Cracks were observed in the slope south of the meadow areas. It could not be determined if this active instability was local or part of the major active slide.

A third station was set up at the eastern most shear flank to determine the slide movement. It was the only area where an accurate measurement could be made however it appeared to be the least active of the shear cracks in the shear zone.

The station was set up at 11:03 a.m. At 12:13 p.m. 2 inches of movement had occurred, a rate of 4 feet/24 hrs.

The fault to the east of the slide area appears to be acting as a conduit for water to enter the bedding planes. The water lubricates the bedding plane and provides a surface for slippage. The beds dip northwest in the same direction as the slide movement. Tension cracks, great shear displacements, compression features, and large amounts of water pooling and filling cracks in the slide, indicate a very active slide. The slide could be structurally controlled by slippage along the fault as well as paleo-landslide rotational block shears. Because of the dip of the bed translational sliding is probably also occurring. The shale beds in the North Horn Formations could provide a failure plane, especially since the beds dip down canyon. The increased flow in Twelve Mile Creek could have eroded the base of the paleo-landslide which may have cut the toe of the slide reactivating the slide. (See Figure 3).

The south slide is much wetter than the north slide due to the dip of the bedding planes acting as conduits for that water. This water is getting further diverted into the slide by the shear and tension cracks. A potential could exist for a debris flow if water continues to saturate the landslide. At the toe of the slide, I observed very small debris flows (6 inches wide) developing. This slide should be carefully monitored.

PHOTOGRAPH NARRATIVE
TWELVE MILE CANYON
TWIN LAKES NORTH AND SOUTH LANDSLIDES

North Slide-Twin Lakes   Photographs are in the 1590 file

Slide Number

1.	Compression features and lateral offset on Twelve Mile Canyon Road on the toe of the slide June 6, 1983.
2.	Compression feature that developed in the same proximity, one day later June 7, 1983.
3.	Tension cracks on the toe of the North slide.
4.	Shear fractures on the North slide. Notice the plant root orientation caused by shearing.
5.	Compression feature on the North slide, north of the toe of the slide, next to the western flank shear.
6 & 7.	East shear near the toe of the slide. Land appears to be flowing.
8 & 9.	Just north of the toe, the western flank shear is evident. Notice the vertical displacement of the shear. (Slide 8 (6/7/83), (Slide 9 (6/8/83).
10.	One quarter of a mile north along the western flank shear. The Twin Lake road is displaced approximately 50 feet (6/7/83).
11.	On June 8, 1983, the shear has widened. A monitoring station was set up at this site (Station 2). Four to six feet of movement per day was recorded.
12.	The stream, the source of which is Twin Lakes, is diverted by the flank shear onto the slide. This area is just east of the displaced road in photographs 10 and 11.
13.	Tension cracks on the Twin Lakes Road approximately ¼ mile north of the toe of the slide is fractured by tension cracks and compression features.

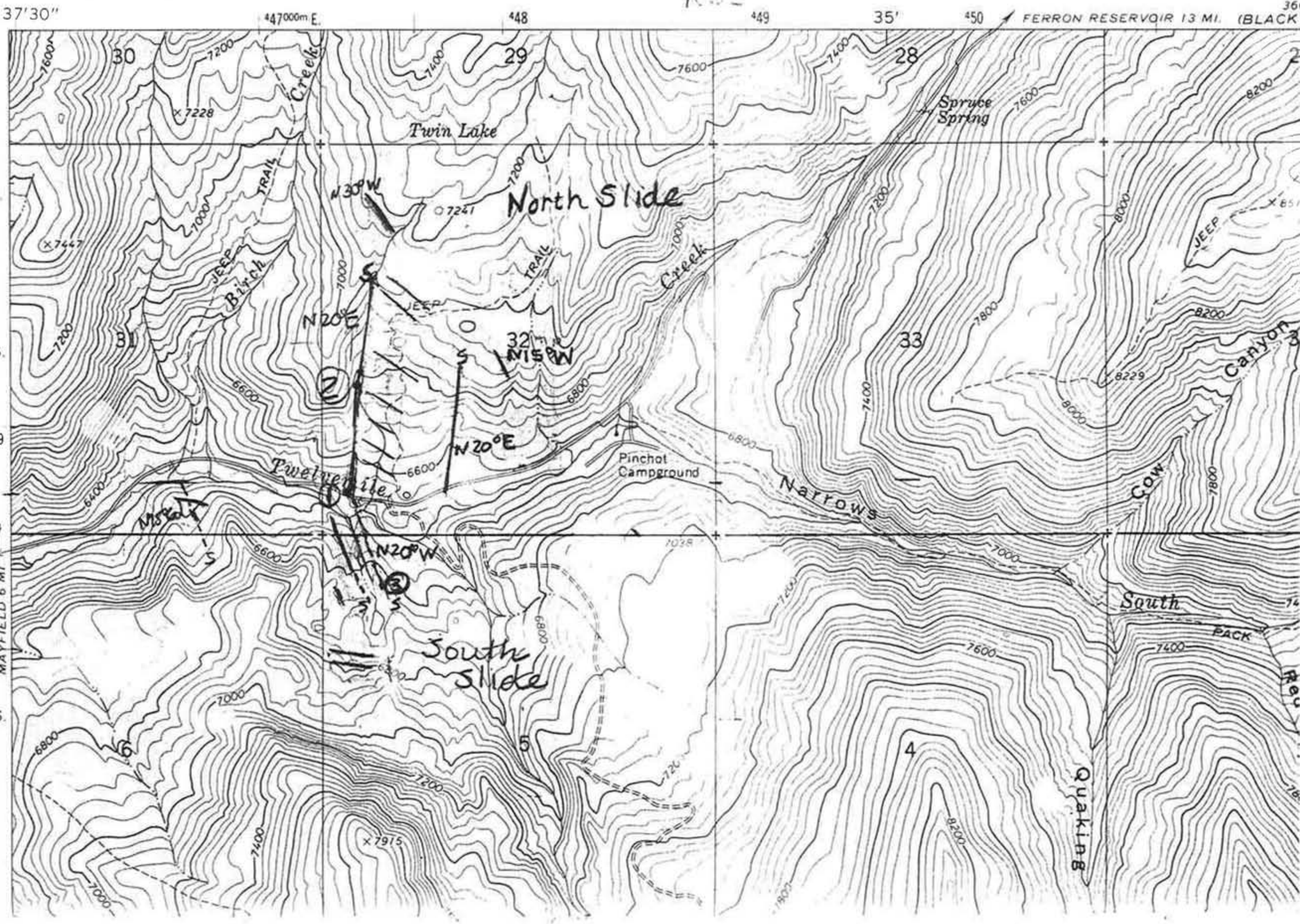
South Slide

14.	Toe of the South Slide, Twelve Mile Creek Slide.
15-17.	The next three photos were taken on consecutive days from June 6, 1983 to June 8, 1983. Notice the trees and the triangular rock in the creek for comparative references.
18&19.	The eastern shear at the toe of the South Slide.
20.	The North Slide as viewed from the South Slide.
21.	Tension cracks on the South Slide-Water is flowing within all these cracks.
22.	Tension cracks on the South Slide in the active zone.
23.	One of the three parallel shears in the active zone of the South Slide. Diagonal slickenslides were prominent on the scarp. Maureen McBrien is on the foot wall of this feature. The arrow drawn on the scarp shows the relative movement.
24.	Active shears on the South Slide.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

3662 II NW (STERLING)

Twin Lakes (North and South Slide)



S———— Shear Crack

– – – S Inferred Shear Crack

———— Cracks

N 15°E Strike (North 15 degrees East)

① • Monitoring Station

↑ North

1:24,000 Scale

Contour Interval = 40 feet